

UNDERSTANDING WEARABLE COMPUTING DEVICES

PRODUCT DESIGN PROJECT III

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GUIDE:

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INDUSTRIAL DESIGN CENTRE
INDIAN INSTITUTE OF TECHNOLOGY
2015

PROJECT



// WEARABLE COMPUTING DEVICES //

PROJECT THREE

RAHUL ANAND

PROF. KUMARESAN



DECLARATI

ITION

The research work embodied in the written submission titled "Understanding Wearable Computing Devices" has been carried out as Project Three by the undersigned as part of the post graduate program in the Industrial Design Centre, IIT Bombay, India under the supervision of Prof. P. Kumaresan.

The undersigned hereby declares that this is an original work and has not been plagiarized in part or full from any source. Appropriate reference information or links have been provided wherever due.

Furthermore, this work has not been submitted for any degree in this or any other University.

I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action if need arises.



Rahul Anand
April 30, 2015 at Bombay

APPPROVAL

This design project entitled "Wearable Computing Devices:" by Rahul Anand, 126130006, is approved in partial fulfilment of the requirements for Master of Design Degree in Industrial Design.

Project Guide



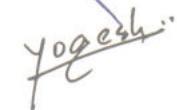
Chair Person



Internal Examiner



External Examiner



Date · 6th MAY 2015

ACKNOWLEDGE

// *Let us rise up and be thankful, for if we didn't learn a lot today, at least we learned a little, and if we didn't learn a little, at least we didn't get sick, and if we got sick, at least we didn't die; so, let us all be thankful.*

Buddha //

DOGE

This work is dedicated to my family. To my loving parents and sister, thank you, for all your enduring support and endless encouragement. It kept me going.

To my project guide, Prof P. Kumaresan, for being a fabulous support throughout these formulative years. For the discussions and ideas that we had openly, and learning through them. For the freedom to explore and experiment, that was allowed.

To all my faculty members, for shaping me as a designer, and being there to help, when things got worse.

To my friends, for the thoughts we shared, for all the lighter moments, and helping me sail through difficult times. For the memories created, and keeping me sane.

Rahul Anand

April 30, 2015 at Bombay

ABSTRACT

*// Project Title :
Understanding Wearable Computing Devices //.....*

What if you can have more than five senses to experience the world? What if your direct perception of the world can be altered? With Wearable computing devices this true augmentation of human capabilities is becoming ever more possible. These devices are changing the way we see, we perceive and do things. In recent years there has been an exponential rise in development of wearable products and it is considered as the next breakthrough technology in computing.

It is important to understand the potential that wearables have to offer. Almost every day, a new wearable device sees the light of the day, but a majority of them have failed to make an impact over the people. What is the reason behind this failure? This research based project tries to understand why wearable computing is important and most importantly it raises questions, finds out the problems that wearables suffer from, currently. It tries to answer how these pitfalls can be avoided to create the next generation of successful wearable computing devices.

A comprehensive literature study was done to understand the history and development of wearable computers, the visions proposed and what is the state of wearable as of now. An analysis of over 500 devices, with focus on 20 different devices helped in assimilating the overall picture of the current generation devices, their functions, target areas and shortcomings. Over the course of project, the author used four of the class leading wearable devices to understand the benefits, and faults in them. To gauge the importance of wear-ability, fashion, individual choices and role of technology in our lives, a user survey involving 250+ users was conducted.

The findings of the research brought out the fact that when computers are wearable, they become a part of our identity and become much more than just products. This calls for a collaboration of product design, interaction. User experience design, fashion design and hardware engineers to conceive and build devices together, to be able to cater to each individual's needs, choices and usage pattern. Moving

beyond fitness trackers and phone repeaters, wearables need to make use of breakthrough technology to change the way we interact with information, data and execute tasks using computers. Based on the inferences and understanding gained during research, a suitable use case scenario is identified and an experimental wearable product is devised responding to the scenario. A music creation glove which allows musicians to create, save, learn and share music on the fly was proposed and discussed with a set of music makers and possible users. The device was prototyped and during a survey, it was received well in its second version itself.

Wearable devices have definitely come a long way, and with hardware becoming ever smaller and smarter, they are putting ever more power onto our bodies. Getting these devices right might be the key to solving a multitude of specific problems that people suffer from, ranging from algorithm assisted artificial limbs to replacing the screens and their limited size to consume and create information. Wearables will soon become invisibles, and initiate the

METHODS

LITERATURE STUDY

- 5 Text Books
- 40+ Research Journals
- 100+ Articles/Blogs

USER STUDY

- 45+ Questions
- 250 Users
- 5+ Interviews

ESSAY

COGNY

DEVICES STUDY

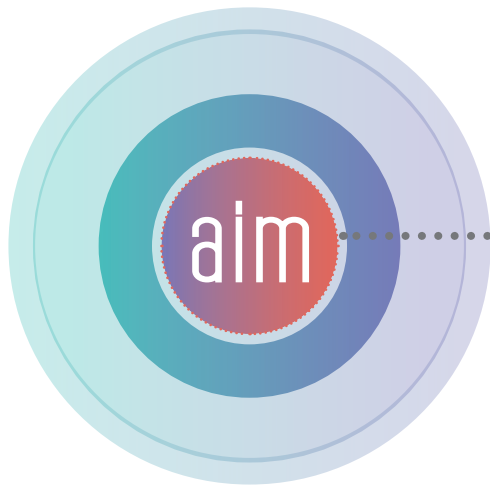
- 500 *Devices Catalogued*
- 4 *Live Studies*
- 20 *In depth study*

DESIGN

- 1 *Scenario*
- 1 *Prototype*

EXPERIMENT

STRUCTURE



To look at the wearable computing scenario and find out the problems plaguing such devices in present context, Understand various human factors, needs and variables involved in designing and envisioning wearable products, and experimenting with scenarios and ideas embodying the findings.

Essay

pages 04-112

Why: Wearable Computing	Pages 06-52
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ESSAY

// WHY

Why wearable computers are the next step to human and technical evolution. Ideas such as man machine singularity become possible with computers worn on our body. An understanding of

History of Wearable computing

The development of progress of wearable computing devices from 1960 to 2010

// WHAT

What is a wearable computer? What are its essential characteristics and paradigms? Understanding them and analysing the contemporary wearable computing devices, their wearability, usage, types, technology involved, and possibilities they offer.

// HOW

Why have wearable computers not gained acceptance by the people? What problems plague current devices, finding these problems, and understanding the variables that get involved in design when a computer is worn on the body, in 24/7 paradigm.

Technology & Human Behaviour

We make things, and then the things make us. How technology is affecting our behaviour and its after effects.

// THEN

The extract of all the research, why wearable computers are useful, and why they have not been able to fulfill their promises, what design decisions can make them more impactful and meaningful to our lives.

WHY

// *To create, one must first question everything.*
Eileen Gray //

//Why. Wearable Computing ?

I was in total 'AWE', as everyone else in the classroom. Our first ever computer science class had just come to an end. Our teacher had arranged for screening of a movie in our library, "The Terminator". A story of an artificially intelligent being which is sent to kill someone. It had a lot of slick special effects which had revved up our brains. I had seen nothing like that ever before. Although I was mesmerized with the whole idea, the thing that fired my imagination, was the Heads up Display of the Cyborg itself. The computer enhanced vision let the cyborg know different objects, their details, it helped him to recognize enemies, calculate trajectories, and have a greater understanding of the world than an average human. It was like a cool superpower.

I found the whole idea so captivating, that the back pages of my school notebooks were filled with doodles of different concepts for the terminator display. These concepts explored the ability to see stars and constellations designated and named overlaid on the sky, to see the world in different hues and colours, in different electromagnetic radiations like radio and ultraviolet, etc

Years later, at the start of this project, I watched the movie again. And though, this time, I understood the story better, the charm of the terminator display was still there. This led me to ask a simple question:

Why did the terminator vision captivate me?

S: SERIES
MINATOR
TYPE

000 STATUS
OF ATTACK
83%
= 54889
= 00933
= F8367
= G0894
YANCE 4FT
= H9837
= J0948
= K8364
= L3748
= Z3864

BILITY OF
TERMINATION:

9846592834
2094875204
8764523456
UAL IN SITE
735358724
345987087
983745809
987435234
876863456
3475689347
5865421234
3230856723
3745692387
3784785747
8344857984
4760847508
4763088959
8745088763
8868388568
4756889975
8858343534
2347623049

DEFENSE MODE LEVEL 69825

DAMAGE TAKEN
RUNNING ON 53
ENERGY
21 BULLETS LEFT

TARGET AQUIRED

VISUAL:
TERMINA
MODEL 10

CAUTION: T-100
CAPABLE OF KN
AND STABBING
EQUIPED WITH H

VULNERABLE T
MOLTEN STEEL
AND LIQUID HIT

PRIMARY MISSION: ENSURE THE
SURVIVAL OF JOHN CONNOR

MATCH:

378
022
022
048

SCAN MODE LEVEL 43545
ASSESS VEHICLE

VISUA
MODE
SLSTS
91 FAT



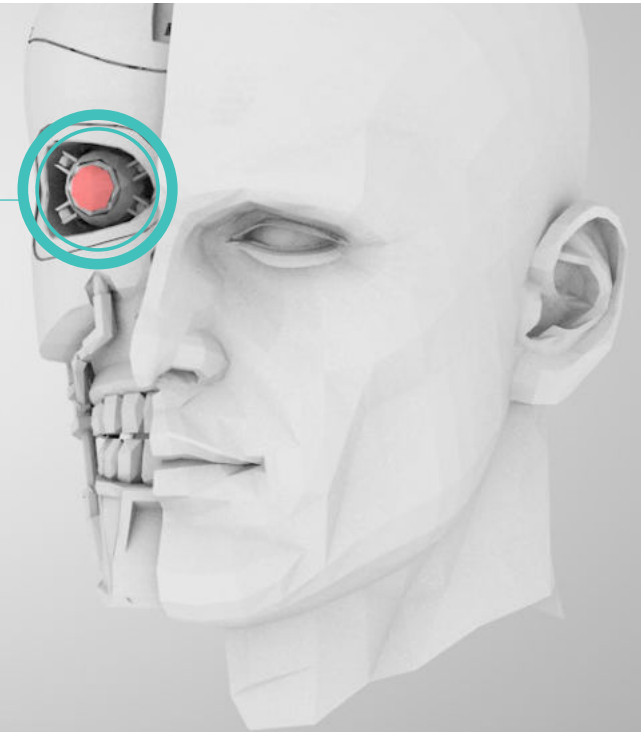
WHY DID THE TERMINATOR VISION CAPTIVATED ME?

// The Terminator Vision
the original was in red hue.
Screenshots from movie:
Terminator:Judgement Day

WHY

CYBERNETIC ORGANISM

.1 A cyborg (short for "cybernetic organism") is a theoretical / fictional being with both organic and biomechatronic parts.
//image source: author



// What makes us human

In search and re/research of this answer, I discovered a fundamental marker that lends a lot, towards making the human race as it exists now, and why wearables might be the next natural stage in technological evolution.

The main protagonist of the terminator was a cyborg. It's an evolution, a different kind of evolution which promises to make humans more than what they biologically are. But surprisingly, this evolution is not newfound, and has been practiced by humans since the time we came into our present form of homo sapiens. And though becoming cyborg might be the other end of this evolution, its roots lies in our first ever use of bone to act as an 'extension of our hand'. Interestingly, as a lot of scientist research points to, this phenomenon of using tools to extend our abilities might have been the reason that differentiated us from apes, and made us humans, in the

// Human life began in Africa. Here our ancestors created the first stone tools to chop meat, bones and wood. It was this increasing dependency on the things we create that makes humans different from all other animals. Our ability to make objects allowed humans to adapt to a multitude of environments and spread from Africa into the Middle East, Europe and Asia."

//Neil MacGregor , A history of world in 100 objects/

first place.

There is a beautiful portrayal of this fact in Stanley Kubrick's Space Drama, 2001:A Space Odyssey. It glo-

riously depicts the moment when an 'ape' realizes that a piece of bone can be *used as a tool* to destroy things, to kill animals. In the scene after, the ape throws the bone into the air and as the bone starts falling back, the bone falls down to give way to a spaceship floating in space, summarizing poignantly, possibly all the progress and technological developments man has achieved since the first tool used.

The ability to imagine tools before they are needed, to create and improvise on them has changed our world single handedly. So much so, that it might have made us capable of speech and language, another marker which

// Recently, scientists have looked at what happens neurologically when a stone tool is being made. They have used modern hospital scanners to see which bits of the brain are activated as stone chippers work their stone. Surprisingly, the areas of the modern brain that you use when you're making a hand axe overlap considerably with those you use when you speak. It now seems very likely that if you can shape a stone you can shape a sentence."

//Neil MacGregor, A history of world in 100 objects/

differentiates us from other species.

Since the first tool, man has been on a roller coaster ride to make objects. Everything we have made, developed, created is the outcome of that understanding, that desire, that philosophy, that we have the power to make things, in order to augment us with capabilities. From the plough that helped us master agriculture and be-

come self-dependent on food to the wooden ships that took us from one landmass to another and colonized the whole world. No other species uses tools to make other tools, and hence create 'technology' to overcome various physical limitations provided to us by nature. (*Technology is a Greek term derived from tekne which means, art, skill, cunning of hand (becoming adept at), by using tools to solve a purpose/problem.*)

And Homo Sapiens is a technological species.

And this ability has single handedly made Homo sapiens the most powerful species on this planet.

It's an evolution happening in parallel to the biological one, but superseding it. And this is why, the terminator vision captivated me. It was the culmination of all technology becoming one with the body itself, leading to real time enhanced being. It showed me a vision that opened up the possibility to see more, it gave me instantaneous and relevant information right when and where I needed it. If I want to know about an object, I just had to look towards it, and all the information will be there. In our world, for an average human, this ability would have meant, no more asking someone, or finding a dictionary/ encyclopedia and searching for it. It overcame the gap between the intention to know more about the real world, and the action that leads to it. In simple words, **it augmented my senses and brain, reducing gap between when i wanted something i.e. 'intention' and when i actually received it, i.e. the final 'outcome'.**



THE ABILITY TO

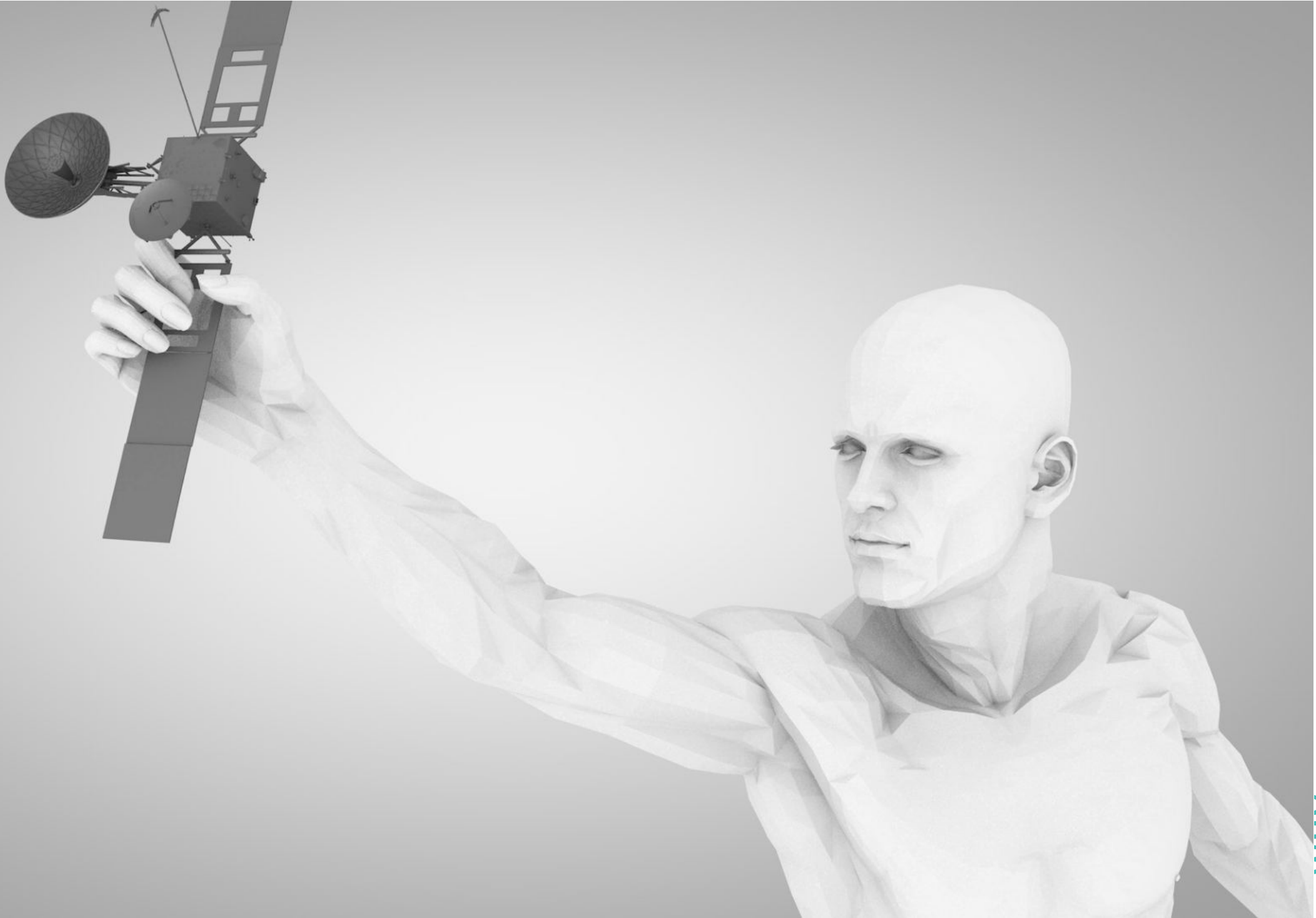
AUGMENT

THROUGH TOOLS, MAKING TOOLS, IMPROVISING THEM, TO EXTEND OUR PHYSICAL & MENTAL CAPABILITIES.

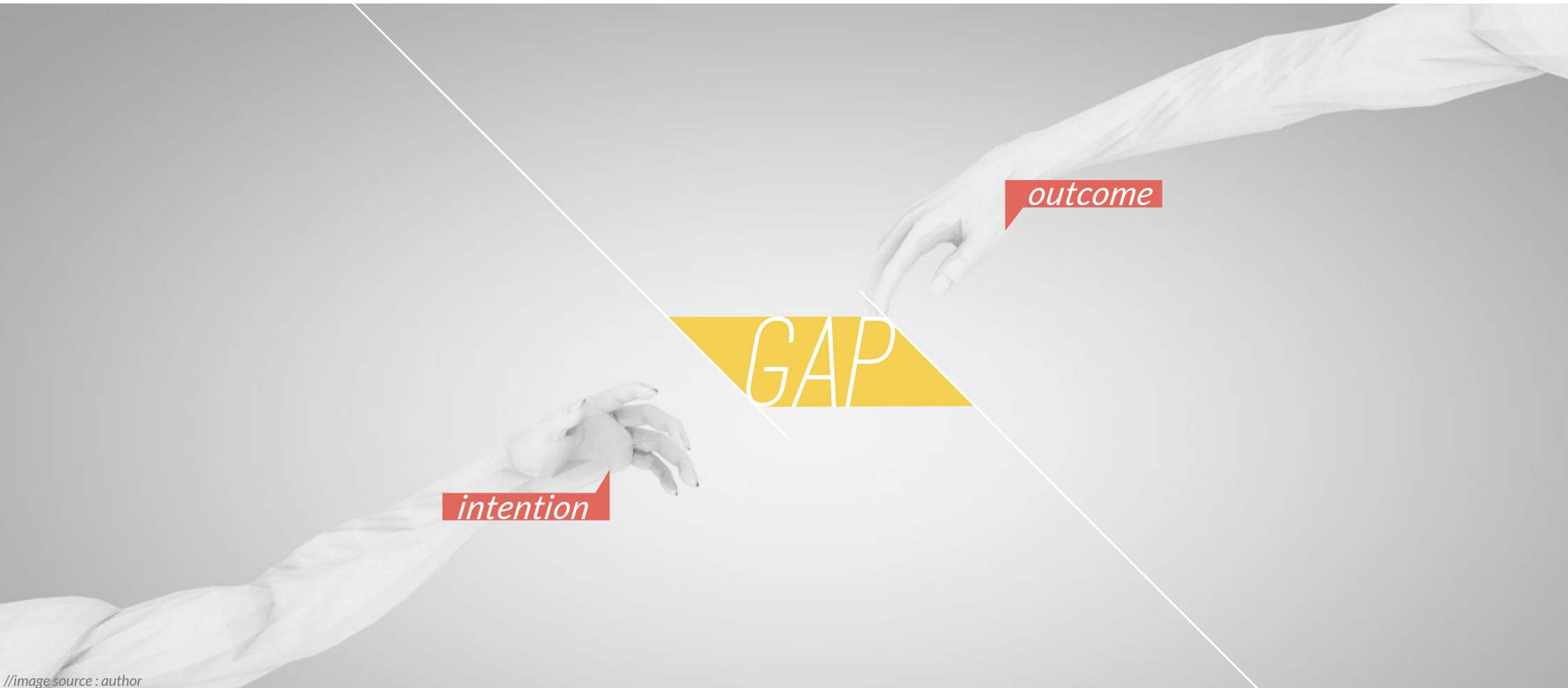
MADE US DIFFERENT







WHY



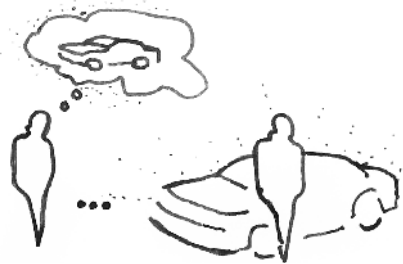
intention

outcome

GAP

// Between Intention & Outcome

And if you think about it, most of the tools we have made, are about minimizing the 'gap' between our intentions, and the outcomes. To minimize and simplify the action that is required between them. Just like a pencil, which acts as a tool to close the gap between what we imagine in our heads, and when it comes out in real world in form of a sketch or writing on paper, every other tool serves as a bridge between our intention in our heads and its realization, an outcome. We want things to get done fast, reducing the time between intention and outcome as much as possible, or in the best case scenario, to do completely away with it.



If you could imagine a car, and it becomes real as you do it, will be the best possibility. And If we could teleport, we would abandon our cars. Because everything in between is a time taking nuisance which is just separating us from the destination. If you have your own car, you will have to first walk to it, open the door, sit inside, put the key in, drive onto the road, stop at traffic, travel all the miles, maybe for hours and finally reach the place,

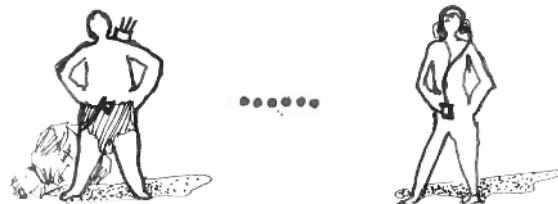
find a place to park, open the door come out, securely lock the car and walk to your destination. If you depend on public transport, it's a more time taking story. But, nonetheless, If you could teleport, there will be no such intermediate delays, and activities.



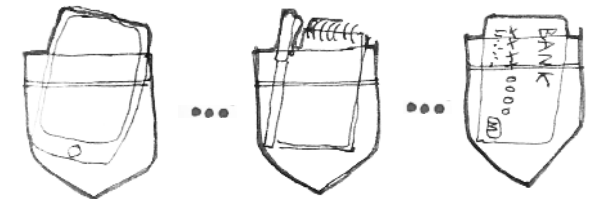
Sadly, we cannot teleport, so we have been making tools to reduce this delay as much as possible. From using our feet as the only way to move between two points, to the invention of wheel which liberated our movement in unprecedented ways, to the present day rockets that have took us to places beyond our own planet.

// Portable, Pocketable, Wearable

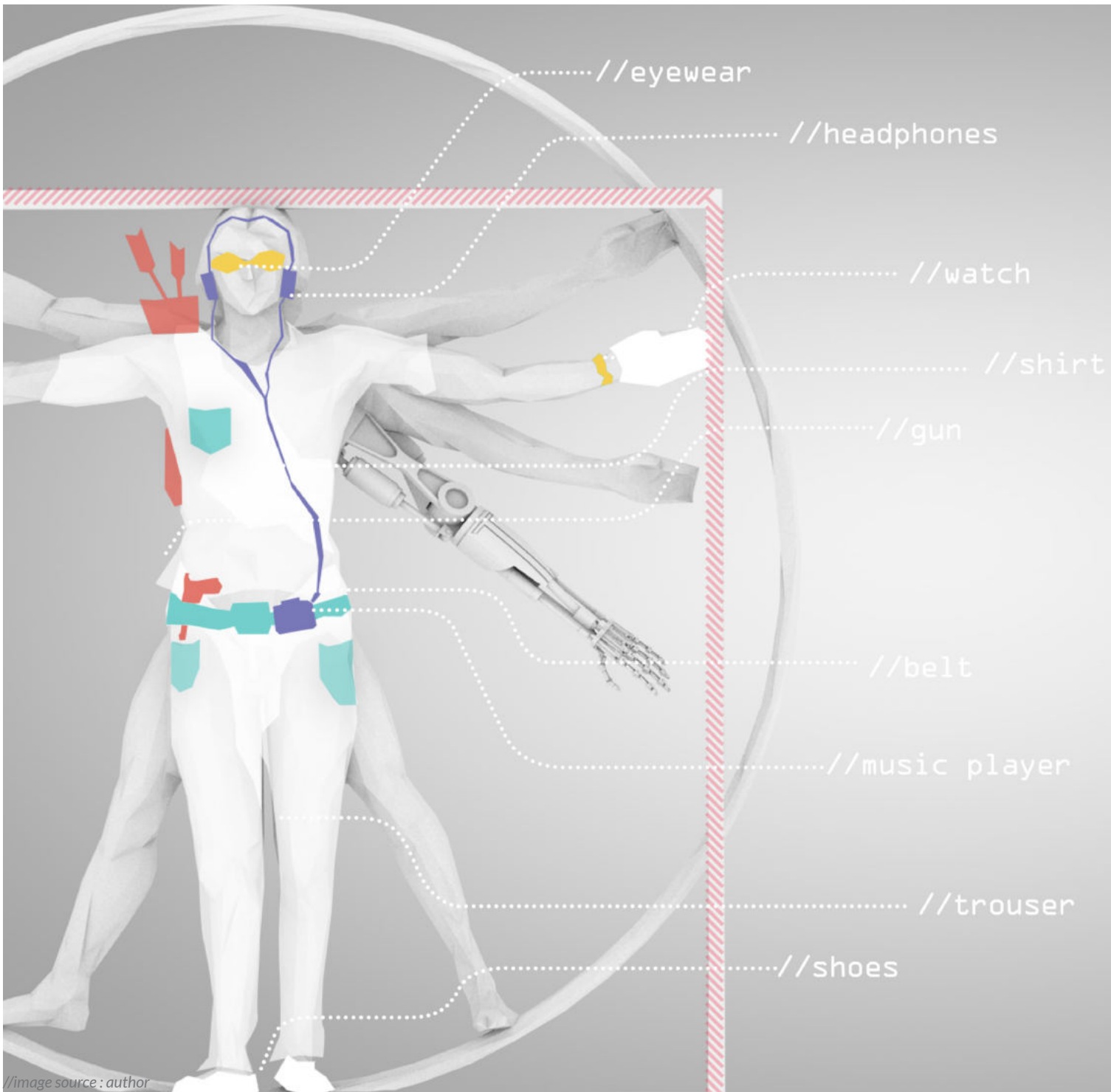
In fact, reaching to the car itself is a big friction point. Any tool first has to be accessed to be used. To reduce this friction of getting to the tool, we have always tried to put them within our reach, accessible with least time and effort, preferably close to our bodies.



We have always tried to worn these tools on our bodies, since the stone age to the iPod age. We made pockets in our clothes to keep more things close to reach, and then we started making things smaller and pocket-able. From pens to diaries, knives to cameras, and pills for cholera, we have tried to make things pocket-able, carry-able, portable, wearable, or simply *bearable* on our bodies.

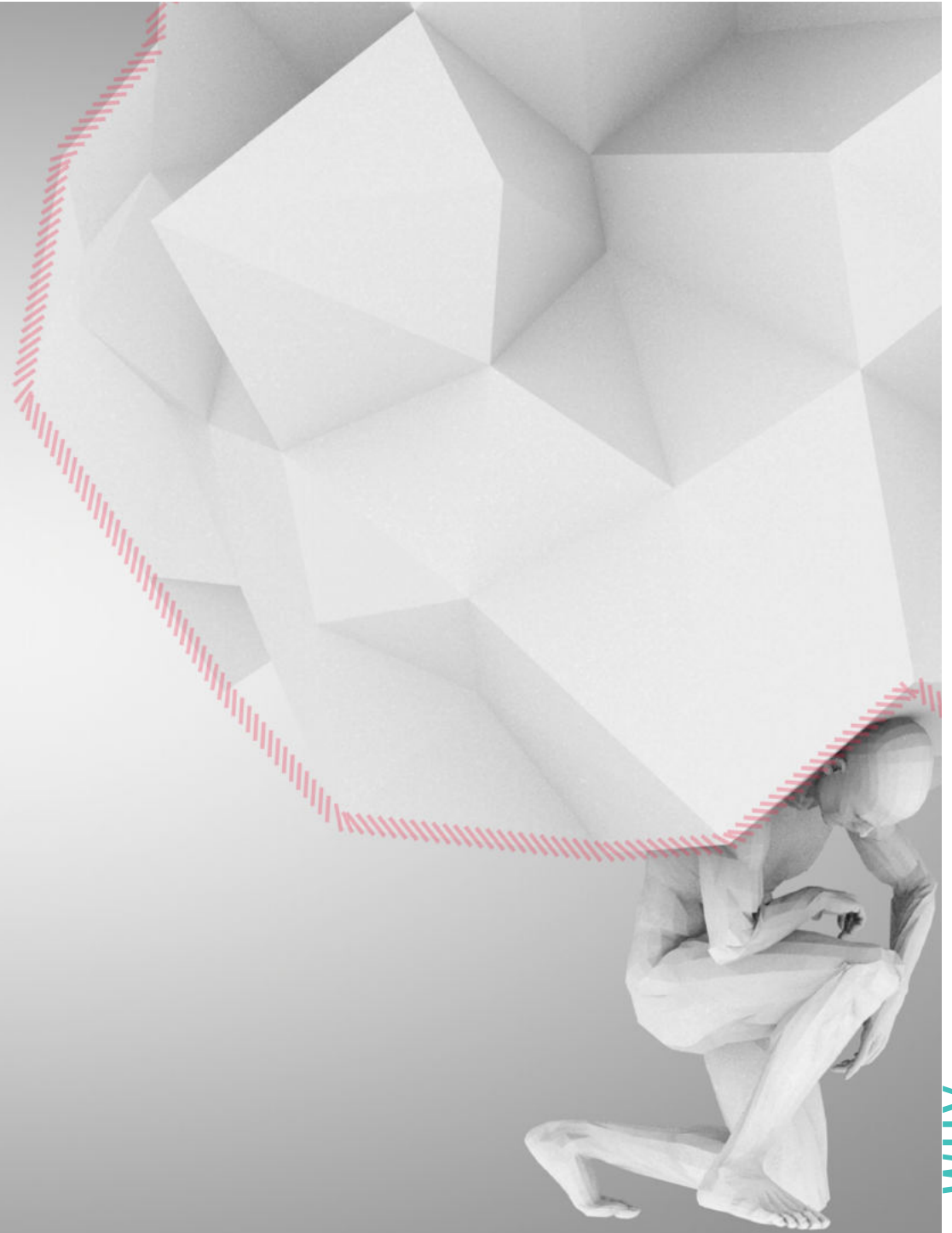


But making things bearable has not been easy, owing to limitations imposed by the size, shape, and weight of the tools/objects. Just a few decades ago, it was impossible to put all the content of encyclopedia Britannica paper edition, in your pocket by any means. Or a few centuries ago, the idea that you can wear a clock on your wrist, would have been seem laughable and mocked upon. But homo sapiens, as a species is adept at not just making things but improvising them. We all love the latest and greatest versions of things. Because with every improvisation, every version, our species makes better tools, which make us more comfortable, more efficient and faster at doing things.

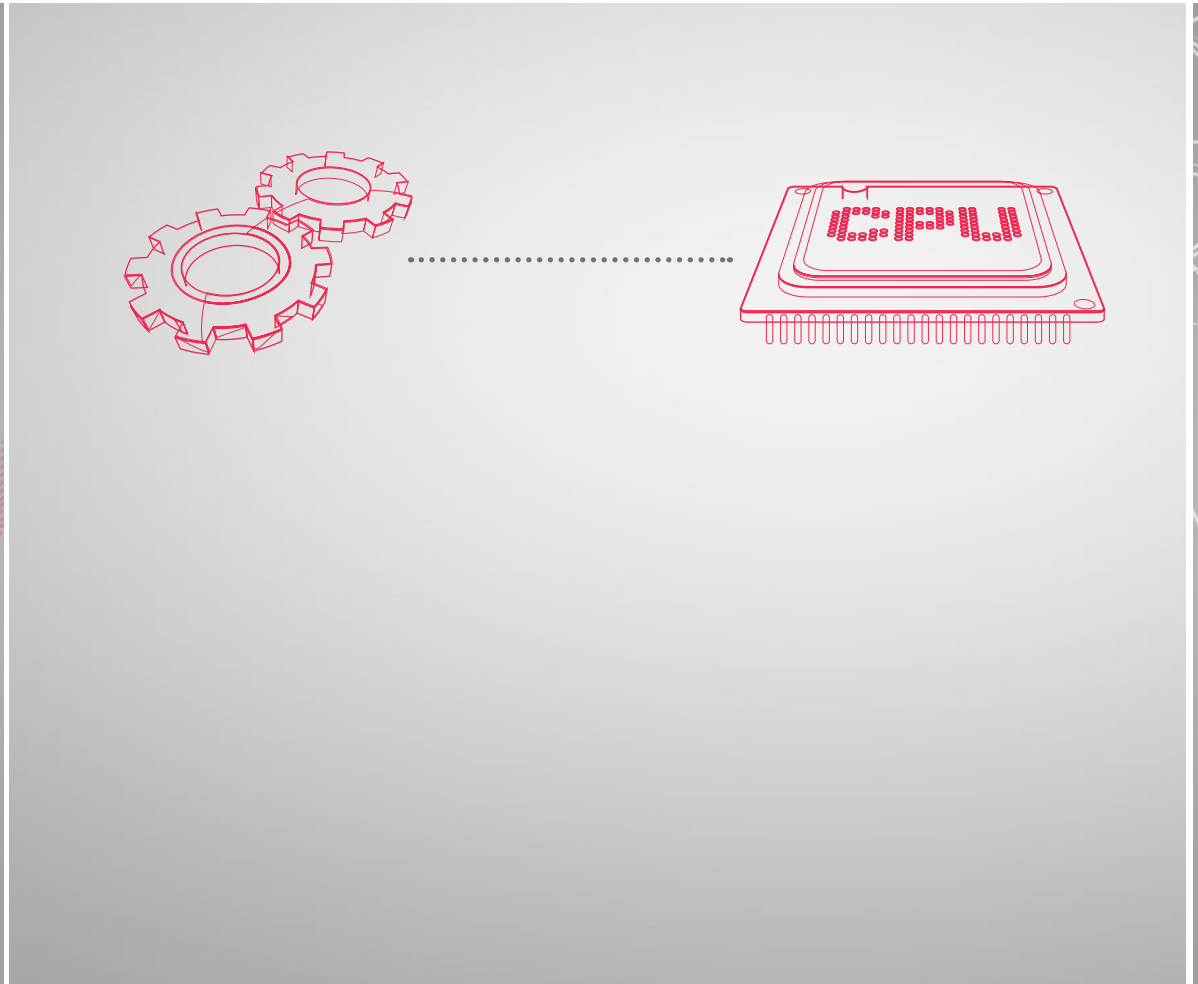
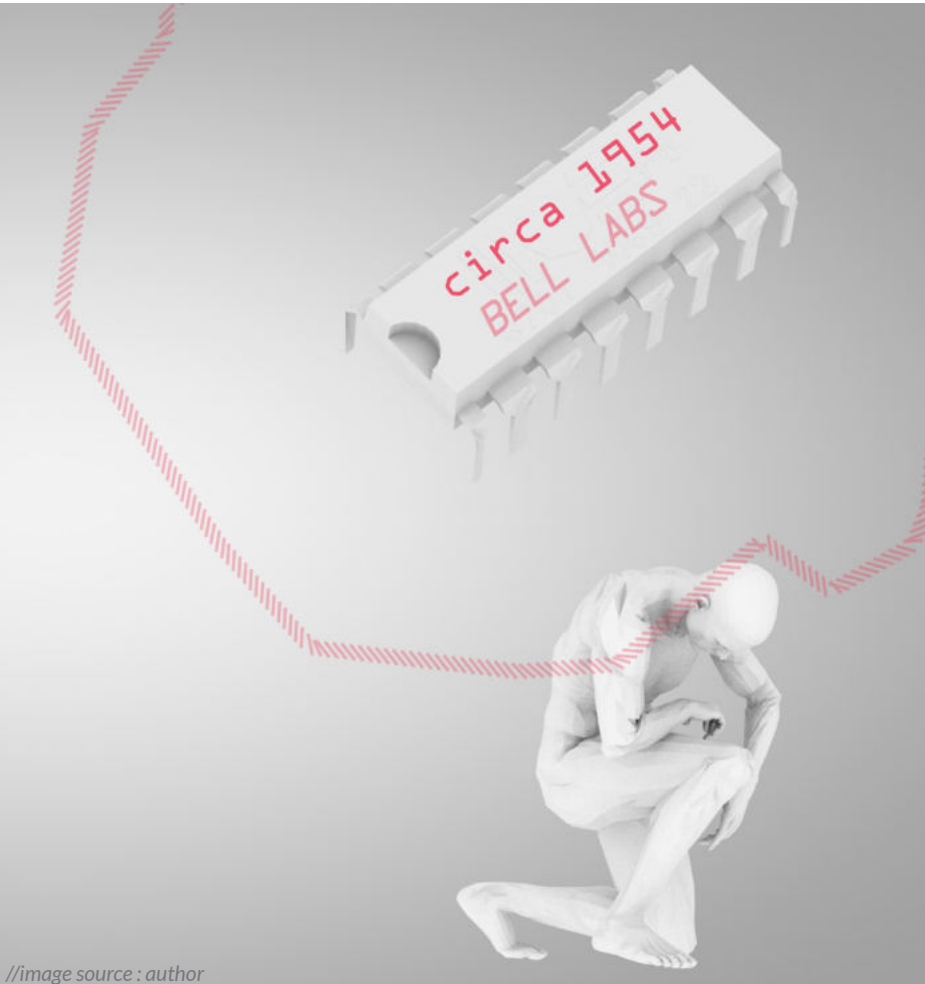


- //WEAR·ABLE
- //CARRY·ABLE
- //PORT·ABLE
- //POCKET·ABLE
- //BEAR·ABLE

making things
bearable
has been difficult
due to limitations
of size, shape and
weight.



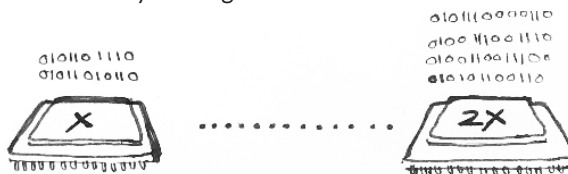
WHY





// From Gears to Solid State

One such improvisation during 1950s, changed the way we compute, forever. Computing went electronic. The first all-electronic transistor could now process numbers without big heavy, clunky cog wheels and levers. It was an all solid state device without any mechanical parts, hence it was easier to miniaturize and manufacture. What did this imply? Huge computing possibilities from tiny components, components that are smaller than nails on your finger.



Gordon E. Moore observed that the number of transistors in an integrated circuit doubled approximately every two years. And in the past six decades of electronic computing, this observation has held up, amazingly well. This technological revolution paved the way of overcoming physical limitations of objects. Over the course of computing revolution, we realised that a lot of tools around us can be coded into algorithms. Since then, more and more physical tools have been emulated through these coded electronic circuits/computers.



This has led to the existence of various tools/objects in a world different from the physical one, albeit a virtual one as we call it.



And it is a world free of size, shape and weight. A whole lot of universes can exist within it, without any considerable weight. And this phenomenon unburdens us, and enables us to access multiple tools and do a multitude of tasks with just one object. It gives way to a formless form of world where computing starts happening in the cloud, light, fast and everywhere.

It is the greatest technological leap mankind made since wheel, or probably inventing language itself.

And out of the various technologies that we have tried to wear, for the first time in human history electronic computing had the scope of making really powerful tools wearable, reachable, accessible, all from the vicinity of our bodies.

W W W W W
electronic computing

//enhance us

//augment us

//continous access

//reduce time lag

//make them better

Wearable Computing

//make them w
/bearable

//within reach

//make things

//access them easily

*The innate desire to make things,
to enhance ourselves,
to make them better,
the desire to access them
easily and timely,
to put them on our bodies,
and the power of
electronic computing
all came together to give birth to
WEARABLE COMPUTING.*

The wonderful vision of terminator, was suddenly possible with wearable computing.

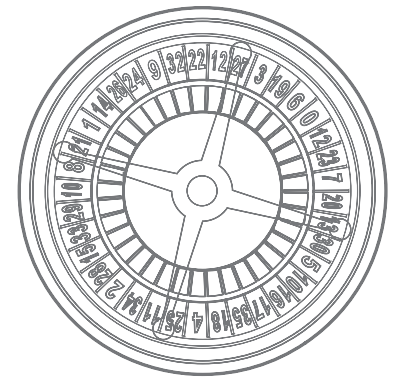
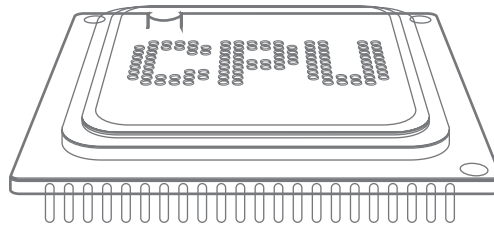
Within 10 years of the invention of first all-electronic computer, visionaries like J.C.R. Licklider and Doug Engelbart had already given future visions of Man Machine Symbiosis, a world where computers will help/augment humans in their formative thinking, in real time, and both will act as a combined organism, enhanced and become an new evolutionary being. The term cyborg was used for the first time in 1960 by Manfred Clyans in a story called "Cyborgs and Space" published in *Astronautics* (September 1960). The term was

used to describe a human being augmented with technological "attachments". We also witness the invention of first wearable computer which predicted results for a roulette game.

And since then, the idea of Machines that we can wear to augment and enhance our selves continuously, has caught on imagination of geeks, scientists, and even general people which have been experimenting and improvising on idea and formulation of wearable computers.

In the following pages, we will see the interesting and weird *history of wearable computing*.

HISTORY



“The next care to be taken, in respect of the Senses, is a supplying of their infirmities with Instruments, and as it were, the adding of artificial Organs to the natural... and as Glasses have highly promoted our seeing, so ‘tis not improbable, but that there may be found many mechanical inventions to improve our other senses of hearing, smelling, tasting, and touching.”

-Preface, Micrographia, Robert Hooke, 1665

Perhaps one of its first kind of scientific publication where such possibilities of augmenting senses, through use of devices is discussed in context of human body. It would not be possible with technology available then to miniaturize devices so that they can add to our senses. For a long time, optical glasses were the only form of wearable devices, (though not true computing devices) that augmented our sense of sight. Apart from very rare objects like an abacus worn on fingers as ring in China (17th century), watches worn as lockets and on wrists, wearable computing devices were practically non-existent before 20th century. It was only after the invention of electronic computers that the first true wearable computer came into existence.

It was the year 1961, when a mathematics scholar Ed Thorpe, to prove his study about predicting results of roulette, made a computer setup, with the help of Claude Shannon. The problem was, in order to test the theory they had to use it in a live game. That would have

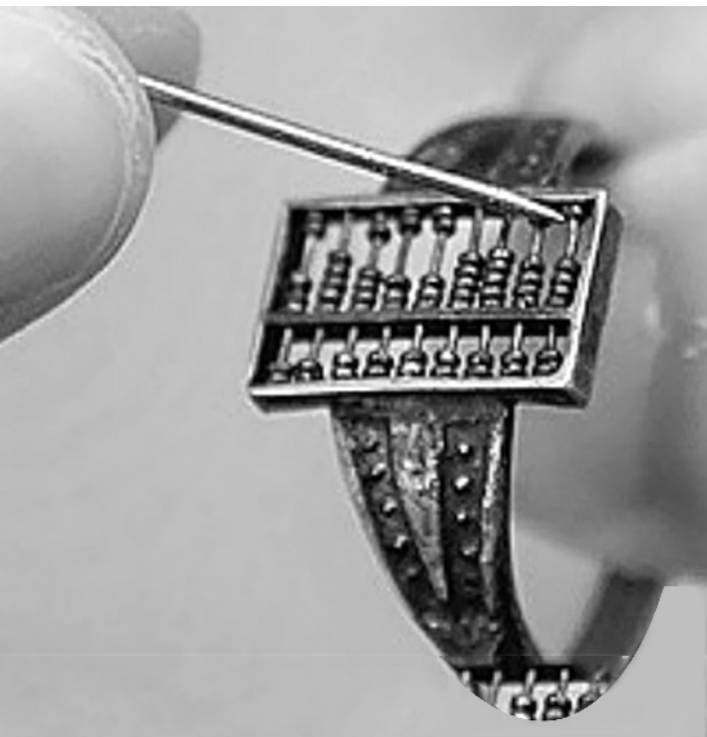
led to a disqualification, maybe even some penalty. So they decided to hide the whole circuit in such a way that it becomes invisible. This resulted in a setup which was a cigarette sized plastic box with integrated electronic circuit, and a controller with four buttons, all hidden inside a shoe (to be worn by user one) . This user would feed the speed of the roulette wheel through his feet. The computer calculates and tells the octant of the roulette wheel to bet upon, by musical tones send to the speakers which were hidden in a second person’s ear, who is actually betting. The system was tested a lot of times, but it remained a secret until 1966, when Thorpe mentioned It in his book “Beat The Dealer”. Thorpe also devised a similar setup to cheat the Wheel of Fortune game in an article published in LIFE Magazine, 1964.

In 1966, Ivan Sutherland created the first ever computer based head mounted display, using two CRTs and a system of mirrors. Next year , Bell helicopter tested different early versions of augmented reality setups. Douglas Engelbart, the computer visionary who talked about Augmenting Human Intellect in his paper in 1960s through the use of computers, arranged a demonstration, in 1968. Regarded now as **“The Mother Of All Demos”**, during a 90 minute interval, he showed a *ON Line System* or *NLS*, which spanned a lot of elements found in modern day computing, ranging from graphical user interface, word processing, video conferencing to input devices such as one handed keyboard and mouse.

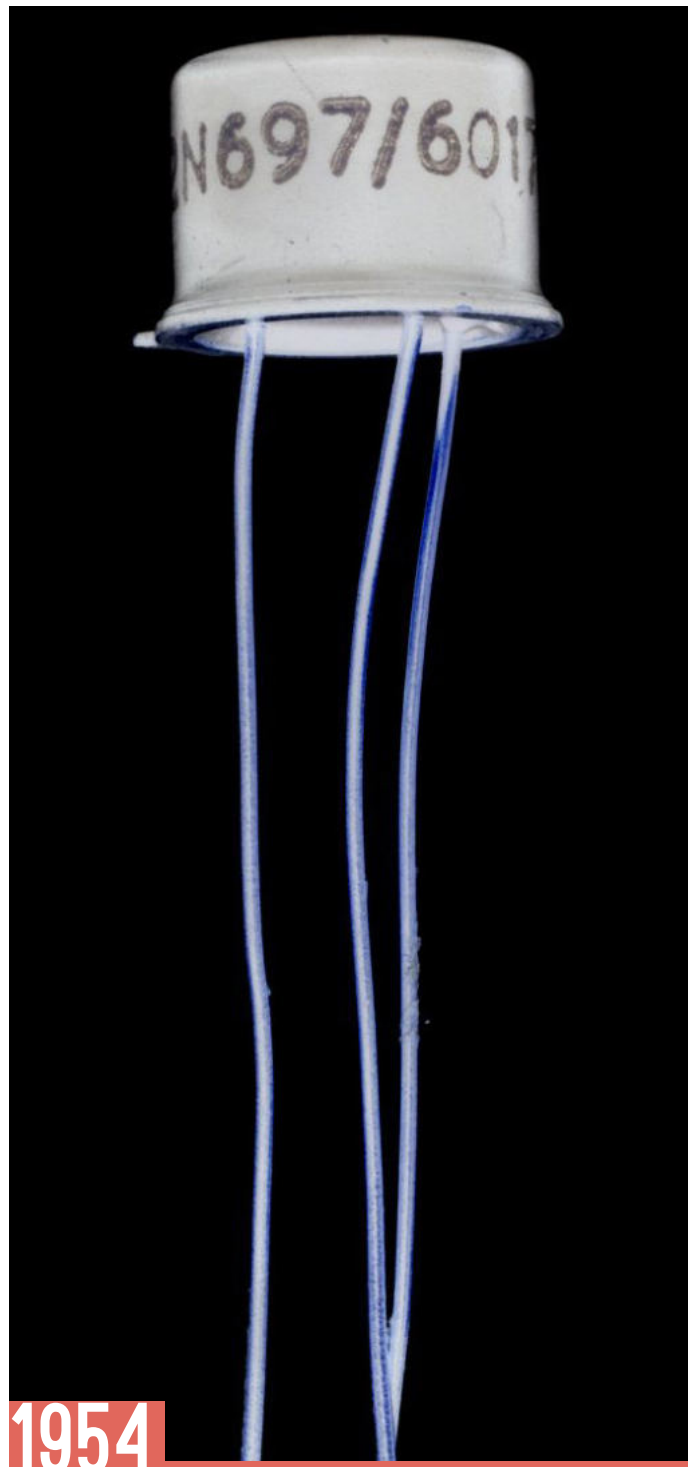
The next four decades witnessed the rise of computers (in a fashion predicted by Engelbart) and their applications in all aspects of life, in an unprecedented way. The wearable computers still remained a curiosity, and sustained mostly as research and do it yourself projects, among students and researchers throughout universities and technology laboratories.

Sony walkman (1979), made music wearable for the first time in history, and became a statement of fashion. Later iPOD (2001) did the same. Wearable pioneers such as Steve Mann and Thad Starner, adapted available hardware to make it wearable and started wearing these computers continuously, thereby becoming first real cyborgs. Countless head mounted displays and their functionality was explored in various labs, but lack of technology and suitable applications never let them become a successful device. In the meantime world caught onto a pocketable computer revolution, the smartphone phenomenon. The phones evolved from mere calling devices to all in one devices replacing your alarm clock to calculator, from your music player to your camera, it became an indispensable tool for the 21st century human being.

Technology has matured and miniaturized to a point, that we stand on the brink of another revolution, when truly powerful yet small computers that can be worn, embedded or even ingested are making their way on and into our bodies. ***The time for wearables starts NOW!***



EARLY



1954



1961



EARLY

The Abacus ring and early pocket watch.

//image source : <http://goo.gl/JDt5j>

//image source : <https://goo.gl/mDK2eS>

1954

The invention of first all electronic transistor

//image source : <http://goo.gl/NJBu7N>

1961

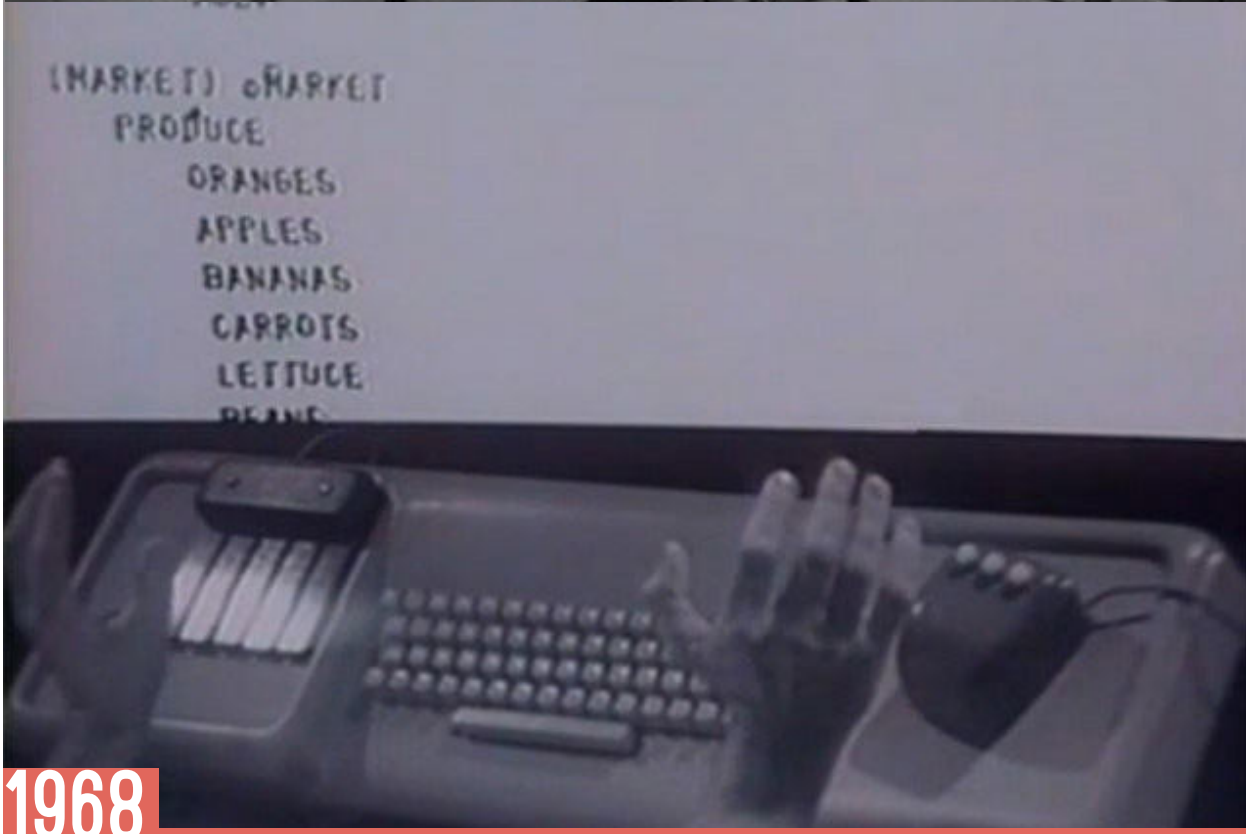
Ed Thorp and Claude Shannon invent the first wearable computer, used to predict roulette wheels [MIT]

The system was a cigarette-pack sized analog computer with 4 push buttons. A data-taker would use the buttons to indicate the speed of the roulette wheel, and the computer would then send tones via radio to a bettor's hearing aid. Though the system was invented in 1961, it was first mentioned in E. Thorp, *Beat the Dealer*, revised ed. in 1966. The details of the system were later published in *Review of the International Statistical Institute*, V. 37:3, 1969. Thorp also disclosed a similar system for beating the Wheel of Fortune gambling game in *LIFE Magazine*,

//image source : <http://goo.gl/Bg2YY5>



1966



1968

1966

Ivan Sutherland creates first of its kind computer based Virtual reality headset setup

//image source : <http://goo.gl/r7Xmwu>

1968

Douglas Engelbart demonstrates, a prototype computer system with a mouse, keyboard like device, alongwith word processing, hypertext and connectivity. This has since then been dubbed as "Mother of All demos"

//image source : <http://goo.gl/rleHjj>

//image source : <http://goo.gl/13A1A6>



1975



1979



//image source: <http://goo.gl/OnifxQ>



1980

1975

First calculator watch is released by Pulsar

//image source: <http://goo.gl/OnifxQ>

1979

Sony Introduces the first ever portable/wearable music player which became a cult product in the decades to come.

//image source: <http://goo.gl/TxTzHF>

//image source: <http://goo.gl/Prg7U4>

1980

Steve Mann (considered as one of the original pioneers of wearable computers) designs backpack-mounted computer to control photographic equipment

//image source: <http://goo.gl/Vk9Q5W>



1987



1989



1987

Movie "the Terminator" is released which features an augmented cyborg and captures the imagination of masses

//image source: <http://goo.gl/kFpyMk>

1989

Private Eye head-mounted display is developed and sold by Reflection Technology. It was a predecessor of what Google Glass is today

The display (designated the "P4") is a 720 x 280 pixel monochrome (red) monitor in a 3.5" X 1.5" X 1.25" package. Screen size is 1.25" on the diagonal, but the image appears to be a 15" display at 18" away

//image source: <http://goo.gl/DrJxPh>

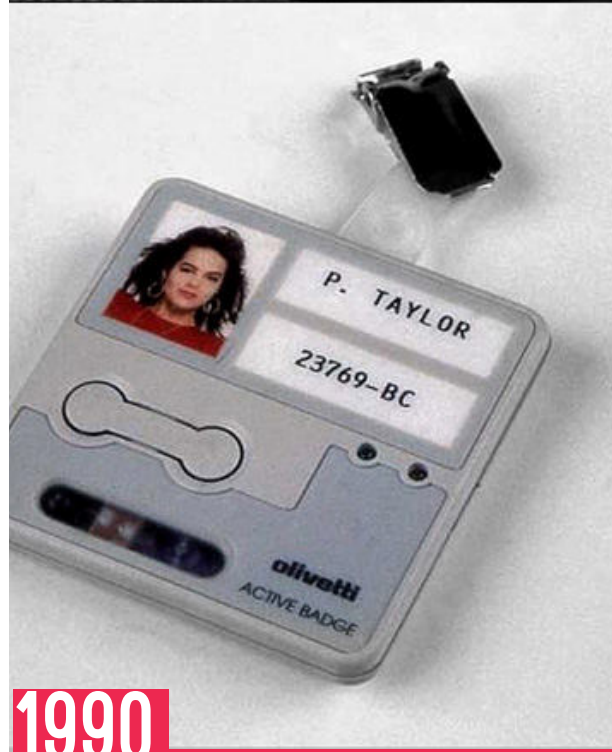
//image source: <http://goo.gl/tUJVIC>

1990

Olivetti develops an active badge system, using infrared signals to communicate a person's location

Olivetti developed a name badge that transmitted a unique id to IR receivers placed in rooms around a building. This allowed these "smart rooms" to track a person's location and log it in a central database. The badges measured 55x55x7mm, weighed 40g, and could be made extremely cheaply

//image source: <http://goo.gl/G3qotN>



1990



1991



Your World.

The astonishing new invention that has room for your whole world but fits in your pocket.

It manages your days, your names, and your numbers.

- Scheduling lunch? Tell your Newton MessagePad™ communications assistant what day—it will put lunch on your calendar for noon, and warn of any conflict. How? With a new concept called intelligent assistance.
- Tracks appointments by day, by week, by month—for over one hundred years.
- Automatically accesses names, numbers and addresses—when you print, fax or phone.
- And since it's also a notepad, it stores all the little personal notes you jot in your day.



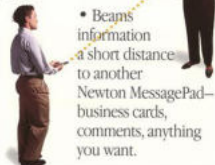
It sends faxes and replaces your pager.

- As your communications assistant, the Newton MessagePad sends faxes you create with it—anywhere—and makes a cover sheet automatically.*



- Exchanges electronic mail with Macintosh® computers, PCs and other NewtonMail® subscribers.

- Receives wireless messages of approximately 50 words—just like a pager.*



- Beams information a short distance to another Newton MessagePad—business cards, comments, anything you want.

It makes writing readable.

- Your Newton MessagePad can turn what you write into print, store it, and find it for you later.
- Formats letters, memos, weekly summaries—automatically.
- Uses intelligent assistance to recognize key words and act on them—"call," "send," "schedule," and, of course, "lunch."

It can draw even if you can't.

- Your Newton MessagePad knows you wanted that circle round, and makes sure it is.
- Makes lines straight, angles exact, and polishes it all.



It talks to computers and printers.

- Your sketch, your memo, your notes—it can print them all out on a PC- or Macintosh-based printer.*

- Shares information with Macintosh computers and PCs running Microsoft® Windows®—so you can back it up.* And in one more way, access your world.



And what you don't know, there's a good chance it does.

- The time in Paris? Newton knows.
- Who has the best brisket in Brooklyn? It will tell you.*
- Hotels, airlines, restaurants—all at your fingertips.*
- And with useful accessories and additional software, you're assured of one more thing. As your world changes, Newton will still have room for it all.



* Accessories sold separately: Apple Fax Modem; Newton Messaging Card; Print Pack; Newton Connection Kit for Macintosh; Newton Connection Kit for Windows (available fall 1993).

* Services sold separately: Apple Wireless Messaging service; NewtonMail on-line service (available autumn 1993).

* Software sold separately.



1994

Your Newton.



1991

Mark Weiser proposes idea of Ubiquitous Computing in Scientific American

Ubiquitous Computing proposes a world in which most everyday objects have computational devices embedded in them. Weiser's Landmark article, *The Computer for the 21st Century* appeared the September 1991

//image source: *The Computer of the 21st Century*, Scientific American, September 1991

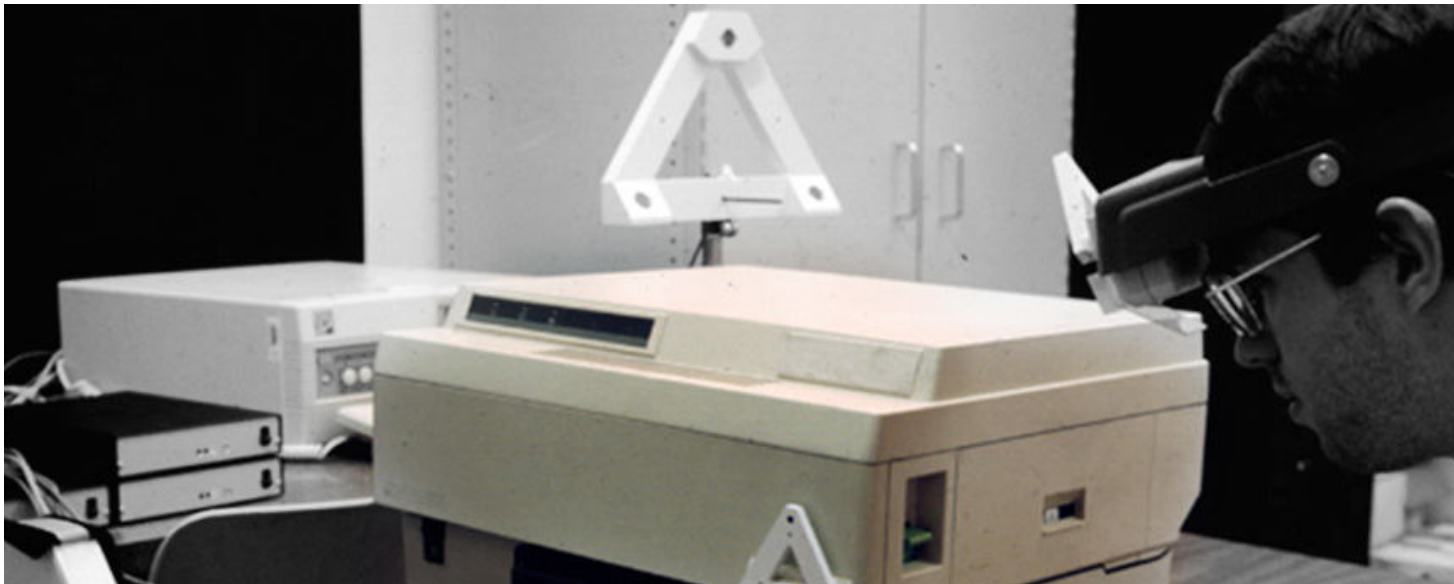
1994

Apple computers release first of its kind tablet computing device which supported pen input.

//image source: <http://goo.gl/1nRJ58>



1993



1993

Thad Starner starts constantly wearing his computer, based on Doug Platt's design.

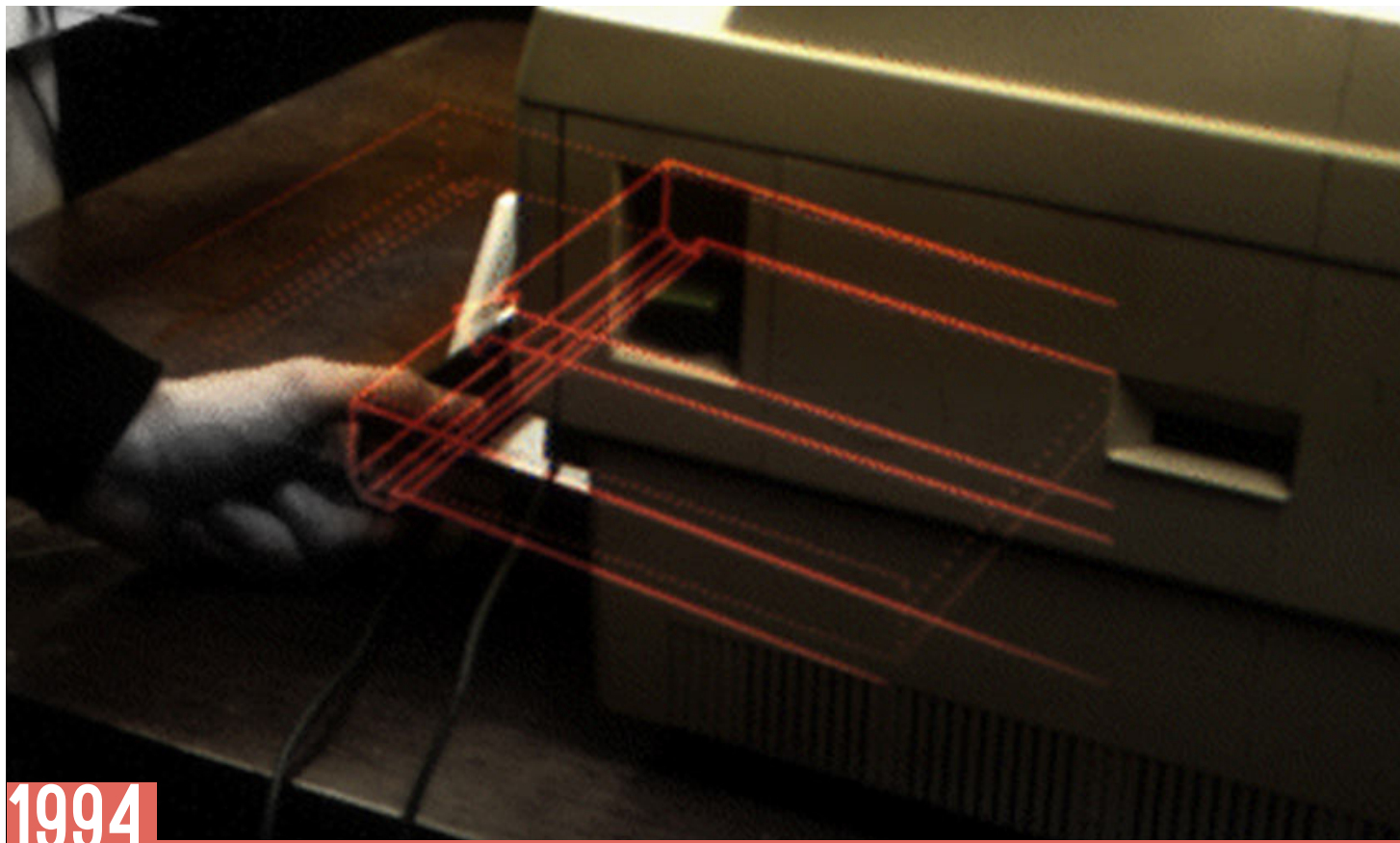
Starner had attempted previous wearables based on both a TRS-80 model 100 and a SPARC Workstation, but never got them working reliably. When he heard Doug Platt give a talk at the MIT Media Lab he shifted over to Platt's system based on a 286 chip. In June '93, Platt and Starner custom made Starner's first working system with parts from a kit made by Park Enterprises, a Private Eye display, and the Twiddler chording keyboard made by Handykey. Many iterations later this system became the MIT "Tin Lizzy" wearable computer design

Same year he writes first version of the Remembrance Agent augmented memory software

he Remembrance Agent (RA) was an automated associative memory that would recommend relevant files from a database, based on whatever notes were currently being written on a wearable computer. The system was integrated into Emacs, and later was rewritten as part of continuing research by Bradley Rhodes.

//image source : <http://goo.gl/9Wbfls>

//image source : <http://goo.gl/pOsrNi>



1994

Feiner, MacIntyre, and Seligmann develop the KARMA augmented reality system

Steve Feiner, Blair MacIntyre, and Dorée Seligmann at Columbia University developed KARMA: Knowledge-based Augmented Reality for Maintenance Assistance. Users would wear a Private Eye display over one eye, giving an overlay effect when the real world was viewed with both eyes open. KARMA would overlay wireframe schematics and maintenance instructions on top of whatever was being repaired. For example, graphical wireframes on top of a laser printer would explain how to change the paper tray. The system used sensors attached to objects in the physical world to determine their locations, and the entire system ran tethered from a desktop computer

//image source : <http://goo.gl/avnQWb>

1994



1994

1994



HEADS-UP DISPLAY

Enhances situational awareness, provides critical data

BIOSENSORS

Sensors in fabric measuring vitals

BODY

Nanoparticles protect against impact

LEG BRACE

Captures kinetic energy

HELMET

Extreme head protection

SOLAR PANELS

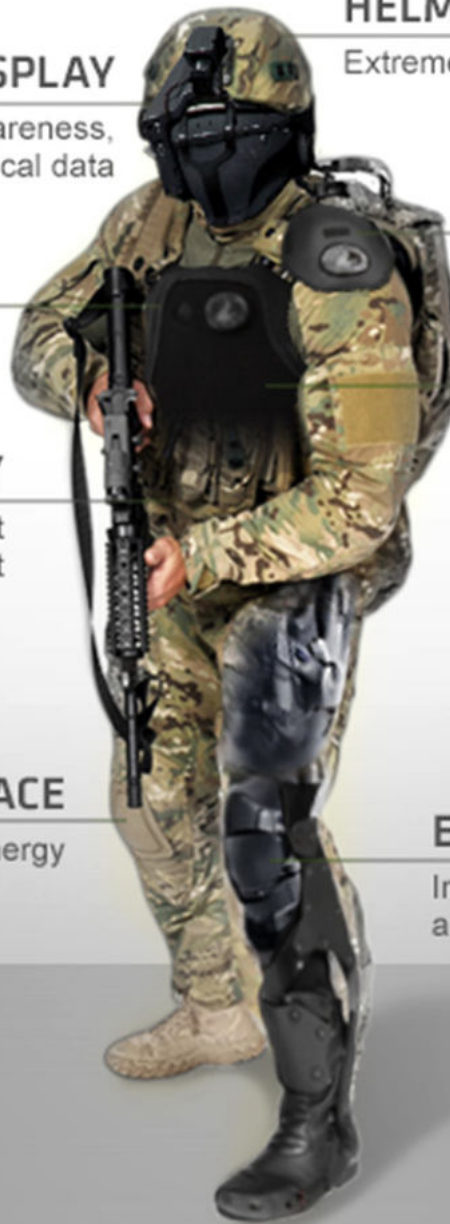
Captures solar energy

ARMOR

Complete ballistic protection

EXOSKELETON

Improves performance and endurance



1996

1991

Edgar Matias debuts a "wrist computer" with half-QWERTY keyboard

Built by Edgar Matias and Mike Ruicci of the University of Toronto, this "wrist computer" presented an alternative approach to the emerging HUD + chord keyboard wearable. The system was built from a modified HP 95LX palmtop computer and a Half-QWERTY one-handed keyboard. With the keyboard and display modules strapped to the operator's forearms, text could be entered by bringing the the wrists together and typing.

//image source: <http://goo.gl/11fNA4>

//image source: <http://goo.gl/33MbKp>

1994

Steve Mann starts transmitting images from a head-mounted camera to the Web

In December 1994, Steve Mann developed the "Wearable Wireless Webcam." Webcam transmitted images point-to-point from a head-mounted analog camera to an SGI base station via amateur TV frequencies. The images were processed by the base station and displayed on a webpage in near real-time. (The system was later extended to transmit processed video back from the base station to a heads-up display and was used in augmented reality experiments performed

//image source: <https://goo.gl/OOIAFw>

1996

DARPA starts Smart Modules Program

DARPA starts Smart Modules Program to develop a modular, humionic approach to wearable and carryable computers. Develops a variety of products including computers, radios, navigation systems, human-computer interfaces, etc. that have both military and commercial use

//image source: <http://goo.gl/LbRmJb>

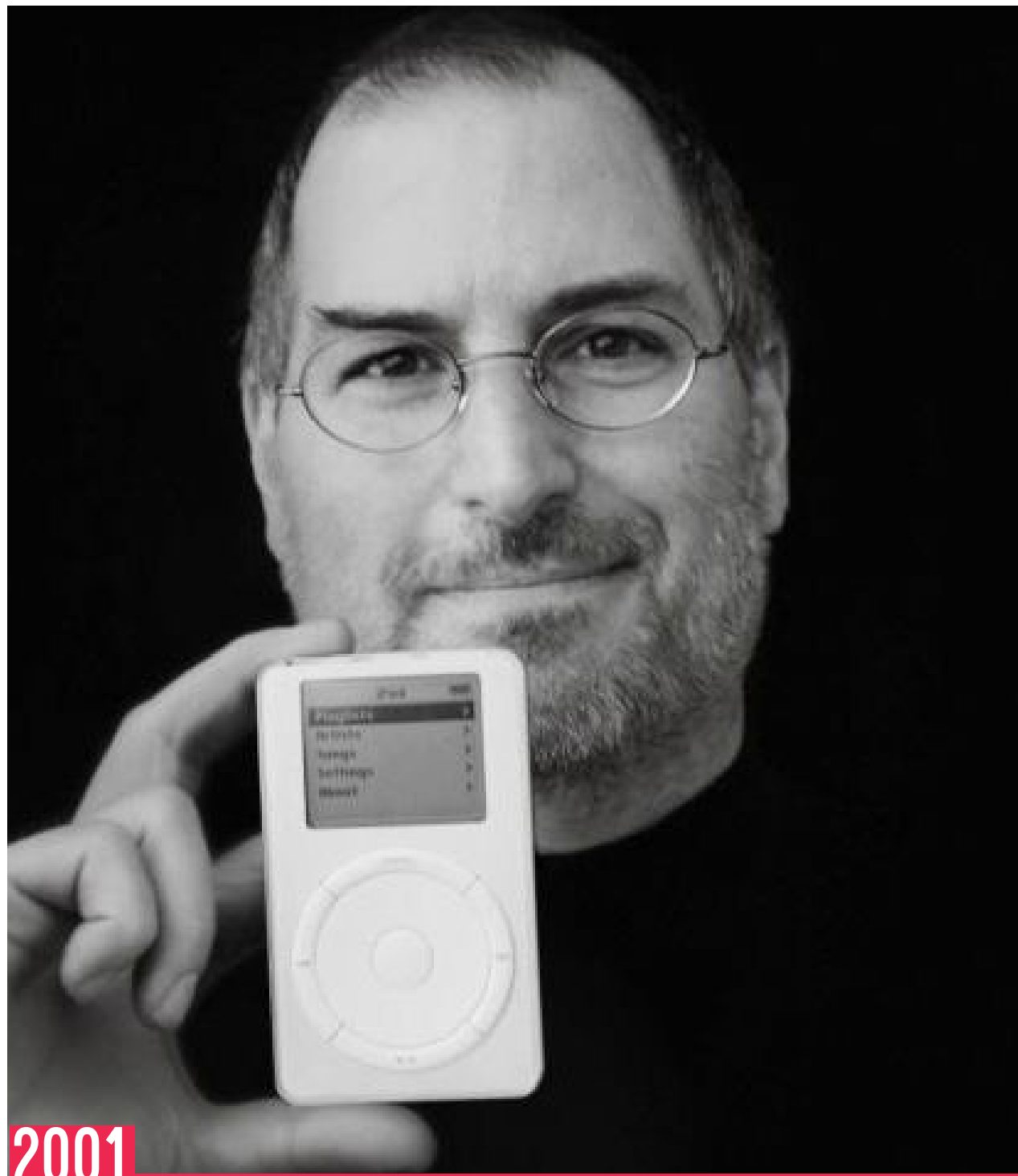


1997



2000

uetooth™



2001

1997

Creapôle Ecole de Création and Alex Pentland produce Smart Clothes Fashion Show

The fashion show was a design collaboration between the students and faculty of Creapôle Ecole de Création (Paris) and Prof. Alex Pentland (M.I.T., Boston), with the goal of envisioning the impending marriage of fashion and wearable computers. Beginning in April 1996, designs were iterated and clothes produced, with the final runway fashion show was held at the Pompidou Center in Paris in February 1997.

//screenshot : <https://goo.gl/Kt8VCn>

2000

First bluetooth phone and headset is released commercially.

//image source : Motorola Headset Manual

2001

Steve Jobs, Apple Computers, releases portable music player iPod.

Becomes an instant hit with the generation of the new millenium. Not only it became a commercial success but also became a similar cult product as sony walkman was 20 years ago.

//image source : <https://goo.gl/ySWpSm>



2001



2004

2001

Xybernaut Poma wearable personal computer was commercially released.

it had a headmounted display, a cpu box which could either be attached to your hip or slided into a big pocket. featuring a controller and optional wearable keyboard, the computer failed miserably to attract the masses due to lack of proper use and softwares available

//image source: <http://goo.gl/JyQkAT>

//image source: <http://goo.gl/jsUT5g>

//image source: <http://goo.gl/Smol23>

2004

GoPro, first of its kind wearable camera is released. It changed the way people capture self footage specially in context of sports and adventure.

//image source: <http://goo.gl/Aoa0iX>



2006



2007



2006

Nike's step counting sensor kit is released.

First of its kind device which measured your step counts and calorie burnt. This included a sensor to be fitted in a Nike shoe. The sensor communicated the data to the iPod where it could be seen by the user. It became popular with a lot of health-conscious iPod owners.

//image source: <http://goo.gl/rM9TFB>

2007

First Apple iPhone starts the smartphone revolution

Apple iPhone redefined the way touchscreens could act as interfaces. It established a new era of smartphones, which has dominated the world of technology since then. Today smartphones have become as powerful as desktop computers of just a few years ago, and act closely as wearable computing devices or as a platform for wearable devices.

//image source: <http://goo.gl/g8Rf9s>

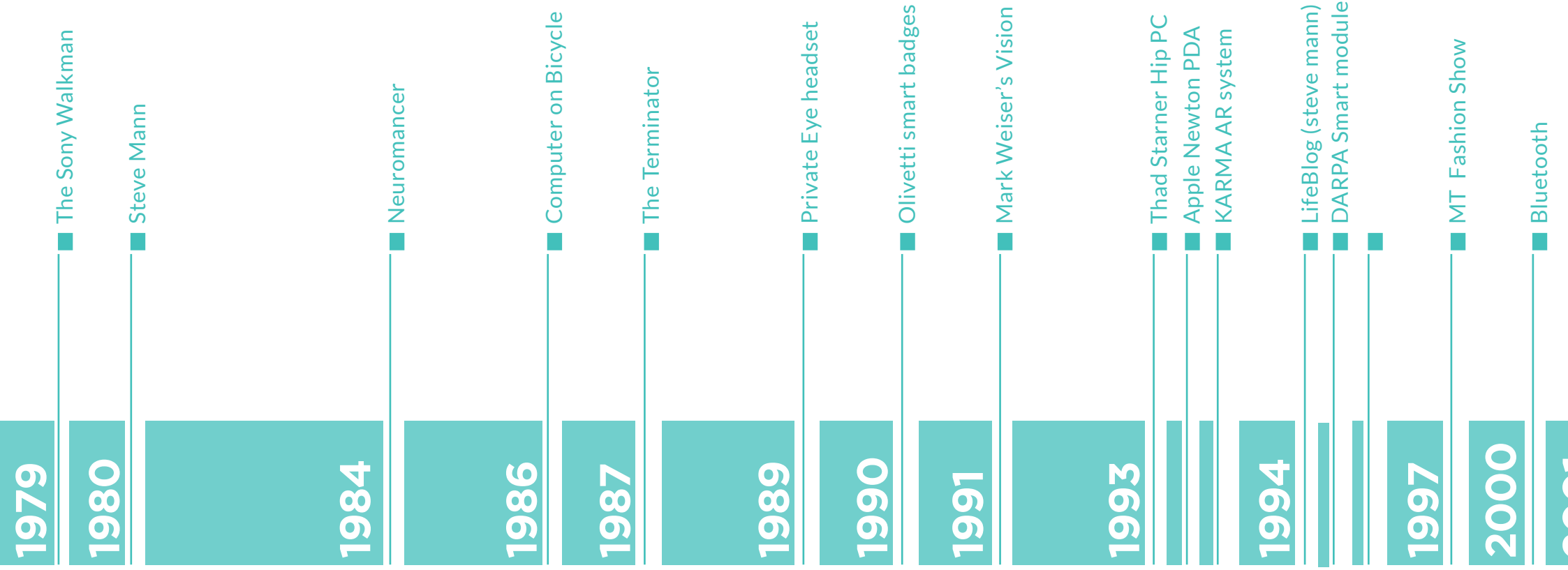
2011

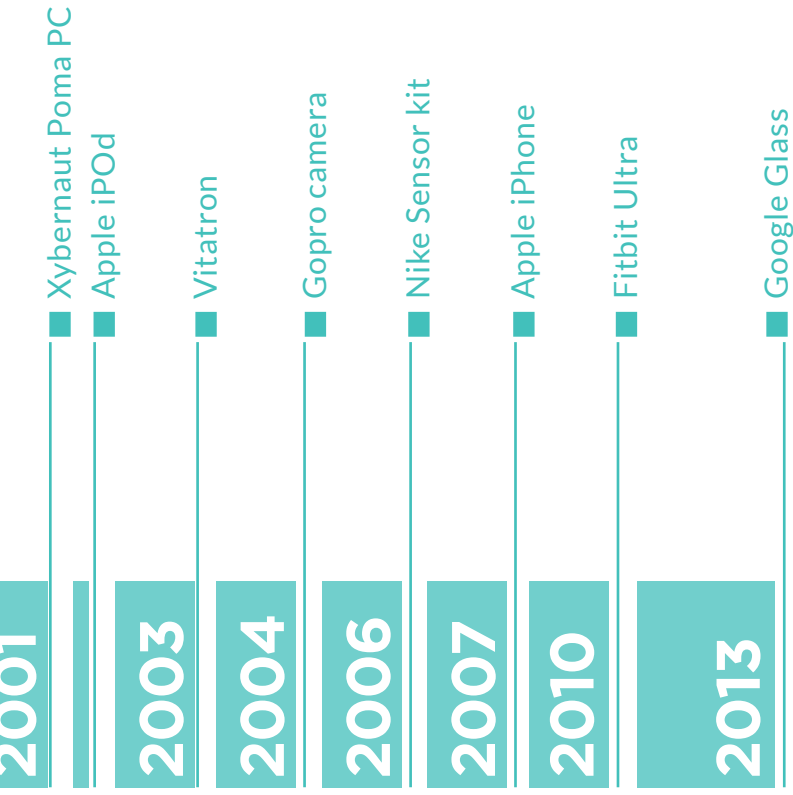
Fitbit Ultra tracker is released.

One of its kind device in 2011, it was a step/calorie counter, altimeter, a clock and a stopwatch. It connected to the smartphone through an app where all the fitness tracking data was visible.

//image source: <http://goo.gl/hTXZcw>

WRY





It is easily observed, that the realization of wearable computers began as early as the development of electronic computing itself, and since then it has been dotted with a lot of trial and experimentation. Broadly, there have been three ways to marrying electronics with/to human body*:

- *Computers that can be worn*
- *Information Appliances that can be worn*
- *Clothing as computers.*

Computers that can be worn

Most of the early concepts and prototypes have been about attempting to make the first kind, i.e. computers that can be worn. These are full-fledged computing devices with which you can access and do processor intensive tasks, and get serious work done. The early years of wearable tech were with such devices but none of them proved viable or bearable enough to go commercial, with a few exceptions like the Xybernaut Poma. A head mounted display/a screen placed on your wrists is used in most cases to present information to the user and some modified form of keyboard/other specially made tools used as input. And through all years, these wearables have been restricted to laboratories and do it yourself phases. Owing to the discomfort, awkwardness in wearing them & lack of an interesting and intuitive interaction with the computer, this category has been till now mostly transitional, resting between conventional personal computers and fully wearable computers.

Information Appliances that can be worn

Sometime during all these attempts to make computing wearable, researchers realized the fact, that it is not required to have all the computing functions, available all the time, and that task specific computers can be made. And it made even more sense in context of putting something onto body. From the process of making a computer powerful enough, and then assigning tasks to it, the shift in wearables happened to assigning a particular task and then asking how much computing power does this task requires? This approach allowed for lesser computing requirements, hence the device could be made small and comfortable to wear. This has created a second wave of wearable computing devices, and this time they are bold enough to come out of the research labs and become commercial successes.(Fit bit, Jawbone, pebble, are a few examples of them). Information appliances as Donald Norman calls them, are devices cater to do just one task, in a specific context. For example, the sole function of fitness trackers is counting your footsteps and measuring your vitals, hence enabling you to carry out a informed workout, rather than having just a vague idea, all that in the context of your physical activity and health.

WHY



Halfway through the second decade of 21st century, we still use our desktop/laptop computers to do a lot of tasks. And even though the second wave of wearables is about task specific devices, we still fancy the idea of an all-powerful computer that can be worn and used from our bodies, and hence augment our intellect. The centre-stage for this desire, has been taken up by primarily, in recent years by *Smartphones*. The smartphone, in a way, has been the closest to becoming a fully functional wearable computer ever(though it is more carry able than wearable). It has increasingly replaced desktops/ laptops as the primary computing device in just a few years. (*USER SURVEY RESULTS*). A large number of tasks that we used to perform on desktops and laptops, are now being done through smartphones, ranging from emailing to banking, from texting to music, and to becoming our personal assistants in some cases. We carry our smartphones all the time, ranging from 8 to 18 hours a day in our pockets, and we carry them to where ever we go, from our classrooms to our bathrooms, while we take a stroll, or sip our coffee, while we are with friends, or going to sleep, our smartphone follows us. (*CITE RESEARCH*) But even though they have become such an important part of our lives and they live on our bodies throughout the day, they are still independent devices, and not truly wearables. And there is still a lot of friction in using them.

“We are inclined to give up on computing tasks, if they take more than two seconds”

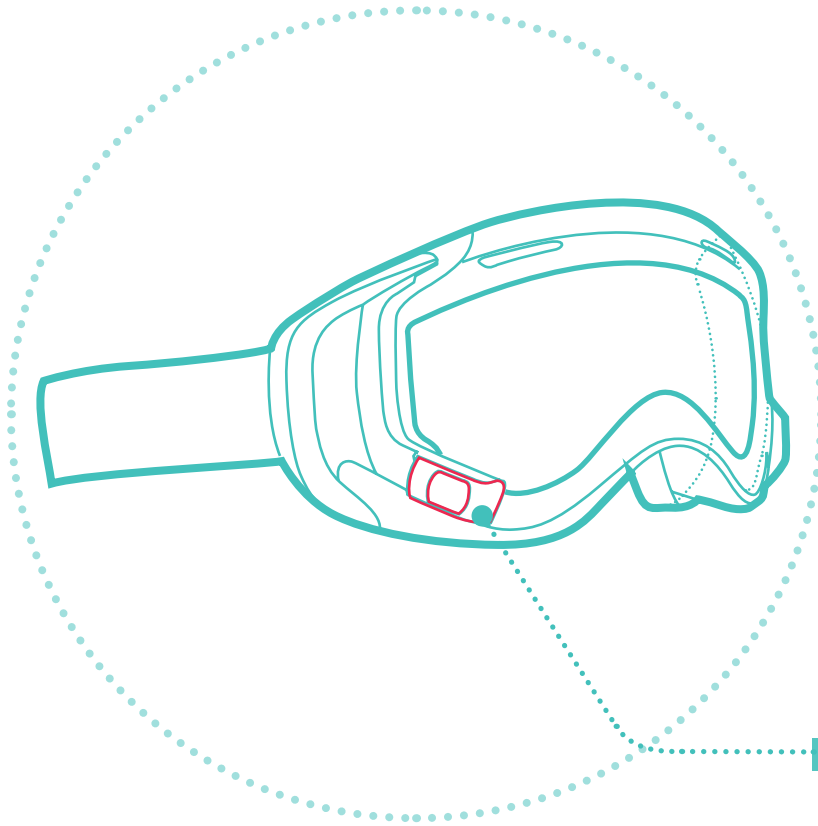
Robert miller, IBM psychologist

Most of the times we do make our way beyond those two seconds, because we want the outcome, that we intended but it surely brings our enthusiasm down and fires up our disinterest and in some cases even frustration. Remember every time, you have to type in the long password to access your email? And the delightful time, when you found something the instant you started looking for it! The fastest of the devices or even smartphones still fail to meet this 2 second deadline and produce delight. From the time, you feel the vibration of a notification or you want to search for something, take out the phone out of your pocket, swipe the screen, type a password, find the desired app, tap on it and finally get to your intention, it has usually taken more than 10 seconds. Sometimes we leave whatever we wanted to do, halfway, because of lost interest, or something else came up in between. Now imagine yourself doing that 50 , 80 or 120 times a day! (Appendix A, User Research) That’s a lot of gap/drag between intention and outcome. This gap needs to be closed.

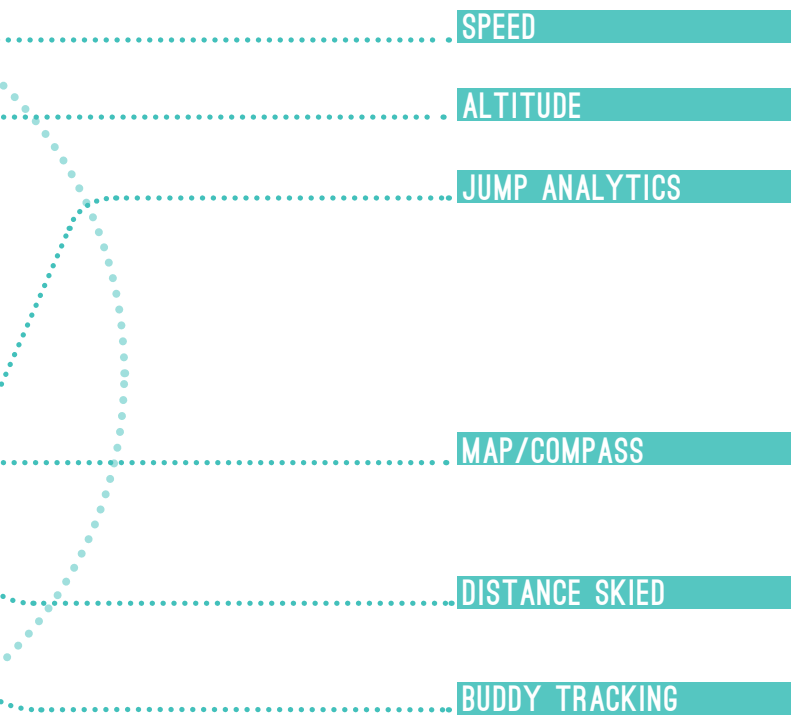
Interestingly, smartphones are the least frictional devices till date. They have already brought the time in achieving a certain result from minutes or hours to seconds. There are lot of such tasks, which still require a lot of time and effort to go through. Take the case of a nor-

mal day to your office. You reach office, swipe your card for attendance, walk down to your cabin/desk, open the door, maybe adjust the room temperature to your comfort levels, pull the chair, switch on your computer, type a password, put your favourite music, check your email, and other schedule and get started with work. There’s a lot of friction between your attendance and getting started with work, is it possible to reduce it? Yes, with appropriate technology, including involving wearables, it is possible.

WHY



// HUD



The Case of Wearable Computers today:

Dan Eisenhardt has been a swimmer, since his childhood. Competing in the long and tiring 1500m freestyle, he soon realized the fact, that if he could get to know one piece of information while he swims, it would optimise his performance. That piece of information was “lap timings”, which in a 1500m event becomes very crucial. If you speed up too fast you might build up lactic acid, which will prevent you from performing in the long run, if you go slow, with every lap, the distance might become impossible to catch up. So it was crucial, if somehow the swimmer could know lap timings. The only way to know the lap timings was after the race, when it is over. The gap between intention (of knowing) and getting the information was not only huge, but it also rendered the information useless, reduced to meaningless figure which would have no effect on real time performance.

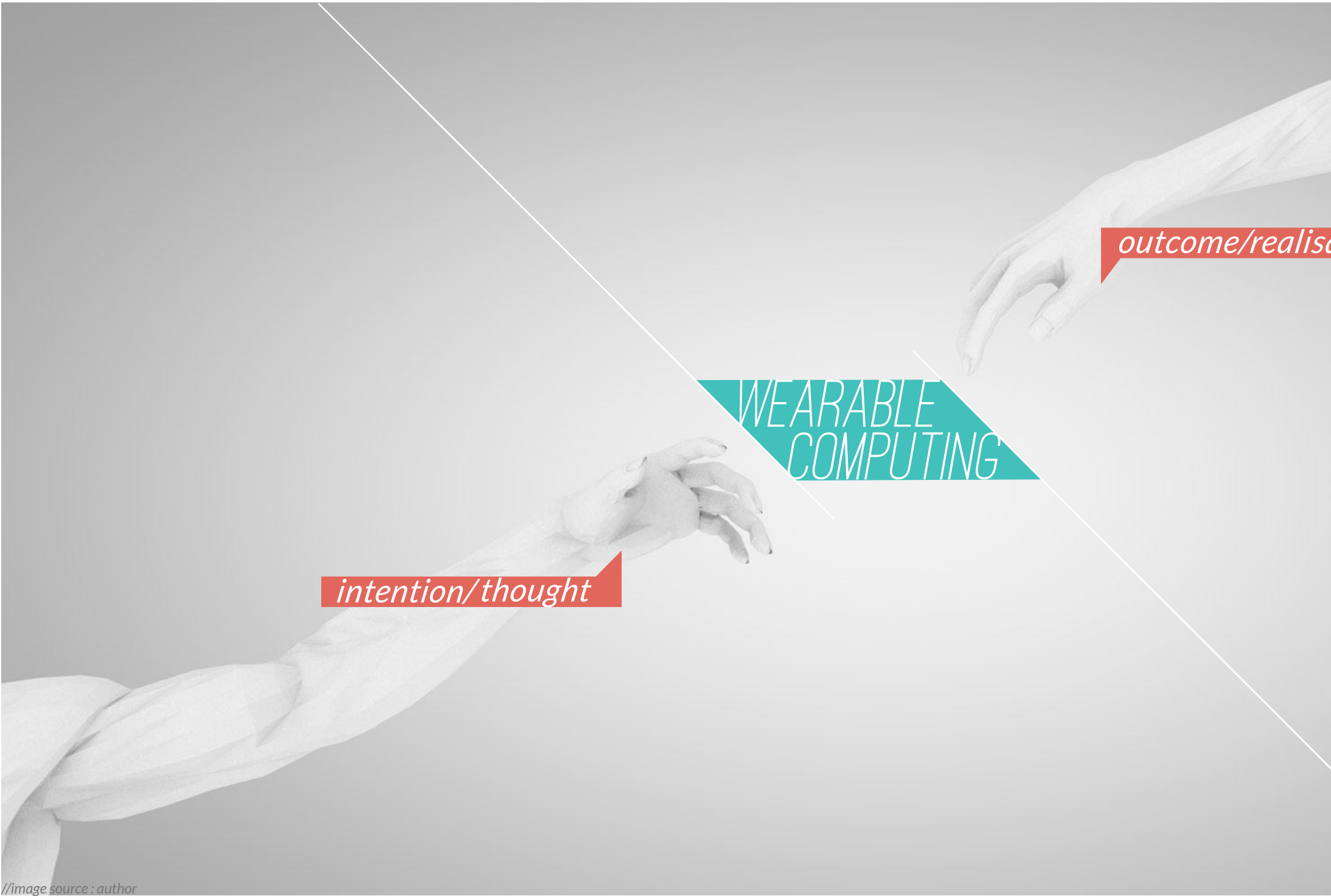
Years later, during his business studies at British Columbia university, he proposed a business plan as part of his class assignment. It was about “information rich swimming goggles”. The idea caught on with a few people, and soon they formed a team.

On realizing the fact, there is an already existing patent for that, they searched for an alternative sports where it can be implied. And what could have better than, ice skating, where skiers already wear big goggles and direly need certain information. And hence, Recon Snow was born. It looked like just any other ice skating

Google, but with an addition of a tiny screen sitting in the lower corner of right eye. This display was used to present information like current speed, compass, directions, distance skied, altitude, jump analytics, and the position of your friends.

Its easy to notice, that this information is easily available on any average smartphone these days, but how would you access it without taking a serious risk to use your smartphone while skiing? You could not. And that’s where wearables make the difference. Recon Snow gave you information, all the relevant information, only the relevant information and relevant times. Right in your vision which otherwise would have remained locked on a screen in your pocket.

And that is why wearables matter. They have the potential to augment our senses directly, reducing the lag/gap between thought and realization, to the bare minimum or even zero in some cases. The new technologies change the way we perform our activities, reducing the friction with every version. And wearables are the next step to that evolution. Electronic computing has already changed the way we access, and take action on information, communication and realization of our imagination. Wearables promise to take this further, by making our us an amalgamation of tools that we use and our bodies into one seamless hybrid organism, they are ever more closer in making us truly super humans.



WEARABLE
COMPUTING

intention/thought

outcome/realisation

ation

all the relevant information
only the relevant information
and at relevant times, rendered in
an useful way, which otherwise
would have remained locked
on a screen in your pocket.



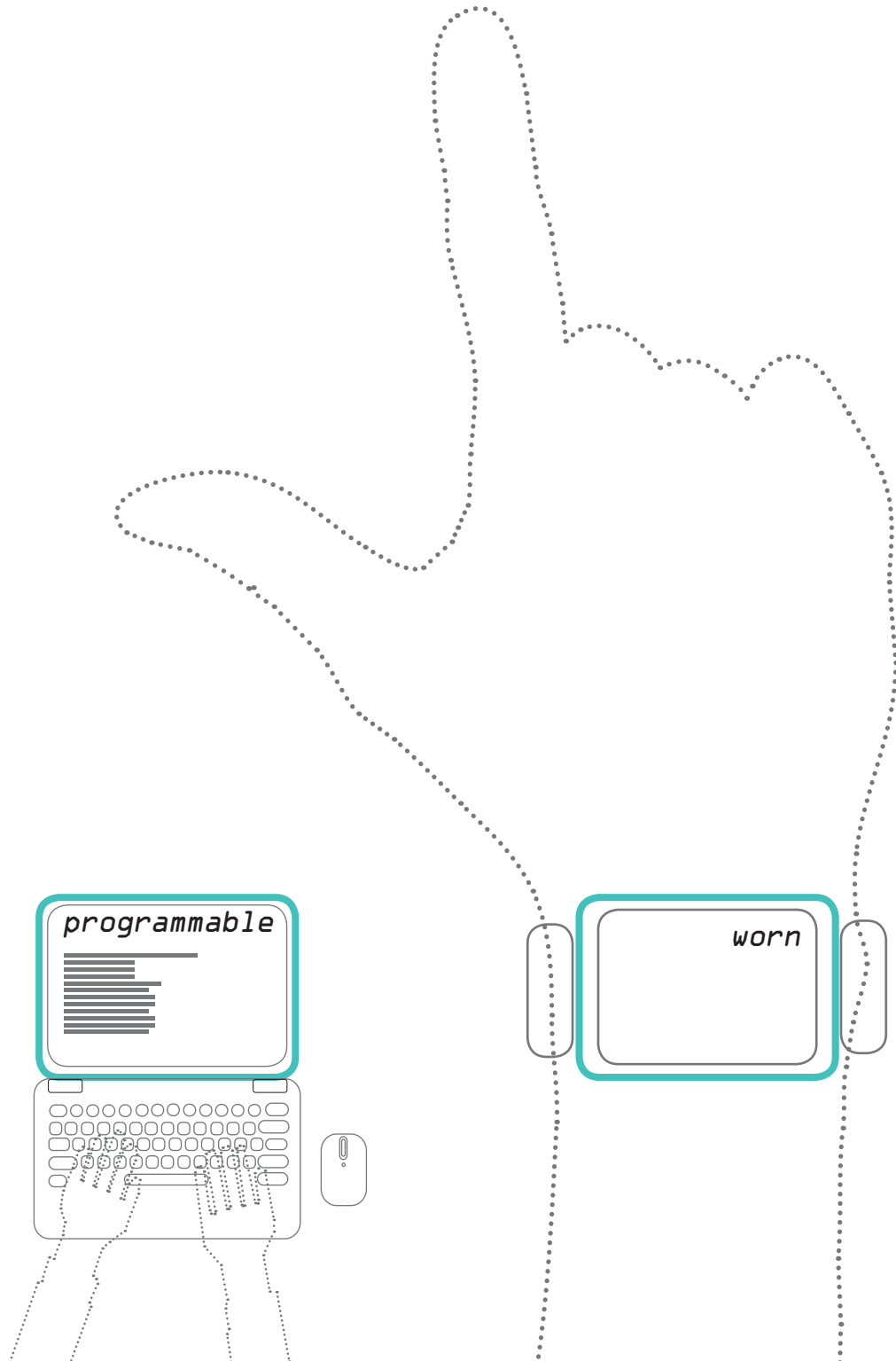
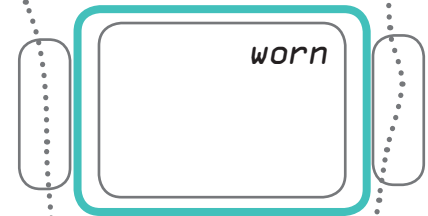
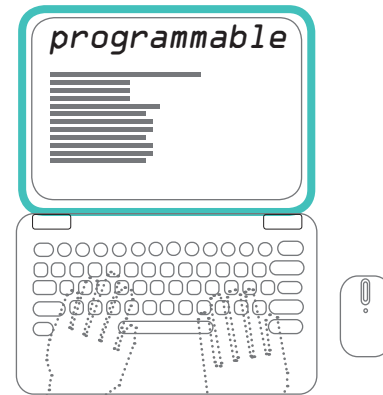
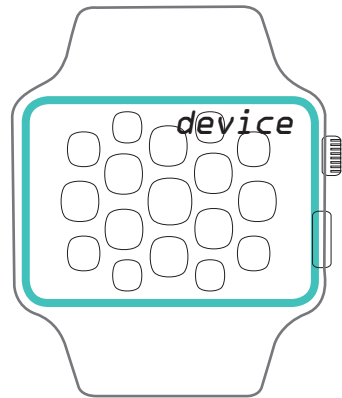
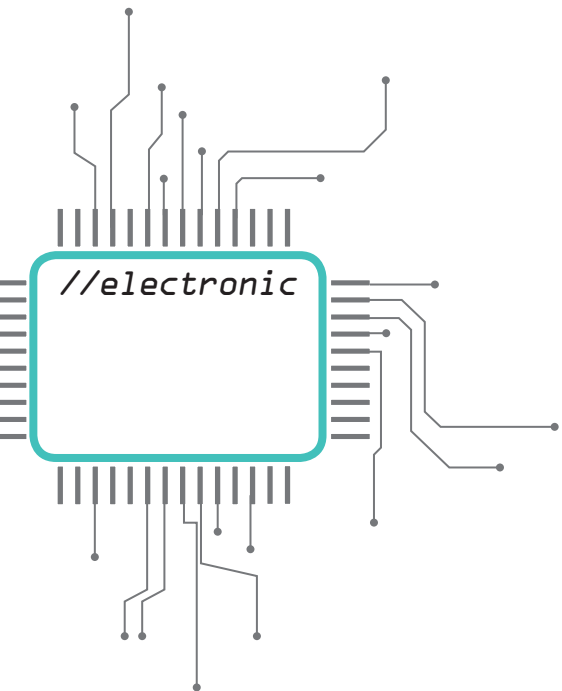
WHAT

//What. Wearable Computing ?

The number of devices connected to Internet surpassed the number of people in 2008. As of 2015, it has already doubled, and is predicted to reach around 50 billion in 2020, around 5 times human population (Dave Evans, 2011). These devices are not just desktop/laptop computers or smartphones, these devices are your shoes, your microwave, your jewelery and even your car. By putting sensors and chips in physical objects, and connecting them with internet, everything around us becomes more responsive and seamless. A thermostat device called NEST, understands when you are there or not, and regulates the temperature of your house accordingly. Initially, for sometime you feed temperatures required, manually through a smartphone app, but gradually it learns your behaviour, your habits and presence in every room and adapts itself to respond better control of temperature. People have reported a better environment and reduction in electricity bills up to XX% (cite research). These devices are being put to use everywhere. A Dutch firm Sparked, is using wireless sensors on cows, so that the farmers come to know whenever some cow is sick, not feeding properly or pregnant. Each cow casted a digital shadow of 200 Mb in a year.

This is the next evolution of internet, where different objects will connect to each other, talk with each other and make our lives easier. It is the realization of Mark Wieser's vision for the 21st century, or the Information appliances of Donald Norman. Now termed as Internet of things(IOT), it is poised to change how we live, in drastic ways. Wearable computers are an important part of this phenomenon, which try to bring human beings into this connected world, hence enabling us to directly interact with other connected objects. *Here the body is not simply extended by information and communication technologies(ICTS) but also becomes their intimate host. This represents a new step in the conceptualization of the synergy between individual(body) and technology(environment), and also affects the ways in which the role and nature of each actor are defined.* (Ana Viseu 2010)

WHAT



A wearable computer is an electronic/mechanical device which is programmable (hence can compute different algorithms/functions), is worn on, attached to or embedded in the body, designed to be context aware, always on and assist user in an unobtrusive manner.

The definition above is an embodiment of various characteristics of a wearable computer, floated by different researchers. Although, there are different interpretations about wear ability and the idea of being contextual itself, what everyone agrees to, is the idea of ubiquitous computing through wearables. Ubiquitous computing is phenomenon of being able to compute from everywhere/anywhere. Computer technology has enabled the idea of accessing information and acting upon it from anywhere. No longer is information restricted to certain buildings or workplaces. And over the years technology has become more and more portable thereby leading us to true realization of Everywhere is here, phenomenon.

“ The net negates geometry, it is fundamentally and profoundly aspatial. It is ambient- nowhere n particular but everywhere at once. (Mitchell)

Constancy, Mediation & Privacy

Wearable computers take this idea further, as they are not just devices , they become a part of our bodies, enabling us to live and act in both the real and virtual world at the same time, hence augmenting our senses and ca-

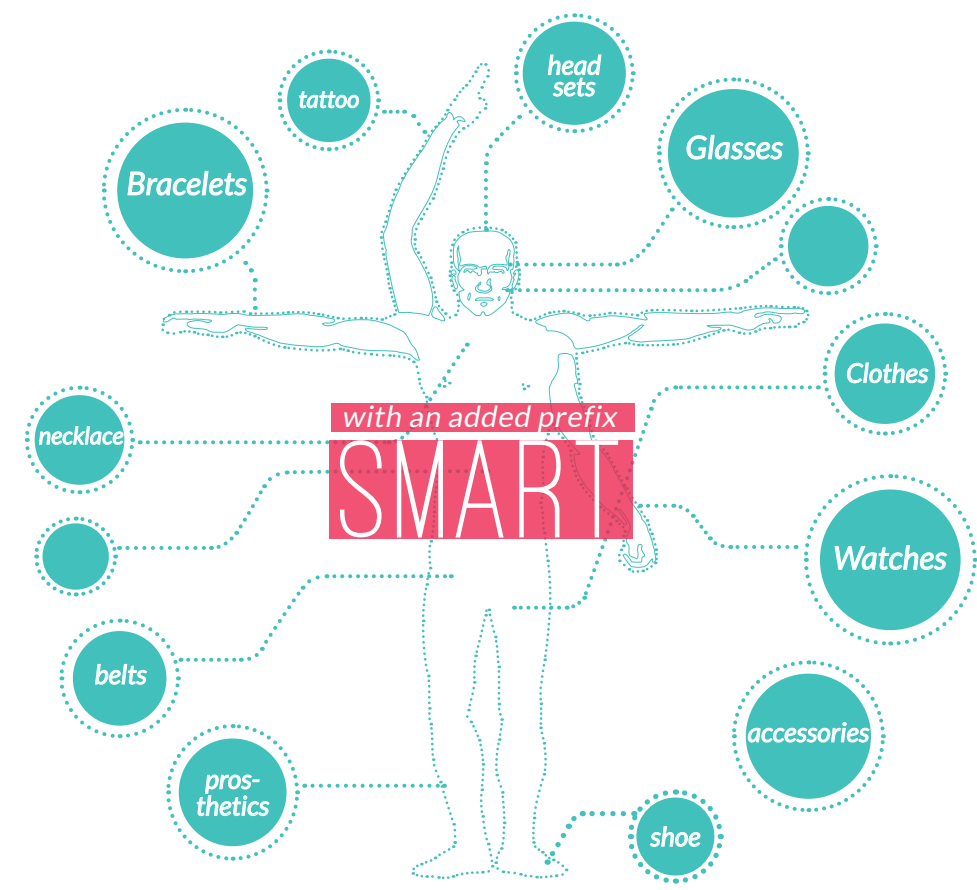
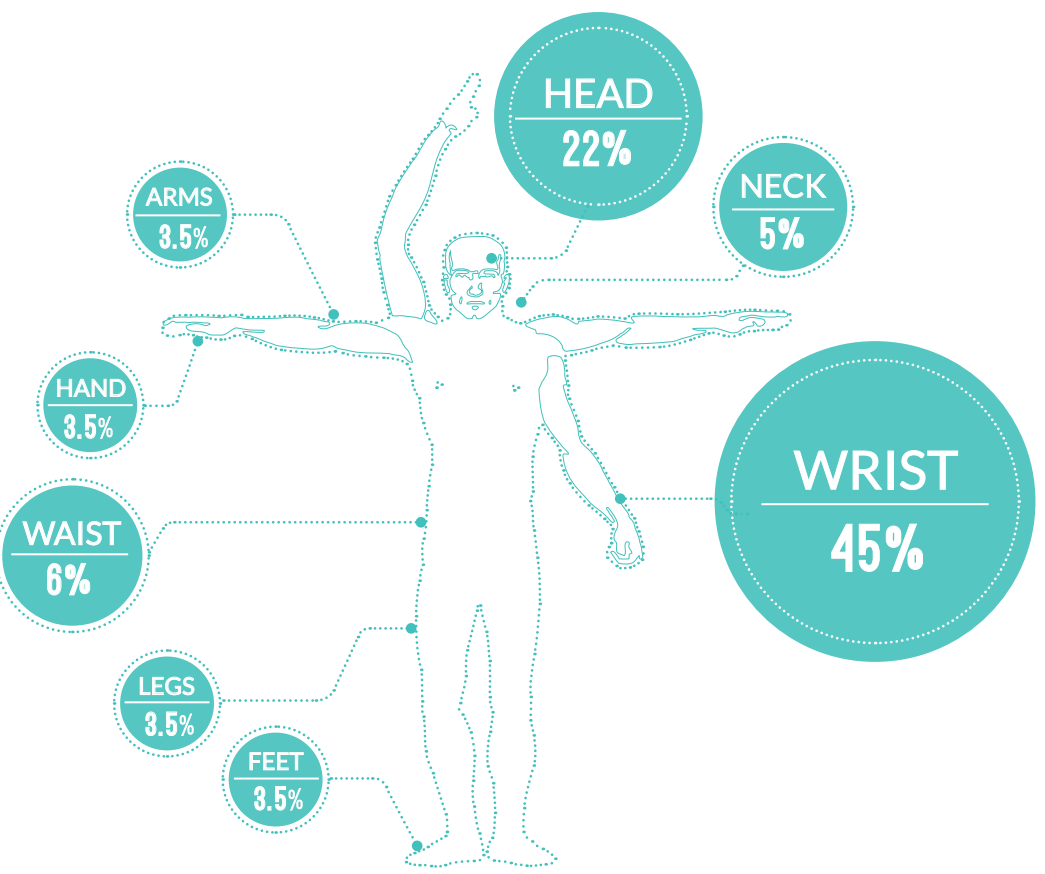
pabilities to see, experience and do more. To achieve this, *The computer runs continuously, and is 'always ready' to interact with the user (Steve Mann)*. Our smartphones for example, have already been becoming such devices, always on, always ready to assist us. We carry them continuously, from our boardrooms to our bathrooms and when they run out of juice, we tend to panic(CITE RESEARCH). They act as an aid to our memory, to our communication, and have already become a means to interact with the world around. When we are lost at a new place, we use maps on our phones to find the way out, they act as devices helping us to create more opportunities between us and rest of the world.

Wearable computers, take this continuous accessibility to the next level, and being always ready to be used , especially from the vicinity of your body, they mediate your interaction with the world, in unprecedented ways. In fact they have the ability to act as another sense organ/second brain allowing you to perceive the world in deeper, richer, alternative ways. They can make things vanish from your visual field(XX), add new sounds to your aural perceptions, and even allow you to see the world in infrared or radio wavelengths. They can block advertisements or entire people from your vision. They create your own version of this world. And it is this constancy as Steve Mann likes to call it, leads to making wearable computers a very personal form of devices, not like the way personal computers were, but personal like your own set of eyes, ears or voice.

And to be truly augmenting us, these devices should not be obtrusive, they will allow us to engage in other activities, unlike our laptop computers or smartphones which take away our attention. These devices should only show up information when and where it is required or if something is deemed important.

And in order to do that, these devices have to understand the environment around them. Humans are highly contextual beings and have different responses and actions to the same thing depending on their surroundings, physical and emotional states etc.. A wearable computer tries to track and understand all these states and responds to you accordingly. This understanding makes them extremely personal devices, as they will know more about you than probably your closest friend.(Already our smartphones have become extremely personal nature, and around 90% people find it uncomfortable to share their smartphones with someone else even for some time). And unlike what we see, hear and feel, which is processed and store in our brains and is very difficult to extract or share, all this information collected by these devices will be stored digitally, making it quantifiable and reproducible anytime, anywhere. Hence it becomes of prime importance that the functionality of such devices is fully controllable by the user. The user should be able to govern and override all the functions (even if automated)and have a complete ownership over the data generated.

WHAT



“ In the next five years we will witness the rapid development—and mainstream acceptance—of wearable technology that integrates into every aspect of our lives. Wearable technology will be used to help record the world around us, nudge us into action, communicate information between one another, allow us to control our environment, verify who we are and reflect our wellbeing back to us.”

PIERS FAWKES

Founder, President, PSFK Labs

// The cause of wearable device explosion

After years of experimentation and research, IOT and Wearables have finally started becoming mainstream, and with every year, both the number and variety of wearable computing devices has been increasing in manifolds. This growth is propelled by an array of factors coming together. The massive growth and acceptance of smartphones in the last decade has caused significant miniaturization and price drop of core technologies such as sensors and computing chips. It has also lead to development of faster and energy efficient wireless protocols such as Bluetooth 4.0. All this enables developers to put these technologies together in small devices, which are easily wearable. Not only that, these devices need not have all the computing power, required, instead they can be just an array of sensors to collect data, which is then sent to smartphone, and is processed on the smartphone itself or on the servers of

the service provider through internet, also called cloud computing. With the availability of do it yourself electronics platforms like arduino and raspberry pi, designers, students, enthusiasts can now prototype their ideas quickly with comparative ease. The advancement of 3d printing means, physical prototyping is faster, easier and possible on a personal experimental level. Not only that, with the help of web, these ideas are floated online, a large portion of them being open source, they are further tinkered by enthusiasts around the world, and improved upon in numerous ways. Finally, if an idea is liked enough, inventors can fund them, to develop on a commercial scale though crowd funding platforms. A large number of the commercially available wearable devices in market today made their way through successful crowd funding campaigns. Every year the time lag and difficulty between an idea and its realization decreases, due to these reasons, leading to a flooding of products and services, including wearable computers.

“ The Time for wearables is now!”

Tim Cook, CEO, Apple

// The Devices Now

An analysis of 500+ wearable computing devices revealed that most of these devices are focused on these key areas: Entertainment, Health ,Lifestyle and Communication ,Industrial and Productivity.

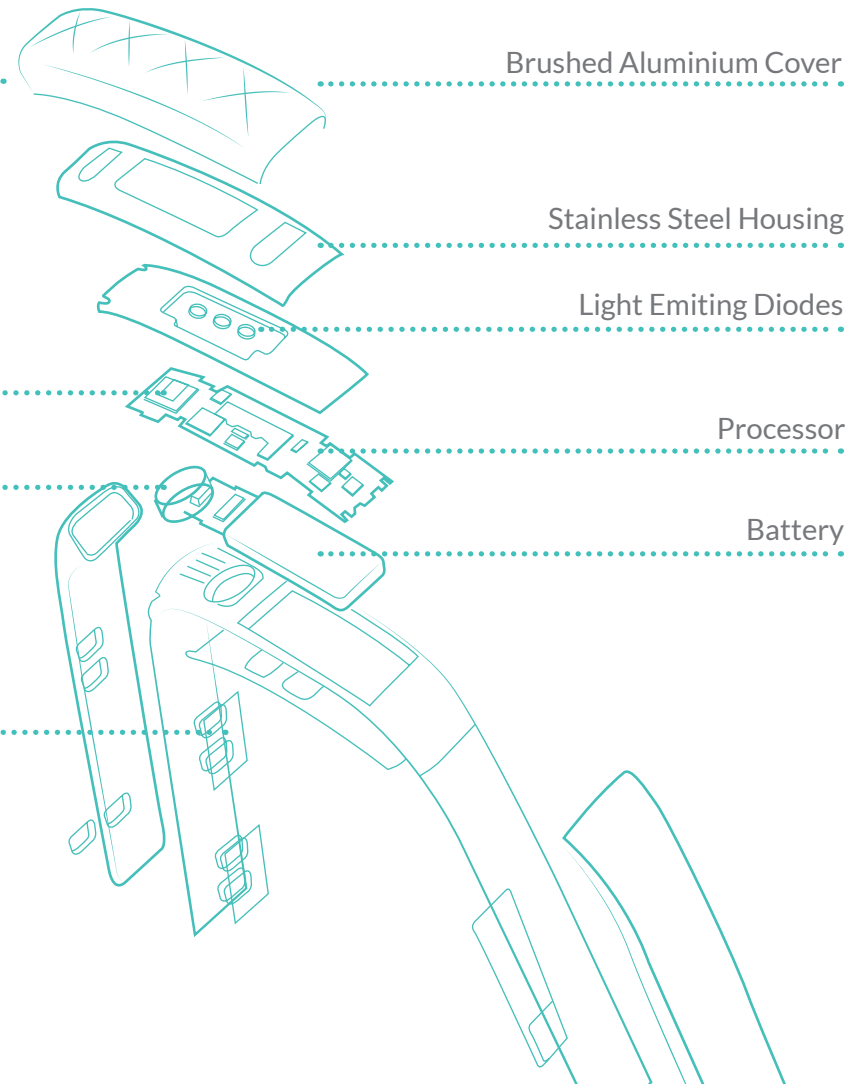
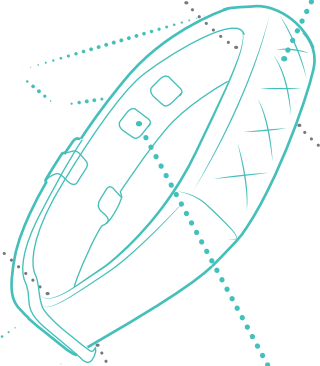
In pursuit of doing these functions, they have tried to take all kinds of positions on our bodies. The analysis revealed that our ‘wrists’ are the most coveted real estate on our bodies. As much as 45% of the devices are designed to be worn on wrist, followed by head, waist, neck, arms and feet, and a few on our skin. Taking the form of watches, glasses, bracelets, headsets, belts, footwear, inner wear, and even tattoos, physically these devices have tried to look and feel ‘traditional’ in order to make users feel comfortable, both in use and adoption. But underneath with an added layer of “Smartness”(read computing chips/sensors) in them, leading to categories like smart watches to smart glasses, smart bands to smart shoes, smart jewelry and wearable textiles, defining the wearable computing platform as of now.

What are these devices doing?

These devices, are doing various things,primarily reducing the friction involved in various tasks. Like the recon snow glasses, they are trying to present relevant information in a relevant and engaging ways. They are trying to connect us with each other in more seamless and personal ways. They are helping us measure our steps taken, calories burnt, heart rate, etc, hence making us aware about health habits, and improve upon them. They are providing us with new ways of entertaining ourselves. They are helping industrial workers get work done, with less effort and more output, in lesser time.

WHAT

// JAWBONE UP3



A majority of these smart devices are basically packages for a multitude of sensors. Leveraging the fact of being worn closely on body, these sensors are able to measure movement, (accelerometer), temperature, location (GPS), electric potential of skin (potentiometer), Heart rate, (optical heart rate meter), Skin conductivity, and even ECG (electrocardiography), EEG (electroencephalography), statistics which were only possible to measure with huge machines at medical facilities just a few years ago.

// Fitness on your wrist

The first commercially successful wearable devices like Fitbit, Nike Fuel Band, Jawbone, were simple step counting devices, with an inbuilt accelerometer, leading to a new category termed 'fitness trackers'. These Wristband sensor devices, now in their third and fourth revision, have become more sophisticated than ever and remain the most successful category of wearable computing devices. There are hundreds of devices, with various feature set and prices. Even low end devices like Xiaomi Band (13\$/approx. 800 rs) and Razer Nabu (45\$/2500 rs) offer step counting, sleep tracking, can show who is calling, text messages and even unlock your phone without typing a pass code (Xiaomi band). Most of these devices look clunky and cheap. Misfit Shine, is a simple step and sleep counter, focuses to become an aesthetically charming object to wear. It is an elegant aluminum circular disc, and with the help of simple accessories, it can be worn as a pendant, put as a pin, or worn on your wrist

as a simple time piece (a ring of tiny LEDs around its perimeter indicates time). Jawbone UP, a high end tracker (180\$), in addition to step counting and exercise, offers heart rate monitoring, tracks your sleep and wakes you up at the lightest moment in your sleep cycle, is able to recognize patterns in your movement and automatically associate them with specific activities such as running, playing basketball or swimming. It also gives recommendations for your fitness, through its companion app on the phone. Designed by Yves Behar, it is minimal, with the slim durable anodized aluminum framework surrounding by a textured rubber finish. It has no screen, but three lights to indicate information. It comes in a variety of colours and patterns, is aesthetically pleasing, and tries to become a lifestyle object which you can wear all the time without feeling ashamed. Another tracker, Basis Peak, does all this and also has a screen which is used to provide activity statistics and notifications for your calls, messages, emails and events (pulling the data from your phone), thereby trying to become one device which you can wear all the time. Multi sensor wristbands are also being used in clinical conditions, e.g. a band detecting convulsive seizures through electric skin activity and accelerometer.

// Everything else on your wrist

But these bands are not limited to tracking health related activities. Tactilu is a bracelet which lets two people feel each other from afar. It is equipped with a touch sensor, which converts touch/swipes/pokes made by one person

into haptic motion on the companion bracelet worn by the other person. Another wristband called Kapture is an always on device, which automatically records important conversations of the wearer throughout the day. The device keeps on recording as 60 second loops and continuously overwriting them until the wearer taps the device to save a particular recording. The file is then saved to the smartphone where it can be edited and tagged. Nixie devises to put a drone camera onto your wrist. It rests as a band on your wrist and comes to life when you want a picture/video of you being captured, it releases itself into a drone flying away from you, and in the process capturing the required video/picture. When its done, it comes back to you where it can be worn as a band again. It won the make it wearable challenge by Intel, and is currently under development. Pavlok is another wrist band, which tries to help you in breaking bad habits and maintaining good ones. You define the habit that you want to break from, It monitors you for it, matching it from its database (ranging from nail biting to smoking) and whenever you indulge in the activity, it gives you an electrical shock, within safe but still pinging limits. Their website claims to have 61% people leaving smoking within 5 days of trying it. Its difficult to testify that, but it remains a whacky idea merging psychology and wearables together, and expands the possibilities of wearable computing devices.



// JAWBONE UP



Image source: <http://goo.gl/qbCDuq>



// XIAOMI BAND



Image source: <https://goo.gl/9FON4p>



// MISFIT SHINE



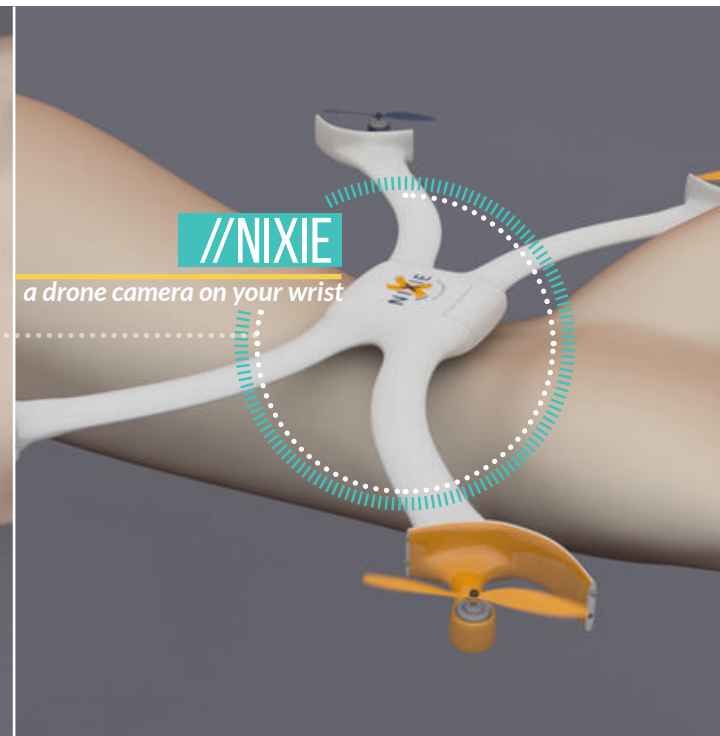
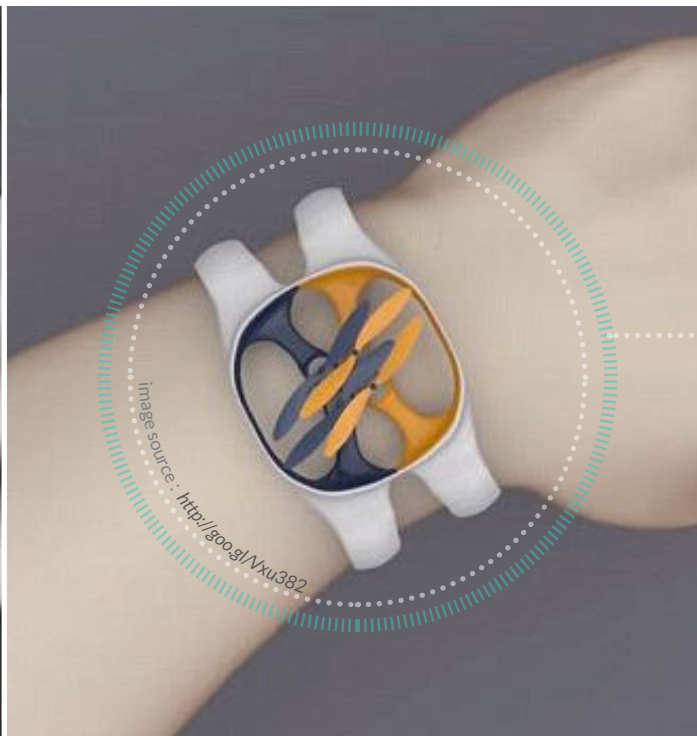
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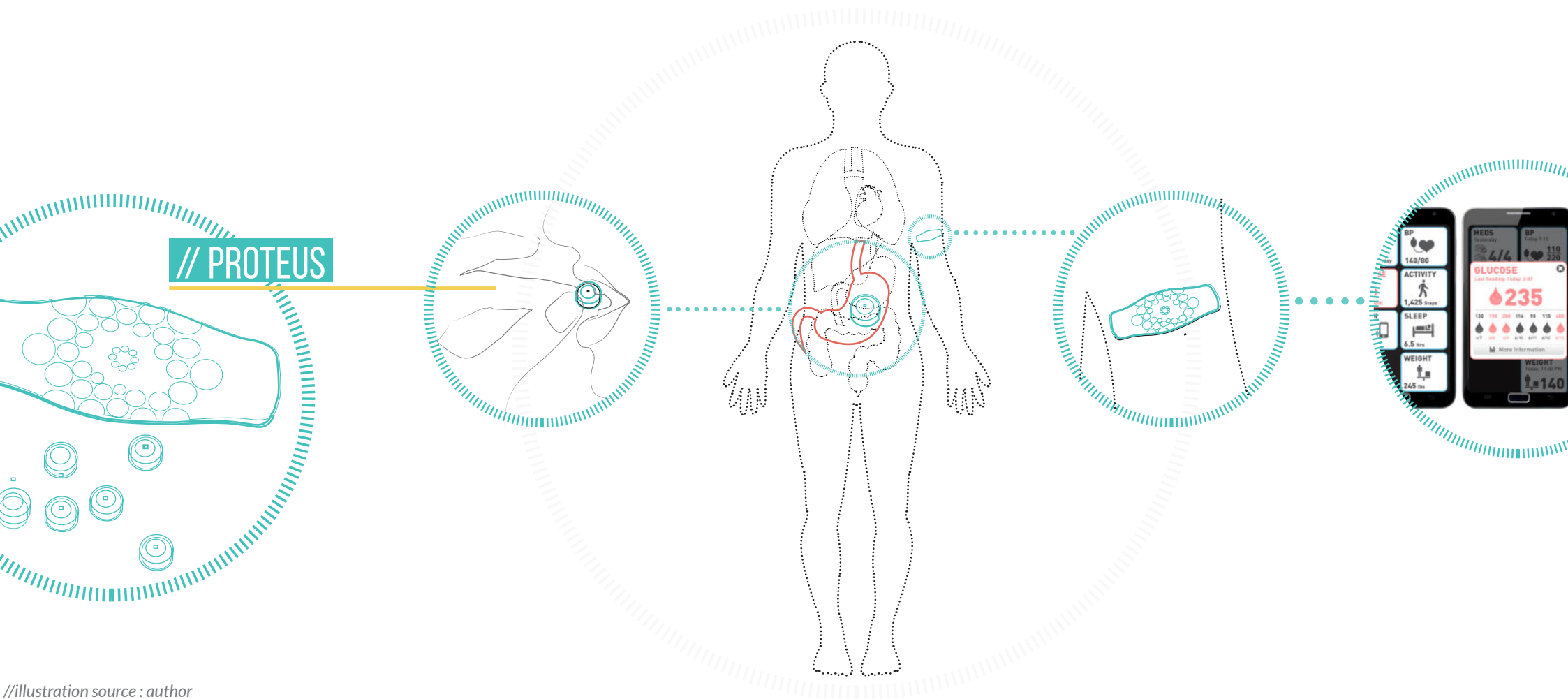
// BASIS PEAK



Image source: <http://goo.gl/DAFGFY>

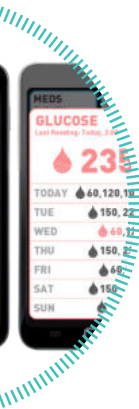


WHAT



// Tattoos that know your Sugar Levels

Another new category that is quickly taking shape, in context of body monitoring is wearable sensors, which are cheap and disposable after a certain time period. They have huge potential in healthcare and continuous health monitoring. Sano Intelligence's wearable patch is like regular nicotine patch, filled with sensors, is wireless, battery powered and sticks to your body/skin like a Band-Aid, measuring glucose level, kidney function, and electrolyte balance, continuously for 7 days. It can send this data to a computer or a smartphone. This has important implications for diabetics and kidney patients, who can monitor their diet and sugar levels and act accordingly, i.e. exercise or use insulin in right amounts at the right time. MC10 Biostamp is another patch wearable, which sticks like a tattoo and continuously monitors and wirelessly transmits body vitals like heart rate, brain activity, temperature and hydration level. It is currently under tests with soldiers and athletes, to improve their performance and keep them from damaging their bodies under high stress conditions. It also can prove to be a great benefit for child care and monitoring because it is a needle less, painless solution. Proteus health system is a combination of an ingestible pill, a wearable patch on the body and a smartphone app. The pill is ingested, it goes inside your stomach and transmits unique ids referring to various statistics to the wearable sensor on the body, which records and stores this data. It is transmitted to smartphone where this data is analysed. Their website says "The product is not intended to di-

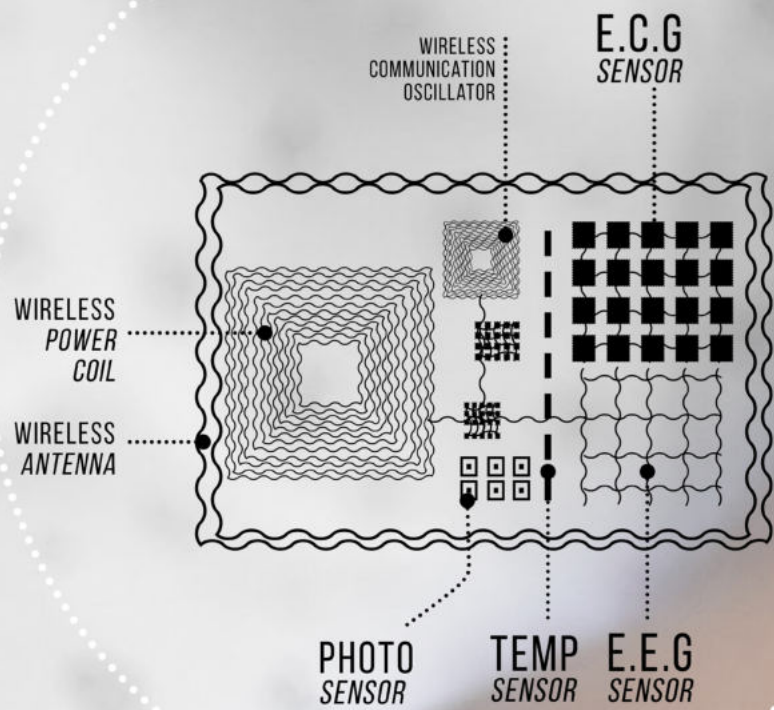


agnose, treat, cure or prevent any disease. The Recover product is intended for use by athletes for surveillance of physiologic information. This includes heart rate, respiration rate, skin temperature, activity, body posture and other associated metrics."(CITE WEBSITE) Though these sensors are still under testing and development phase, once they hit consumer market they will change the way we take care about our bodies and how diseases are detected and managed.

// More than time on your wrist

Unlike the category of fitness trackers, which is filled with crowd funded products and small firms, smart watches have seen major tech firms like Google, Motorola and Apple, vying for the top spot. Most of these devices are companion products to the smartphone and try to peel off some functionality of smartphones and make it available on your wrist. All the important functions on your phone, like receiving/dismissing calls, text messages, notifications, maps, music, etc. are now just a glance away right on your wrist, helping in reducing frustration of swiping the screen, typing the passwords hundred times a day to access these functions.(CITE RESEARCH). Apple watch includes an accelerometer and heart rate monitor to act as your fitness tracker, thereby trying to become one device that takes your wrist. Two people with apple watch can send their heartbeats to each other, which is regenerated on the wrist of the user by watch as a soft tap, through a mechanism, apple calls "taptic" (touch+haptic) engine(a function similar to

the tactilu wristband). Featuring a button on the side to scroll through the interface and access apps, the interface is accessible by both touch and physical button. It comes in 38 possible various combinations of exchangeable straps, and body materials, to cater to the various tastes and choices of people. The most expensive combination called Apple Watch edition is made of exclusive materials such as sapphire glass, 18 karat gold plated body, positioned as a premium accessory. Pebble Time is another smart watch, which is a non-touch, a low resolution coloured e-ink display. The e-ink display helps the watch last 7 days on a single charge which trumps any other smartwatch, most of them hardly lasting for a day. A very simple linear interface is accessed by three physical buttons. Sony's FES smartwatch has a e-ink display which spans all through the dial and straps. This enables to change the patterns and colours of the whole watch and can use the whole space for displaying information. Smartwatches, as a category, have been improving continuously, and becoming more popular among the masses (CITE RESEARCH), because they save a lot of time and make communicating more personal and faster.



//MC10

continuous body monitoring through tattoo



Image source: <http://>

Image source: <http://>



//SAMSUNG GEAR S

<http://goo.gl/UxU9ah>



//MOTO 360

Image source: <http://goo.gl/rfbuPl>



// PEBBLE TIME

Image source: <https://goo.gl/L50u18>



ASUS ZENWATCH

<http://goo.gl/XCVp2s>



//LG G WATCH R

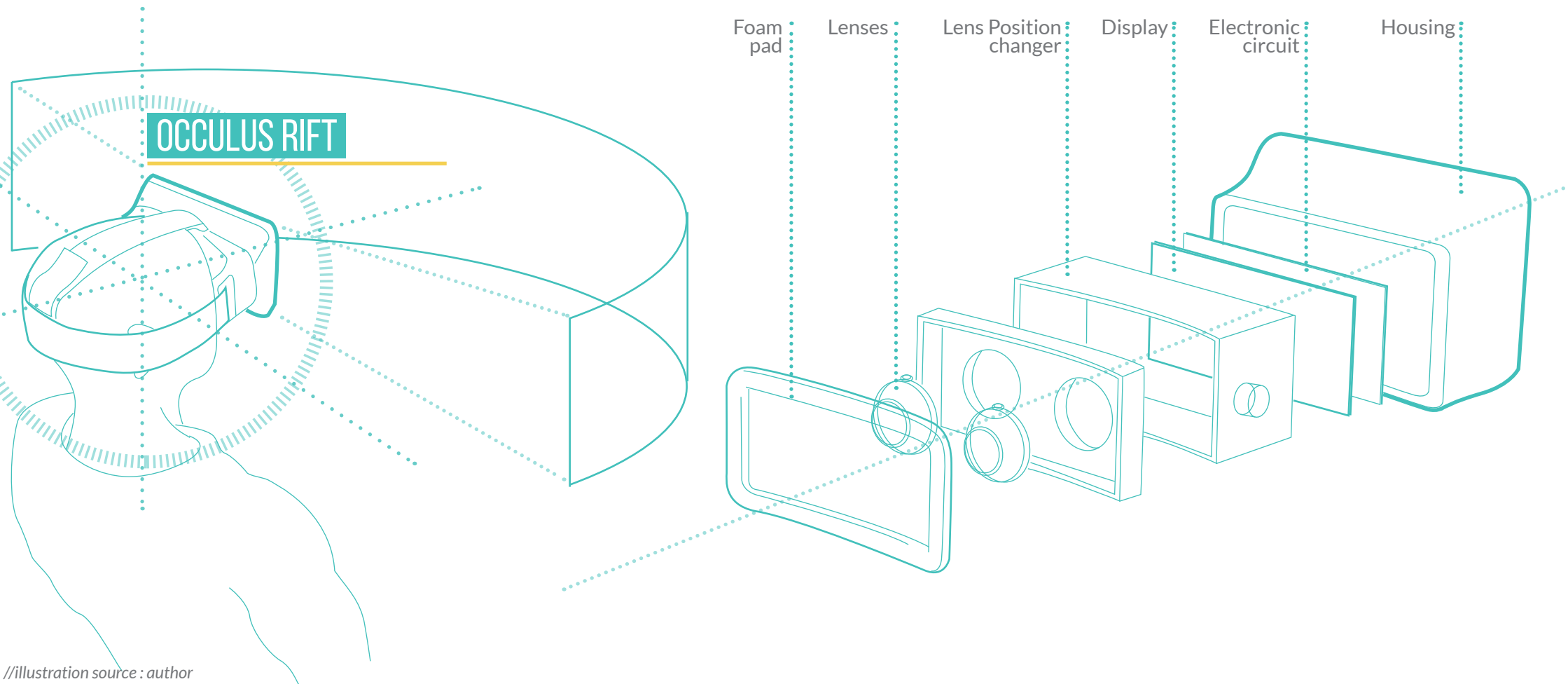
Image source: <http://goo.gl/4RP6GO>



//APPLE WATCH

Image source: <http://goo.gl/Fshi0F>

WHAT



// When eyes can see more

Like smartwatches, Smartglasses and headsets have been trying to present information in a more optimized and frictionless way. But by considerably affecting how and what we see, they make it a whole lot more engaging and immersive through virtual and augmented reality. Though heads up displays have been used as early as 1960s (CITE) the technology has only recently made it possible them to be truly effective in creating alternative realities by directly projecting into our visual field. High resolution displays which make it difficult to percept pixels by our eyes, and low latency create life like images and simulations right in front of our eyes. Oculus rift is a virtual reality headset, which connects to your computer as a peripheral screen and allows to play games and take part in 3d worlds. It creates 3d images by projecting slightly different images in both eyes, through a high resolution 7 inch, 60 hz screen. It also has a motion, position and orientation tracker built within the headset which helps in aligning your real head movement and position within the virtual world. Though still under development, it is already creating worlds immersive enough that people respond to falls in virtual world as real vertigos. Sony's Project Morpheus is a similar virtual reality headset under development for gaming for its popular PlayStation gaming platform. Samsung Gear VR, powered by Oculus software platform, uses a smartphone that can be inserted into the headset to act as the screen which through a compatible app enables virtual reality experience. Though virtual reality has remained one of

the most exciting possibilities of computing, through out science fiction and real development, the idea of augmented reality is gaining popularity. While virtual reality totally cuts you off from the real world creating an alternative world, augmented reality superimposes images, graphics and information over the real world. Hence creating a mix of both the worlds. The experience may not be as immersive as virtual reality, the applications and computing possibilities are humongous. Recon Snow glasses, enabled the skiers to get needed information right in their viewfield, creating and augmented reality vision enabling them to perform better. While they are specifically designed for a task, Glass from Google is an augmented reality device which is meant for wider use and aimed as an ubiquitous computer. It superimposes a tiny transparent display over you field of view. The device enables the user to take pictures, find directions, search internet, take notes, video chat with people, read and dismiss phone calls and notifications all by voice commands, and a touch strip embedded in the side of the glass, thereby keeping your hands free for other tasks in the meanwhile. Vuzix's M100 is a similar attachment of monocular display , including a onboard cpu and memory making it a wireless wearable computer. Based on Android operating system, it becomes more like a smartphone that you can wear and use handsfree, it allows use of buttons and voice commands to navigate and use the applications. Although intended to be used by anyone, it is being targeted to enterprise and business applications. Laforge Optical's Shima is aiming to be fashion



smarteyewear, hiding all the tech within the frame, making it almost impossible to differentiate from other non smart eyewear. The users can choose from a range of 5 styles and it can be fitted with prescription lenses too, thereby making people with prescription glasses use it comfortably. Featuring a camera on the nose bridge, and display on both eyes, it has richer information to display at the sides of the visual field, making it less intrusive and more intuitive than Google's Glass interface.

And its not only smartwatches and smartglasses delivering notifications and allowing controls through gestures, a range of smart rings and smart jewellery are trying to do the same. Consider Ringly, which is a ring crafted with a 18 carat gold plating, and with precious stones, can alert you about different notifications ranging from phone calls, text, alarms and other apps. Using 4 different vibration patterns and 5 light colours you can customise to know intuitively what kind of a notification it is, and how important it is. Fin is a smartring that is worn on your thumb, and it turns your palm and hand into a gesture control device, it understands the movement of thumb in relation to palm and can turn the segments of fingers into a number pad! It can be used to swipe through tv channels or controlling characters in a video game. Smartyring, has a tiny screen allowing to check notifications and at the same time can be used to trigger some functions on your smartphone.

//LAFORGE SHIMA

fashionable and full of smartvision

//image source: <http://www.fox.com>

5:11 PM   SW

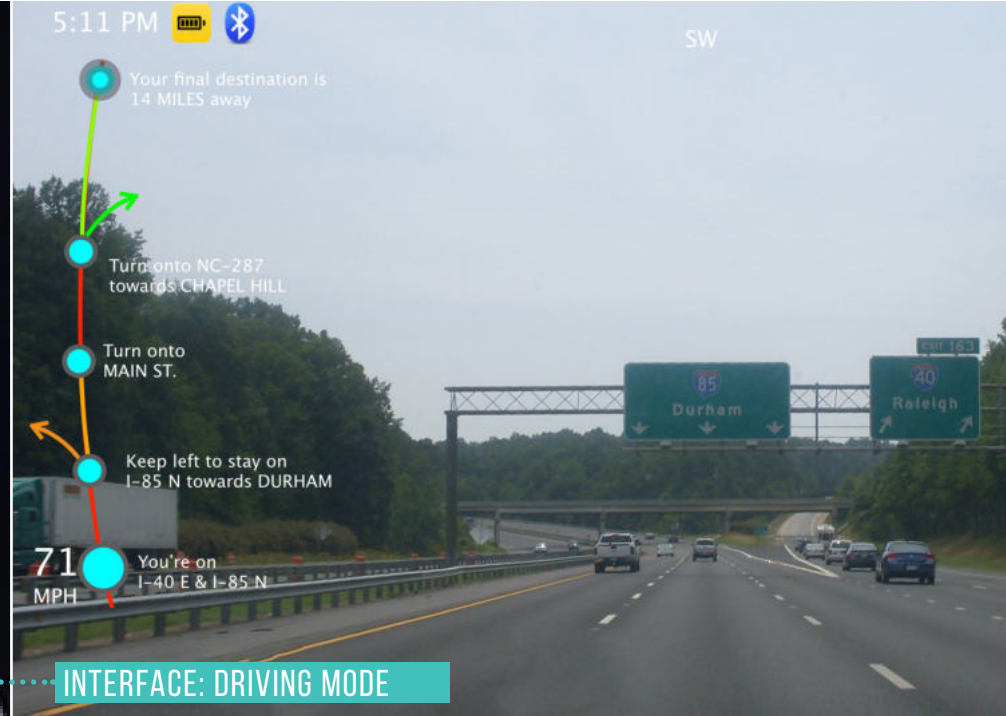
Your final destination is 14 MILES away

Turn onto NC-287 towards CHAPEL HILL


Turn onto MAIN ST.

Keep left to stay on I-85 N towards DURHAM

71 MPH You're on I-40 E & I-85 N



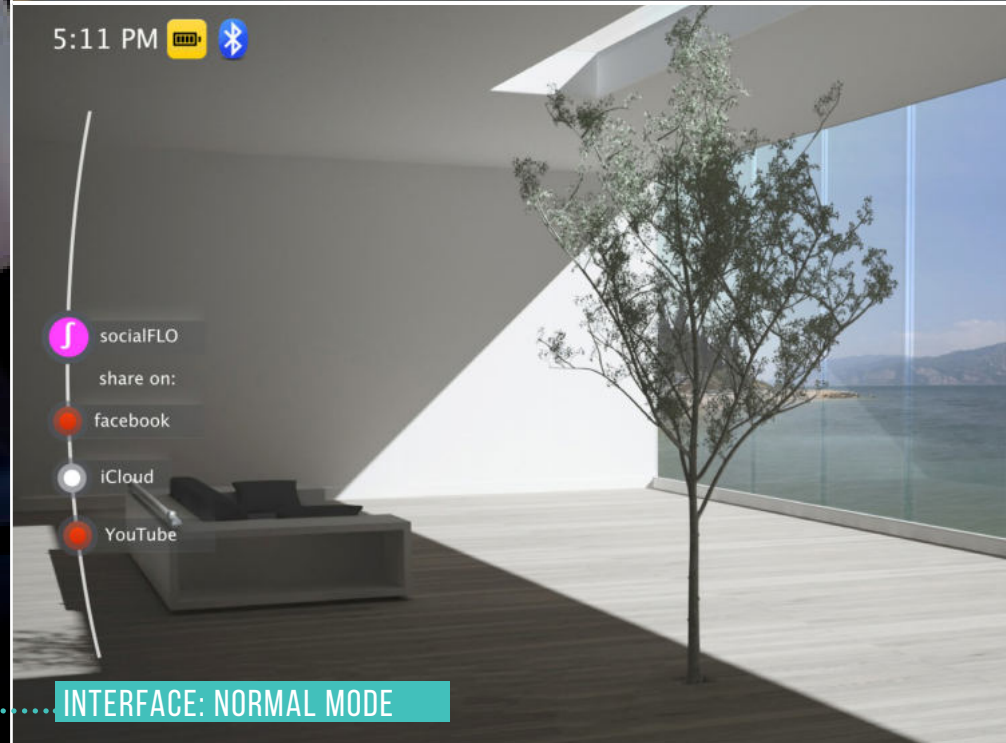
INTERFACE: DRIVING MODE

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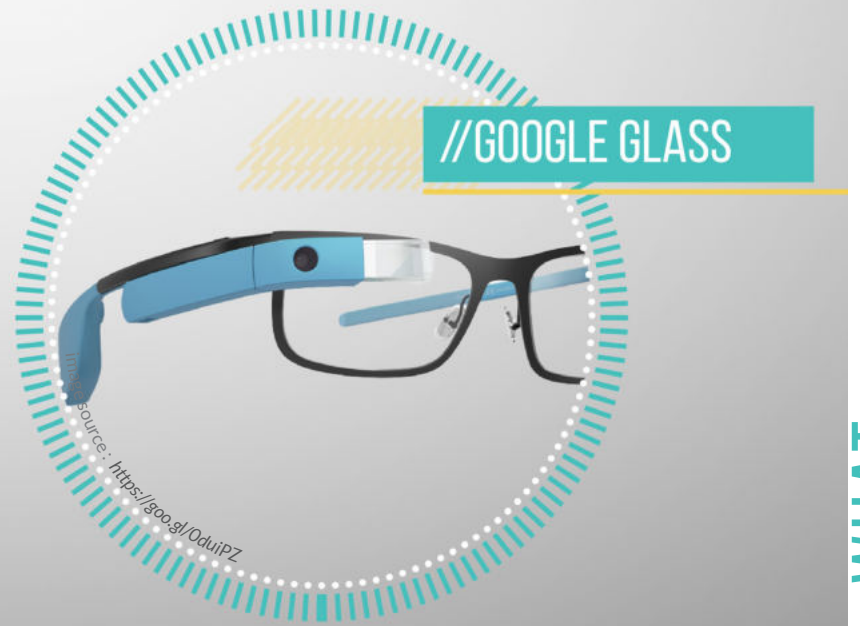
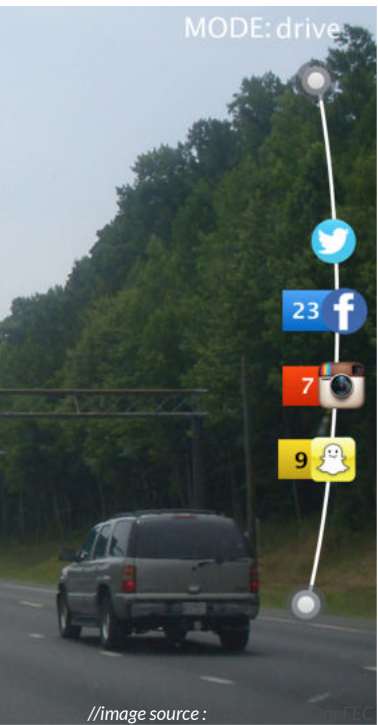
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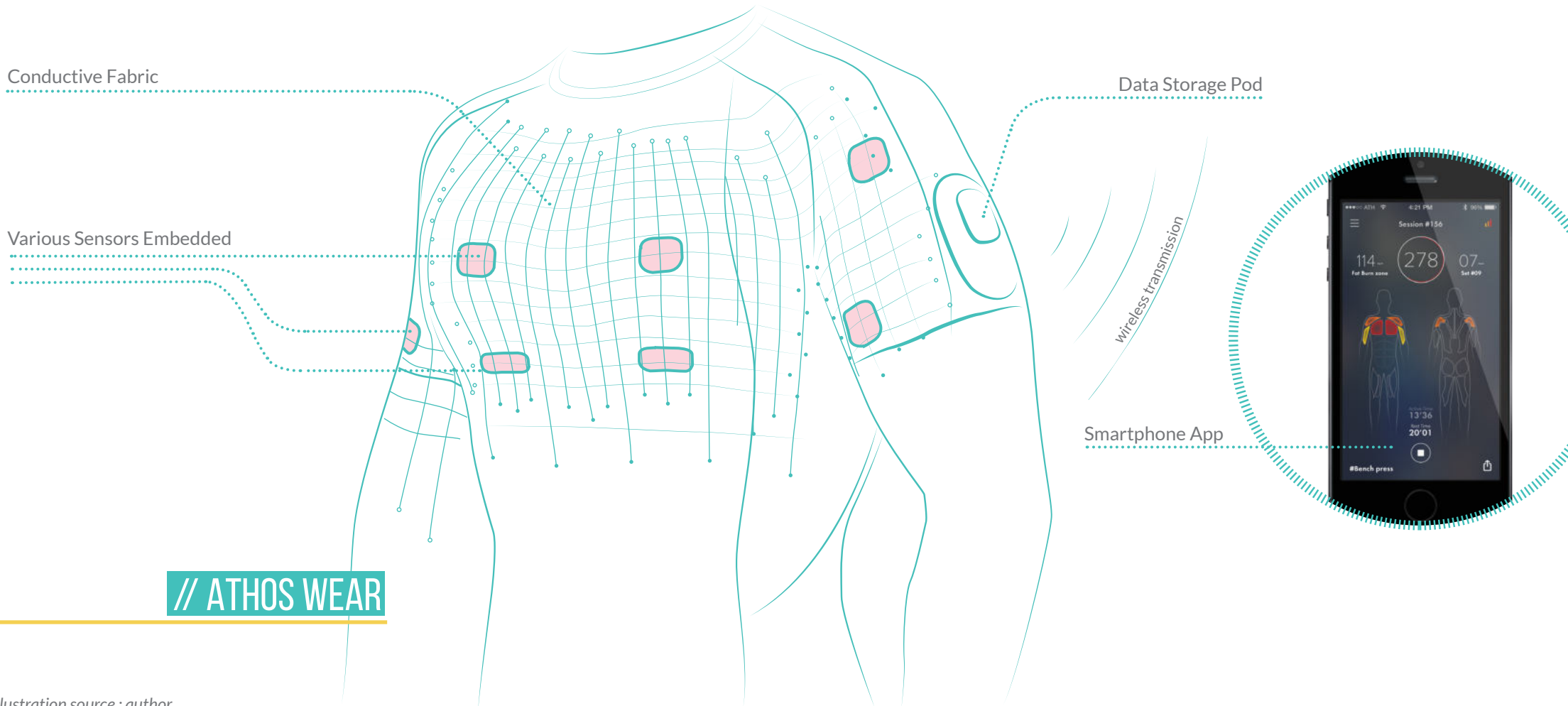
- facebook
- iCloud
- YouTube



INTERFACE: NORMAL MODE



WHAT



// Second Skin

Athos is a sportswear, with bio signal monitors built directly into the apparel itself. A set of nylon sports vest and pants, these are woven with 22 EMG (electromyography), 6 heart rate and 2 breathing sensors. All this data is read by a capsule core which fits on the clothes itself. All this enables the athletes to know muscle effort and fatigue, heart rate and breathing patterns while training. All this data is analysed to help the user to understand response from different muscles of the body and which ones need more build/toning etc. Smartclothing as it maybe called, holds a lot of potential, simply, because unlike a lot of objects like watches and bands that are not worn by all, and by some on only a few occasions, clothes are universally worn, almost all the time. Recently technology has enabled creation of fabrics weaved directly with conducting yarns, and sensors. This is a huge step, because clothes can hold more sensors and at more precise locations throughout the body making the collected data both richer and more precise. "They can collect more information and produce better data, like the full wave of the heart beat rather than just the pulse." (CITE:GARTENER RESEARCH) . There are sports-bras and tennis t-shirts (ralph lauren) that measure your vitals, and diapers that can be used to check a baby's health through urine samples (pixie diapers). But smart clothes aren't limited to health and vitals monitoring, for example T-jacket is a hoodie vest that can simulate the feeling of a hug onto the wearer. Developed for autistic children in mind, using the theory of

deep touch pressure, this jacket calms down the children without creating any anxiety of real human interaction. It has air pockets around waist and shoulders which fill up through a command from a phone/tablet computer. The jacket was conceived with the help of psychologists, researchers, therapists on board, and it has since then found application beyond autistic children. Fundawear is an experimental innerwear, which couples can wear to share touch and vibrations even if they are apart, taking the intimacy of clothing and being with someone to a new meaning. Clothing, since its inception has been as much about protecting and comfort as it is about being a symbol and style of oneself. Wearable computers are poised to take this element of style and fashion to a whole new meaning. Technology today has the ability to turn anything and everything, from static to dynamic interactive state. Synapse is a 3d printed thermoplastic polyurethane dress, embedded with an array of led lights and biosensors. If someone approaches too close to the wearer, a camera captures their image, and the various biosensors measure the emotional state of the wearer, accordingly changing the colour and intensity of the leds on the dress. Though not quite a dailywear, it shows what is possible with making clothing as a computing platform. A similar fashion project by Sensoree is GER Sweater (ger: galvanic extimacy responder) with the help of sensors on hands, it conveys the mood of the wearer through a varying colour palette exhibited through leds on the big collar of the sweater. Likeaglove is a dress that you wear once in a while to check your

body size. The data is stored and working In conjunction with online stores, this data assures that the clothes that you order online fits you perfectly everytime, thereby reducing one of the biggest issues with online cloth shopping. Darpa is developing clothing, with exoskeleton like parts, which with the help of mechanics and computing algorithms will help reduce the energy and effort spent in walking and running, and also allow soldiers to carry even more weapons.



//T-JACKET

Image source : <http://www.myjacket.com/>





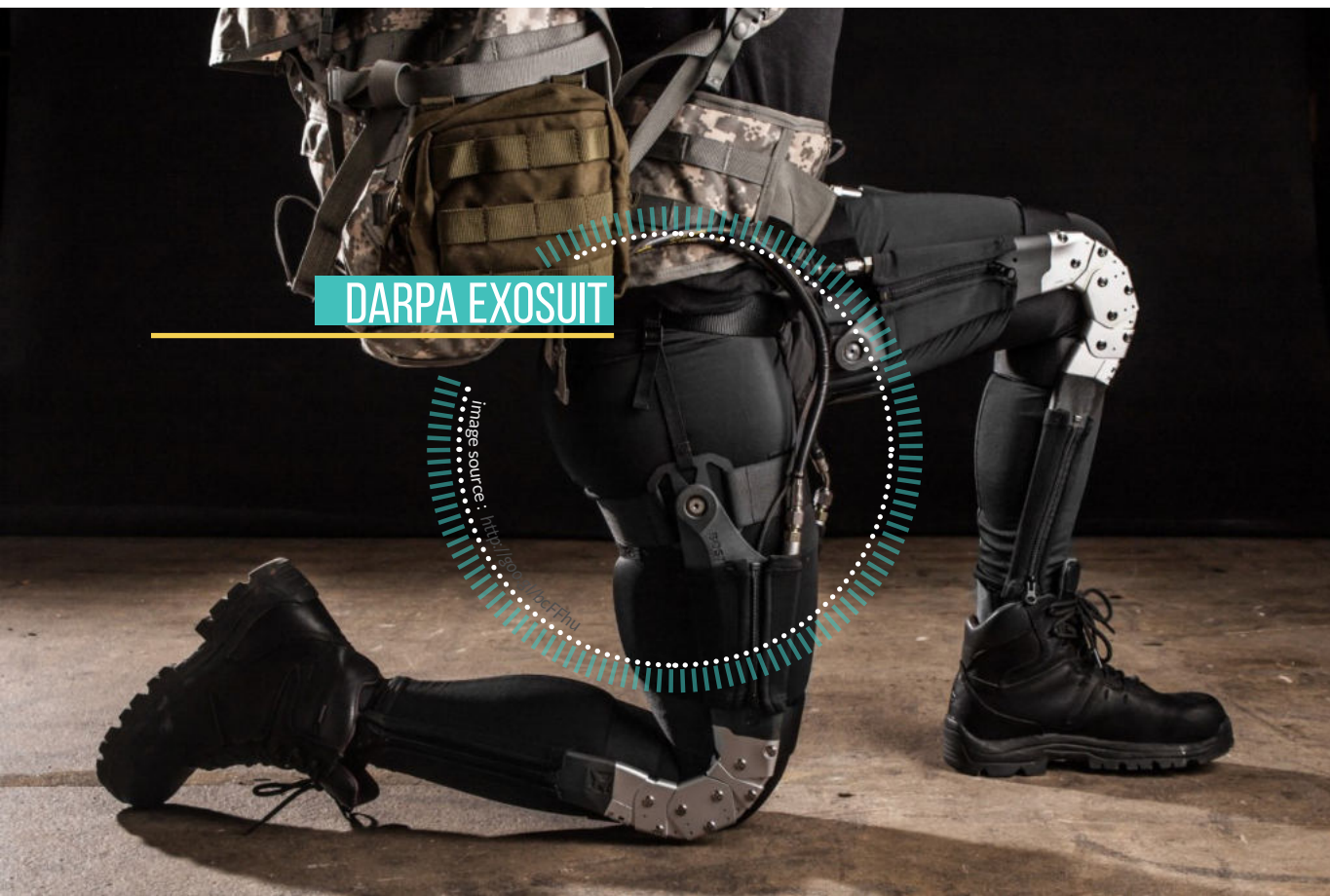
SYNAPSE

//image source : <http://goo.gl/gvSRkR>



VISIJAX

//image source : <http://goo.gl/6Bl9Ps>



DARPA EXOSUIT

Image source : <http://goo.gl/6eFFhu>



GER SWEATER

//image source : <http://goo.gl/F7bE28>

CASE



how does it make my life better?

Do i really need it?

Why would i want to wear it?

How do i feel when i wear it?

Does it simplify my life?

is this the right direction ?

//Experience with a Prototype Smart Wearable

During the middle of the project I got an opportunity to work as a industrial designer for a Indian smart ring startup. The opportunity was exciting, and i immediately accepted to work with the team. Within a span of three months, the industrial design for the ring had to be finalised and made ready for manufacture. This ring, acts as an input device which allows you to use gestures and motion of the hands and fingers to control various devices and interfaces.

As I tried the prototype, I was enthralled, to play the game of Mario all by hand movements in air, or to browse through the television channels by just flicking fingers. These functions were on a pretested setup and gestures. The ring allows anyone to register new gestures for different tasks, through an app on the smartphone. It was only after 9 attempts that it succeeded to register my gesture for initiating camera on my laptop. A little bit frustrated, I gave my gesture a trial, the gesture was to form a rectangle by joining two hands together, but nothing happened.

//Simple or Complex ?

It seemed, the gesture was too complex yet for the device to understand fully, so I went into the app once again, re-registered the gesture after trying again for 6 times, this time it was drawing a simple quick rectangle in air. And though it failed to recognise the gesture first two times, it succeeded the third, but the whole experience left me with a bitter aftertaste. *What was easier and faster?* Making that rectangle in the air, Or clicking a button? 60% accuracy or 100%? Even though it was a prototype, and its accuracy might be improved, but the device failed on a simple test, it did not help me to reduce the time between the intention and outcome in an easier way.

//Lacking Depth and Usage Experience

The next one week, I was continuously trying out the device and developing digital models for the design. While doing that, I realised no matter how well the electronics are packed inside, it is going to be a big ring, big enough to create problems when writing, holding things or even bending fingers, thereby creating issues while I do my normal tasks too. Then do I have to remove the ring everytime I wash my hands? Or hold a glass of water? Or when I try using a pen to take a note? How does me gesturing something in the air, while I am in a public space

will be taken? How many unique gestures will I be able to remember and use for different things? I conveyed all my thoughts to the team, but wasn't accepted well. I was asked to work on the manufacturing design and leave the rest. I had kind of lost faith in the viability of the product, and pulled away from the project.

//Unanswered Questions and Realisations

This event left me with a lot of unanswered questions, and made me to look the wearables from a different perspective. I started asking similar questions in context of every wearable product I had come across, tried in person or saw as a concept.

- *What is it good for?*
- *How does it make my life better?*
- *What does it help me to accomplish?*
- *Why would I want it to wear it?*
- *How do I feel when I wear it?*
- *Will I continue to wear and use it?*

Does it lend simplicity or increase complexity in my life? And most importantly, does it really adhere to the basic idea of reducing the friction between intention and outcome? Augmenting us in an easier & smoother way?

And the realisation dawned soon enough, most of the wearable products had issues in answering these questions. Some of them didn't make much meaning as a product, others failed to convince me to wear them, a few of them did help me achieving benefits but couldn't pursue me to continue using them over their non wearable alternatives.

HOW

*// Much of what is being done with wearable devices is happening simply because it can be done.
Donald Norman //*

//How. Wearable Computing ?

All These questions need an answer and in-depth understanding of the reasons why wearables are still not accepted by the masses. The very reasons that have caused the explosion in wearable computing, such as cheaper sensors and easy prototyping have become its weakness and the cause of thoughtless, direction-less development. From smart-bands to smart-glasses and smartrings, the promise of a hassle free assistance to make users smarter is missing from the experience of these devices. They are only marginally or not much useful than previous tech like smartphone and have a long way towards attaining maturity and becoming indispensable to our daily lives. Before that, the problems plaguing these devices need to be found out and eliminated soon.

//Understanding the Problem

To understand the problems, an analysis of functions, style, wearability and interface of more than 50 devices was done. It also included live studies on 3 major wearable devices, i.e. Google Glass (augmented reality headset), Moto 360(a smartwatch), Fitibit (fitness tracker) for varying periods of time. (Google glass was tried for two days, smartwatch for a week, and a fitness tracker for a month) .This in depth analysis helped in understanding various reasons why wearable devices are failing to perform and gain acceptance.

// A lot of new Variables

“Initial development of wearable technology (those of engineering and computer science) have no precedent of intimate interaction with the human body/mind/psyche in a continuous operation, body mounted paradigm, since these variables have not existed in prior research(mobile or desktop devices) Ignoring these considerations is often the cause of failure of new product.”

Lucy E Dunne.

It was observed that these devices are simply not considering a lot of factors that come into play when “design for wearing” is considered, rendering the users getting disillusioned with the device after using it for a certain time period. The devices are still being designed as per traditional computing paradigms, modified to adapt to the new usage on the body. Let us look at the definition and characteristics of wearable computers again, “A wearable computer is an electronic/mechanical device which is programmable(hence can compute different things), is worn on, attached to or embedded in the body, designed to be context aware, always on and assist in an unobtrusive manner” Now let us take out the keywords in this definition : “Electronic/mechanical, programmable, worn/embedded, context aware, always on, unobtrusive assist”, it becomes clear that all these properties call for new precedents and variables to be taken care of while

envisioning wearable computing devices. For example “worn on body” requires variables like comfort and safety of the user, durability of the device, identity of the user, style and fashion that it will lead to the user to be considered. Similarly being “always on and context awareness” requires variables like engagement , attention, language between man and machine, prediction, artificial intelligence, privacy, etc to be understood and factored into the design process of the wearable computing devices.

To understand these problems plaguing wearable products, it is necessary to study the various human and computing factors, that come into play when man and machine become one entity , when they function as a combination. *How does wearable machines augment us? What is the nature of this augmentation? How does this augmentation is carried out?* and most importantly : ***_How can we design for this type of augmentation?***

A comprehensive user study([appendix 1](#)) to understand how people treat, choose and use things that they wear and put on their bodies along with their use and adaptation of computers and recent technology was done to understand these factors that will come into play when both these worlds mix and create a new level of augmentation, usage scenarios, oppurtunities and experiences.



// what is wrong with these wearable devices?

not catering to **real needs/deeper needs**

neglecting **human behaviour** and factors

low understanding of **new variables involved**

lack of **coherent vision** for wearables as whole

body part
context
physical footprint

safety
durability

comfort
identity
fashion
mobility

Variables:

Wearable Computers are **electronic** devices that are **understanding the**
worn/carried/embedded in the **body**, designed to be **relationship**
contextually aware, **always on** and **augment** us **man+machine**
in an **unobtrusive** manner.

control
disappear
interaction

privacy
intelligence
prediction

attention
engagement
security

senses
abilities
perception
behaviour
multi tasking

HOW

Envisions a future where computers will help/augment humans in their formulative thinking, in real time, and both will act as a combined organism, enhanced and evolved.

// J.C.R. LICKLIDER 1960 MAN COMPUTER SYMBIOSIS

Summary

Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It will involve very close coupling between the human and the electronic members of the partnership.

The main aims are:

- 1) to let computers facilitate formulative thinking as they now facilitate the solution of formulated problems; and
- 2) to enable men and computers to cooperate in the analysis and controlling complex situations without inflexible dependence on predetermined programs.

In the anticipated symbiotic partnership, men will set the goals, formulate the hypotheses, determine the criteria, and perform the evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific problems. Preliminary analyses indicate that the symbiotic partnership will perform intellectual operations much more effectively than either alone can perform them. Prerequisites for the effective, cooperative association include: in computer time sharing, in memory core-sharing, in organization, in programming languages, and in the design of equipment.

1 Introduction 1.1 Symbiosis

The fig tree is pollinated only by the insect. The larva of the insect lives in the fig.

// DOUGLAS ENGELBART 1962 AUGMENTING HUMAN INTELLECT

By "augmenting human intellect" we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension of it, to suit his particular needs, and to derive solutions to it. This concept is taken to mean a mixture of the following: more-rapid comprehension, better comprehension, the possibility of gaining a useful degree of comprehension in a situation that previously was too complex, speedier solutions, better solutions, and the possibility of finding solutions to problems that before seemed insoluble. And by "complex situations" we include the professional problems of diplomats, executives, social scientists, life scientists, physical scientists, attorneys, designers--whether the problem situation exists for twenty minutes or twenty years. We do not speak of isolated clever tricks that help in particular situations. We refer to a way of life in an integrated domain where manches, cut-and-try, intangibles, and the human "feel for a situation" usefully co-exist with powerful concepts, streamlined terminology and notation, sophisticated methods, and high-powered electronic aids.1a1
Man's population and gross product are increasing at a considerable rate, but the complexity of his problems grows still faster, and the urgency with which solutions must be found becomes steadily greater in response to the increased rate of activity and the increasingly global nature of that activity. Augmenting man's intellect, in the sense defined above, would warrant full pursuit by an enlightened society if there could be shown a reasonable approach and some plausible benefits.1a2

Lays down the conceptual framework for augmenting human mind, through electronic computing. Describes means of augmentation and how man and computer can come together to solve the most complex problems.

Envisions a future where computers will act as a second brain/sensor network which will help tackle the world in unprecedented ways.

//Understanding Wearable Augmentation

J CR Licklider¹, talks about the phenomenon of man and computers becoming one, in his 1960 research paper called 'Man Computer Symbiosis'.

"The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."

This symbiosis is different from the tools acting merely as an extension of human hand/physical or mental capabilities. Throughout history, machines and even computers have assisted man as a separate entity, "the human operator supplied the initiative, the direction, the integration, and the criterion. The mechanical parts of the systems were mere extensions, first of the human arm, then of the human eye. These systems certainly did not consist of "dissimilar organisms living together..." There was only one kind of organism-man-and the rest was there only to help him." (Licklider 1960) In recent past, computers have evolved to a level where they can process huge amounts of data and churn them into information, but they are still extremely bad at making sense or knowledge out of that data. They are also bad at solving unforeseen problems as they are only able to act upon preformulated problems. While a human input or logic is advanced at

1. J.C.R. Licklider was an American psychologist and computer scientist who is considered one of the most important figures in computer science and general computing history// wikipedia

handling new situations and solve them well. Similarly humans are bad at storing large amounts of data, and processing it all by themselves. Man computer singularity or symbiosis enables to take the best of both and tries to combine computer and human thought process into one integrated system. The computer enables to store and process large amount of information which is acted upon by the human logic in real time, making sense of that data, reducing the overall time required to solve a particular problem. This is true augmentation of human capabilities, through computers.

//Layers of Man Machine Augmentation

In 1962, Douglas Engelbart² laid out a conceptual framework when computers are used to augment human beings. "By augmenting human intellect" we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems." (Engelbart).

Augmentation through technology is a complex, multi-layered process. Interpreting Engelbart's four ways of augmentation, in simple sense, it happens as:

Artefacts : First of all there is the tool itself, the physical part of the technology, which is used by the man to solve a particular problem.

Methodology & Language : To access/use this tool there is a particular methodology and a language that is required

2. Douglas Engelbart was a computer visionary who invented keyboard, mouse, desktop publishing, graphical user interface and more. Considered the father of interface between computers and humans// wikipedia

between the tool and the human, hence enabling an interaction between them, leading to problem solving.

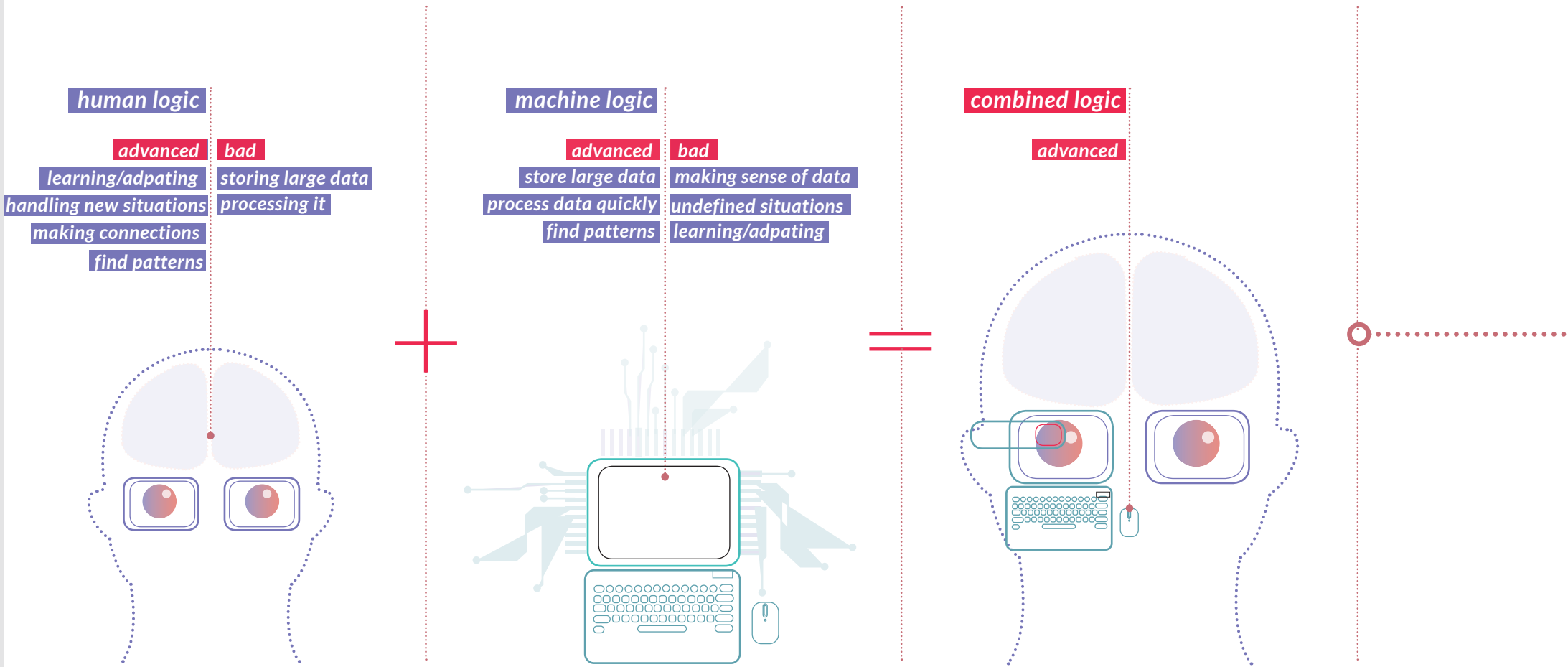
Adaptation : lastly and most importantly, the human has to adapt himself, physically, cognitively and psychologically in order to learn and use that tool, the language required and the method to follow, so as to be able to finally solve the problem using that tool.

//New Paradigms & Variables

With computers/machines that we put on our bodies, it is clear that all these layers are going to be affected and have to be understood in much deeper ways than in case of previous devices and technology. From the *physical form of the tool* to the methodology required to make it functional, *the dialogue between wearables and humans* and the adaptation to the technology, are all uncharted territories and are still being understood.

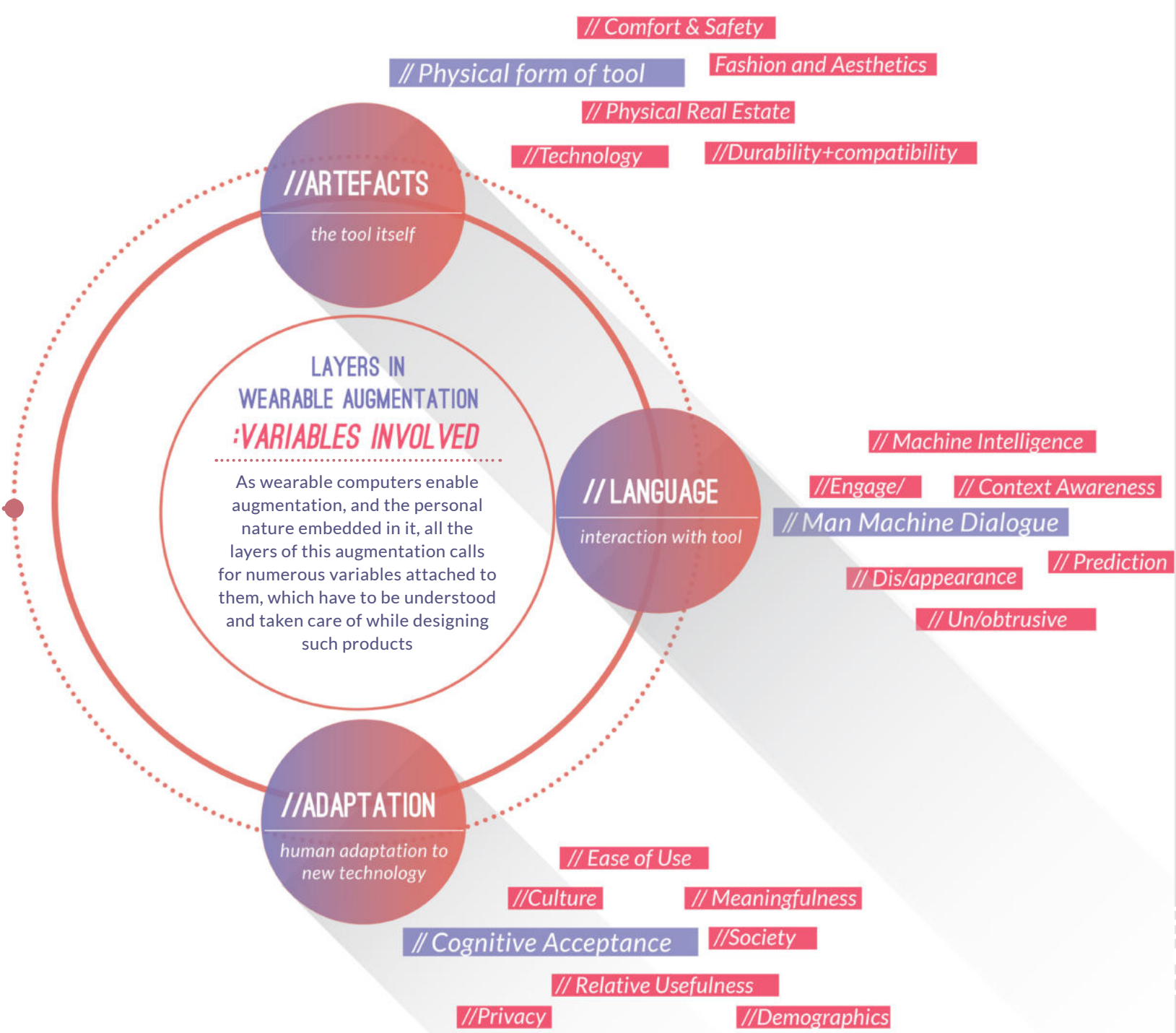
A lot of contemporary wearables are based on language and methodologies used in traditional computing, thereby failing to make sense. Traditional computing paradigms are based on the fact that computing happens in a static well defined environment (e.g. a desk in a room or office or on a lap while sitting on a chair or bench)

While something put on the body, moves with the body, jumps with the body, can cause discomfort to the body, is visible on the body, and all of this happens in a constantly changing environment. This requires a fresh understanding of computing paradigms and leaving the world of mouse and keyboards and touchscreens to something else. Both the dialogue and methodology of computing needs to be evolved from scratch.



//Wearable computing adds more physical/cognitive/psychological variables as the interface is worn on the body, interactions change and increase in frequency, and change as per context and the whole thing becomes more intimately related to an individual's sense of self.

_Lucy E Dunne



HOW

//ARTEFACTS

the tool itself, the physical part of the technology, which is used by man to solve a particular problem.

// Physical form of tool

// Comfort & Ergonomics

Fashion and Aesthetics

//Safety

// Physical Real Estate

//Technology

//Durability+compatibility

In the upcoming essay, an analysis is done to understand these layers of augmentation and various sub-variables that come into play while designing for a successful wearable augmentation .

//ARTEFACTS /First Layer /The Tool Itself

//Physical form //Comfort & Ergonomics //Safety //Physical Real Estate //Durability //Fashion & Aesthetics //Technology

//Physical form, Comfort & Safety

Being put on the body, worn on the body, the form of wearable devices need to conform to the form of the body itself. This aspect of the wearable computers has been the most explored and experimented. Initially the form of wearable computers was heavy, bulky, odd looking and unwelcoming. This led to problems in comfort and safety related to obstruction in natural heat and moisture dissipation, problems in movement and flexibility of the body. It also caused mechanical damage to the body parts over a prolonged usage. Over the years, a lot of focus has been put on getting the technology and the physical form of the tool right, and they have succeeded considerably. Lately, wearable devices have shifted to take forms of regular body worn accessories, such as garments, eyeglasses, helmets, bracelets, watches, hand gloves, necklaces and other jewellery, belts, socks, shoes and anything else that human kind has been wearing as regular daily objects. These objects have been worn for much longer before the dawn of wearable computers. Development in technology has reduced problems of

discomfort and safety that once prevailed. Most of the wearable devices as of now have minimal weight and physical footprint which has lifted a significant barrier in their adoption. Another advantage behind this philosophy is that people find it easier to adapt and wear these devices, as they have been tested by the masses for comfort and wearability for centuries and are socially accepted.

As technology improves and wearable computing matures, it may be possible that wearable devices become smaller and almost invisible on our bodies, hiding themselves behind our clothes or even the skin. Becoming formless, wearables will overcome a lot of stigmas and issues people have towards accepting on body computer, thereby leading to a better and more natural symbiosis of man and machine.

//Physical real estate

Our bodies have a limited space where we can put or wear objects. And with every passing day, the number of devices that try to take position of a certain body part are increasing. In an analysis of 500 wearable products, it was found that around 45% of devices are targeted to be worn on the wrist itself. Nobody would like to wear more than one such device on their wrists at one time (User Survey) From Smartwatches to fitness trackers, bands that allow haptic touch messages to be sent, and even drone cameras are all fighting for that real estate. This creates a contradiction, how do I use more than one

device providing different functions? One way might be creating all in one powerful devices that combine functions from several devices. Apple watch tries to combine a smartwatch, a fitness tracker and a touch exchange into one device. But it is important to understand, these devices have just precious little space for interaction and putting a lot of functions might create delays and complexity in accessing these functions, rendering a lot of functionality, overlooked and useless. Device makers need to understand this contradiction and look for other forms and body parts to aim while designing the product. A good alternative for placing fitness and heartbeat sensors might be undergarments which have the advantage over wrist because:

//undergarments are much more closer to heart/body and cover larger area which can provide for more sensors and higher accuracy of data collected.

//wristband fitness sensors get inaccurate readings of steps taken because they take in arbitrary movements of the wrist throughout the day, while undergarments are more stable and putting sensors there will allow for better and true readings,

//undergarments are generally worn throughout the day, are not visible and hence can easily provide for longer and more in depth tracking of body vitals.

HOW

// past



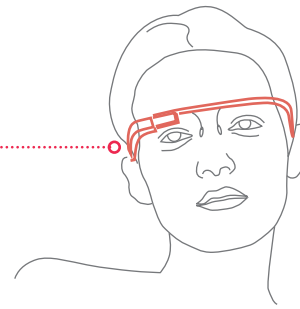
//barely wearables //heavy //clunky

// now

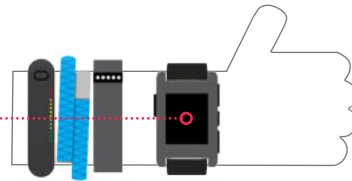


//Wearables //bearable //minimal

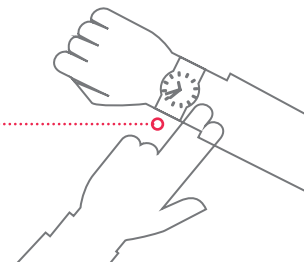
//still too noticeable



//too many to use



//too small to use



//problems with form factor of current wearable products

// future



//Invisibles? //hidden //un-noticeable

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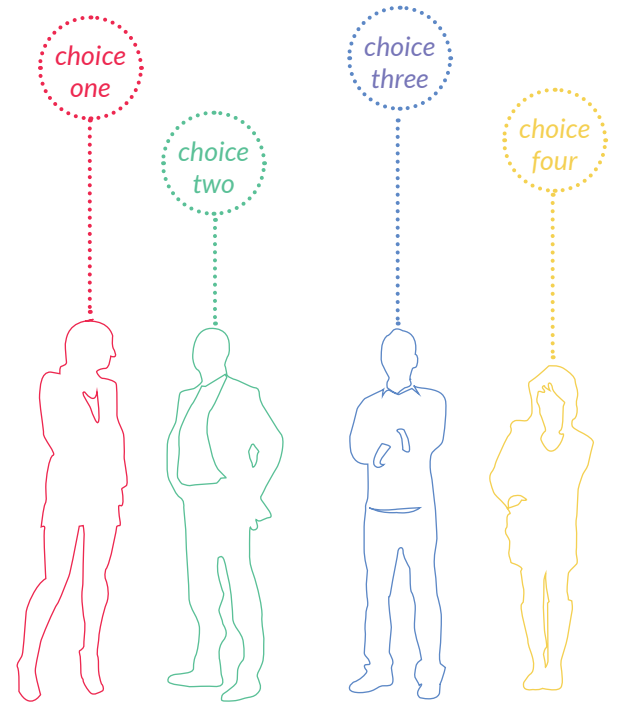
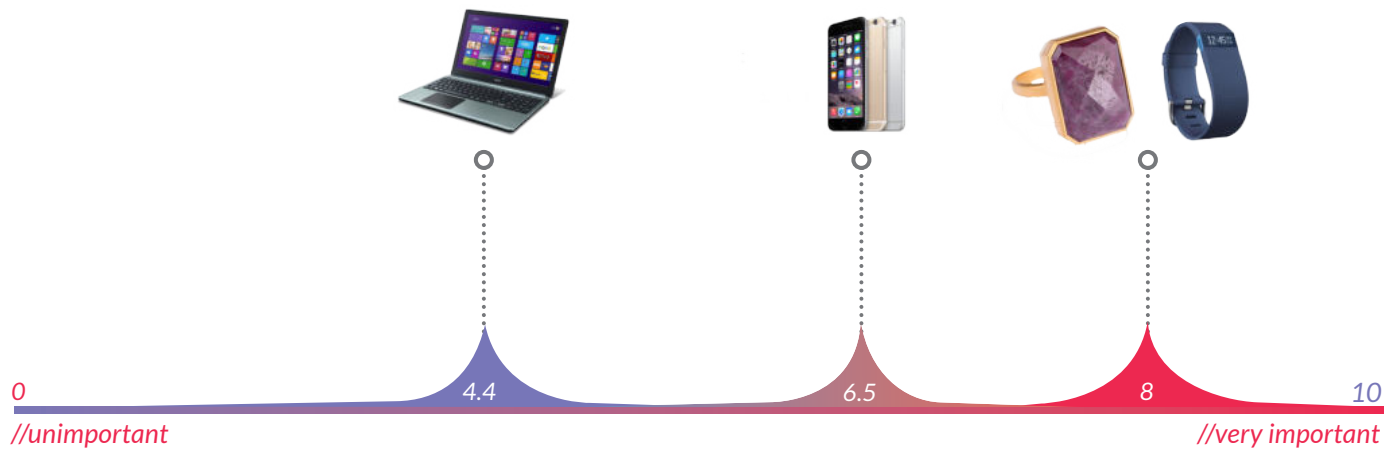
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HOW

//importance of style/aesthetics



Every person has a different body and equally diverse are their choices.

//Fashion & Aesthetics

Another very important factor that comes into play when an object is worn on the body is aesthetics and style. Anything worn on your body becomes an important part of your identity and character. It becomes a reflection of you. *When asked, people rated the importance of things worn on their body, to their identity as 8 out of 10 (average) (appendix A).* Computer devices have been mostly bland, with a few exceptions and that has been accepted by the masses, being okay to give preference to functions, because a desktop or even a laptop does not become a much visible part of your identity. This started changing a little bit with the coming of smartphone era, where it is carried throughout the day. People said that they give the aesthetics of their smartphone much more consideration than their desktops or laptop devices, (rating 6.5 for smartphone vs 4.4 desktops/laptops) The reason for this higher rating is that even though a smartphone resides majorly in the pockets, a lot of people hold it in their hands for easy and quick access, thereby becoming a visible addition to your body, a lot of times. (42% said that they have held their smartphone in their hands for more than an hour on a daily basis) Such people want their phones to look attractive and they flaunt them too, just as the young generation of the 1980s flaunted their walkmans, or ipods of the 2000s.

A smartphone is a device carried, residing most of the time hiding in the pockets of the users and not worn or held continuously, thereby people still overlook and

compromise the style and aesthetics of the device. But this preference for style and fashion statement changes drastically as we move towards the realm of wearable computing devices. People (92%) choose style and colour over price (70%), utility and other factors when choosing things to put on their bodies. Every person has a different body and equally diverse are their choices, and wearable technology industry has to embrace this factor. How does a device available only in one colour and finish is going to capture the imagination of masses? The answer is, it is not. And though wearable devices have come a long way from cyborg like additions to minimal daily wear accessories, most of the fitness trackers and other wearable products are still bland in terms of catering to individual tastes and choices. The problem is that they are still designed as products, and a lot of them are good examples of industrial design but fail badly as something fashionable. All the three products that I used, were an example of well thought design process. Be it Google Glass or the Fitbit fitness tracker, every thing was crafted and detailed neatly. The Moto 360 smartwatch even received a lot of attention and appraisal on its design by people around me. Almost everyone who liked it, asked whether it was available in any other style or colour. Apparently it is not. This is due to the fact that design philosophy behind designing a technology product does not consider the product being worn on the body over a long time and by a number of different people. Though they have started tending to the fashion need, wearable products still have a long

way to go beyond giving people the option of just a few colour choices. Consider the example of a technological product meant to be worn on the body i.e a wrist watch. Now, if you have been to a watch showroom, you know there are hundreds of various options available, neatly racked in glass cases. Clothes and other accessories also provide such wide array of sizes, colors and styles. Even with so many options, People still get confused what to opt for, not because its overwhelming but because they are not able to get the piece as per their liking (survey result). Wearable makers need to think how to design products that can cater to this individual need for style.

Moreover, the preference for clothes and accessory that people wear, change within a day corresponding to different occasions and context, and over the various seasons. One cannot wear the same plastic band throughout the day, though it might be okay to wear it in the morning while jogging, the same green plastic band will look odd with the formals worn for the office or at the party. (80% respondents said that context or occasion affects their choices for clothes and accessories followed by their moods and seasons). One month with the fitbit fitness tracker required me to take off the device a number of times a day, owing to various changing contexts. At times I felt the device could change its colour or disappear from the wrist responding automatically to the situations. A number of times I forgot to take off the device and owing to its bright shade, it was noticed and being asked about at awkward times.



100s
OF CHOICES

//image source : <http://www.bEqua7>



52%

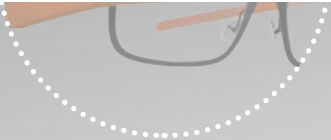
*people are confused when
buying things to wear ,
failing to find some
thing they like*

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#SS13MANDS

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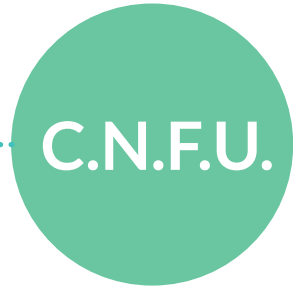
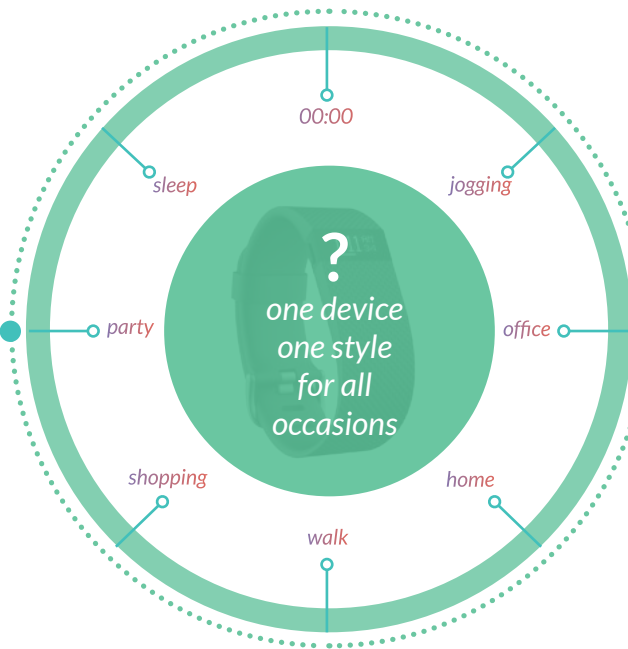
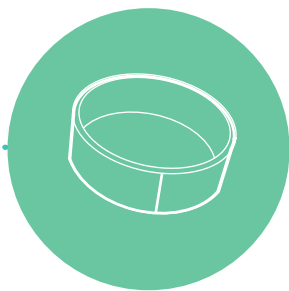
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The problem with wearable devices is that they are still being designed as per traditional product design methodology, and though a lot of them are good examples of industrial design but they fail badly as something fashionable, when put on the body. People need more than just a few colour choices to reflect their identity through the product they wear. People change the things they wear as per context and occasion even within a day. A single styled device will have hard time fitting to all such occasions. Modularity might have solutions.

HOW



Wearables are hiding as jewellery to become stylish and adapted easily by people



This will even be a bigger problem with female users who give a lot of importance to color and style corresponding to the time and occasion. This remains one of the challenges for wearable device makers to solve.

Different body parts hold different importance in terms of visibility and expression that they convey. Anything worn on face is much more visible than on wrist, and there is a hierarchy to this. Depending on where you put the device, it is going to convey a specific message to others about you. People who wear glasses, know how much importance they give to choosing the right set of frames before deciding to put it on themselves. (58% said glasses are more important part of their identity than clothing or other accessories.) Devices like google glass are a prominent visual addition to the face and meant to be worn all throughout the day, and though it is available in a few colour choices, it still fails to create a unique identity for one's face. Consider a situation where you move into a café and everyone is wearing the same glass, or maybe the same glass in a few different colors, 65% people said that they will uncomfortable to find themselves in such a situation.

People want to have a unique identity, to differentiate themselves from others around them. 54% users said that they are ready to wear something which is generally not worn in their environment to create an unique identity of themselves, if it doesnt make them look like aliens. Wearable products have to move beyond good industrial design to fashion design methodology so as to

cater to this need for "identity", which is so important in the fashion industry that there is a separate quantitative scale for it, called CNFU (consumer need for uniqueness).

Misfit's shine is a wearable product(a fitness tracker) that tries to solve this issue by becoming multiple jewellery like products throughout the day. It is designed as simple circular disc with minimal led lights that tell you different statistics as well as time. This disc can be worn on wrist as a bracelet/watch or around the neck as a pendant and so on. It is available in a few different finishes and colour. Similarly, to overcome this hurdle of providing an identity and fashion statment to the user, many wearable devices are hiding themselves as jewelry and other fashionable accessories While that is a good step towards making them fashionable, very few people actually wear one particular accessory all throughout the day. This creates another contradiction to the whole idea of wearable devices. If a device is meant to be worn 24/7, how can it respond to various moods, contexts and occasions? If it cannot, then do I need to have multiple versions of the same smart device/accessory for different occasions? Or maybe I will just put the smart device off my body in favour of a dumb accessory that suits more to my choice for an occasion. How can this issue be addressed? Probably a modular system can be used which allows swapping different parts of the device and create a unique style for a wide array of contexts? Or maybe the electronics/tech part becomes a module small and light enough to be attached to regular accessories thereby le-

veraging their edge in availability of choices. Here again we are looking towards an invisible form of tool/technology that can practically be embedded inside anything ranging from our daily wear accessories, clothing to our biological boides itself. That will liberate the wearable devices from the idea of being stylised or aesthetically treated itself. When tech becomes small enough, the circuits and chip manufacturers can collaborate with fashion firms to create daily wear apparels, accessories that look normal but are smarter and connected. This collaboration is needed even today where a team of engineers, industrial designers, interaction, user experience designers and fashion designers should come together to create devices and experiences as a whole and not in a layered one by one process. My experience with a prototype smart ring brought out the flaws of making a device in layers(*which is generally solving tech first then applying the layers of industrial design, interaction and finally fashion, if any*). Wearable smart clothing, has a lot of potential to solve this issue. With the development of fabrics that have conductive fibers woven with traditional ones, sensors and electronics can be directly built into the wide array of clothing available to choose. But such fabrics are still under development and still a little uncomfortable to wear. No doubt electronics embedded in nomral garments will usher a new era of acceptance and use of wearable computing, specially with the ease of making them available in literally hundreds of choices, similar to regular garments. This brings us to another issue, because the way we treat our garments and electronics is very different.

HOW

//Daily Wearability & Durability

The way we use our clothes/accessories and electronic devices are very different in context of their life cycle, cleaning frequency, prices, frequency of usage, way of usage etc. Something that is worn daily has to take in a lot of beating, from varying environmental conditions, different postures and even accidental food and water spillages. It is due to this wear and tear, we replace majority of our clothes, quarterly or every six months(56% said that they change their daily wear every six months, 22% said they do it quarterly). Most of the contemporary wearable devices have tried to overcome this by using durable materials like rubber and being waterproof by design. But this restricted choice of materials leads to contradiction with the need for unique style at different occasions.

In an observational survey for a week, the use of a music player and clothing/footwear was considered. While a music player is used for entertainment and in a diverse range of situations throughout the week the clothes and footwear kept on changing, even on a daily basis. The clothes were washed a couple of times, the music player was not. The footwear changed as per the environment(for walking in rainy environment or taking a stroll on sea beach) but the music player remained the same. We have different clothes for different tasks, for morning walk, for office, and even while sleeping, but a similar choice is not available or does not make sense for wearable gadgets. The music player was in usage for 2

years while the clothes/footwear changed within a span of four months. When these electronic devices become a part of our clothes and footwear, how will the dynamics change? What happens to the electronics embedded when a certain clothing becomes old/outdated/wears off? The price of the music player gets justified for a usage over several years (coming with a 1 year warranty too), how does the price point of electronic garments hold up, which one might wear for just one season? Wearable technology has still to figure out these issues, and find a common ground, a common set of usage pattern for both worlds. Modularity might provide a solution where devices can be attached or removed from the clothings/accessories as per requirement, and hence can be priced at separate price ranges. Infact with carefully designed universal standards, the clothes can even take modules from different manufacturers, by just becoming a basic infrastructure for the wearable tech. Invisible or very small components will make this process easier.

//Technology

Wearable computers have become faster, smaller, lighter and comfortable for long usage durations due to the rapid development in electronic technology. A lot of wearable experts believe that technology has finally matured to create perfectly viable wearables which can augment us 24/7. But during analysis and user survey, few issues came up which can be traced back to the shortcomings in terms of technology. Consider the smartphone, what are the times you have been frustrat-

ed during its usage? Apart from the unwanted calls at unwanted times, 63% users blamed it on poor battery life. Battery life has become the achilles heel of wearable devices. The analysis of 500 wearable devices today, revealed an average battery life of 20 hours for such devices. The maximum being a week. Now these are based on ideal conditions and real usage values maybe even lesser. A watch which needs to be recharged at the end of everyday, or maybe 2 times a day is a major drawback(my experience with moto 360 required putting the watch to charge at the end of the day). Apart from the poor battery life, a lot of these wearable devices are still big and technology part of the object becomes visible. A major drawback for google glass is that its easily distinguishable that it is some kind of electronic device due to the electronic box and the camera housing on the side of it. Some devices like smart ring are too big to be worn in the fingers without disrupting a lot of other daily activities, like holding a glass of water. Not until technology becomes even smaller (which also is going to hit the technical limit with this being the last decade when moores law will hold good) and hides itself seamlessly behind daily wear, it wont find acceptance among the masses. Another technological issue is the accuracy of the sensors used in these devices. for example the optical heart rate sensor used in majority of wrist fitness bands gives variable readings and is considerably inaccurate when compared to a standard heart rate monitor. So technologically there is a lot of room for improvements and analogically, probably wearables are in the 1990s of the smartphone era.

HOW

//Methodology & Language

//Human Machine Interaction //Intelligence //Prediction //Context-Awareness //Engagement //Disappearance //Unobtrusive

//Man Machine Dialogue

The language between the man and computer becomes ever so much more important due to the personal nature of wearable computing devices. In traditional computing paradigm, all the interaction and dialogue between man and computer has happened through an intermediate interaction device, a mouse, a keyboard a joystick, etc. as the input (controlling different states of the computer) and a screen as the output (providing feedback of various states of a computer). These devices become the controller/display of the virtual world of softwares. Although they have become very efficient over the years, and almost universal, these devices require the user to fully concentrate on the task being done. Also they are designed with the context, that the user will be sitting and performing the task, with an almost fixed set of tasks at his list. The whole environment is static.

In case of wearable computers, this paradigm doesn't work. Suddenly we find ourselves in a black zone. The context of using wearable computers is very different from the desktop or even laptops. The user maybe in any posture, walking, sleeping, eating playing, and more importantly that he/she might be doing these activities parallel to interacting with wearable tech. The user

maybe dividing attention between using computer and performing other activities. So how do we establish a dialogue between man and machine in this scenario i.e. always dynamic, ever changing ? Even more, a question arises whether this is possible or not? Is it possible to divide our attention to two different activities at the same time?

“For most of the past two decades of computer technology, it has been about static interactions in well-defined environments. But the newer concepts of ubiquitous and wearable computing have introduced a lot of new variables related to movement, comfort, social interaction, and in a dynamically changing environment.”

With the dawn of touchscreen enabled smartphones, the input and output device converged into a single slab. Smartphones didn't become a success until touchscreens became available, easy and precise for interacting in a limited space. But even touchscreens fail to be practical for the wearable devices. the problem with touchscreen as interface devices are many, primarily they require all the attention of the user to them, leaving no room for other activity to happen. Because of the limited size of screens and fingers that operate on them, they cannot be successfully incorporated for Wearables devices which are small and tiny . Still contemporary wearables are using these older interaction paradigms, leading to a disappointing, limited and stale experience. Devices like Pebble watch still use physical buttons over

touch screen of Moto 360 to avoid the limitations and confusion of operating a small screen on your wrist with your fingers.

//Need for New Technology

A breakthrough is required for interacting with these devices. Smartwatches are touch based, fitness trackers and other wearables cannot be directly interacted upon, but accessible through smartphone screens. When drifting into the virtual world of Oculus rift, one still uses traditional joystick to control the various things inside the virtual world. Google glass incorporates voice command system to control the various functions. The output is a tiny screen overlaid on your visual area, and calls can be heard through bone conduction sound technology. Though the whole experience is hands free, the fact that the output is still a two dimensional rectangular screen on my vision is a remnant of smartphone screen, and sometimes creates a disturbance in my vision too. When i am looking at the notification on Glass, i am no longer there, very similar to what happens when i look to a smartphone screen. The technology behind voice commands is not accurate and it misses a lot of commands. In a public space where there is a lot of noise, the voice interaction system becomes even more inaccurate. A simple trial with two Google glasses worn by two users revealed the confusion that the device gets into when both the users try to give commands to their glasses. Now consider a future where a lot of people wear these

HOW

glasses while walking on the footpath and try to instruct them, how will the glasses differentiate between commands from its user and other users that pass close by?

The bone conduction is a novel technology which can be utilized more efficiently to create an output interface based on sounds and aural perception. Microsoft developed a headset which uses bone conduction technology to create a 3d spatial world with cues for objects and barriers to help blind people navigate through the real world. Taking information from map data available it guides you and still keeps the users' ear and hands free to hear real world sounds. and navigate with a stick. Another interesting development is the eye tracking technology which can lead to eye movements being used as a means to interact and communicate with wearable devices.

//Minimal Interaction// Machine Intelligence _____

A good approach is to minimize the interaction required between the machine and man. This requires wearable computers to become 'aware' of the users' habits, context in which the user is, activity performed by the user and respond only when it is required or called upon by the user. Leading to "interactional constancy (steve mann) i.e. the device's input and outputs are always potentially active. Interactionally constant implies operationally constant, but operationally constant does not necessarily imply interactionally constant". A smartphone is constantly operational, but fails to be interactionally con-

stant as it is required to take it out from the pocket and then do the operation. A smartwatch is both constantly and interactionally constant, but still requires a little lag of orienting the wrist to your face to see the information. Wearable devices also need to consider the idea, that computing might not be the primary task (mann) , and that the user might be involved in doing something else, such as walking, talking or calculation. Hence it should not cut you from the world, but understand the context and stay silent if it has to, leading to unobtrusive nature of the interaction. This will also help in minimizing the deficit in attention that wearables might cause while their use. It is not easy to understand the wide variety of situations that humans put themselves into, but with the wearables devices being there on the body all the time, they can be built with algorithms that can keep track of the users activities throughout the day, week, months and years thereby getting better. There will be various patterns that algorithms can figure out with such huge, high resolution data and a certain 'intelligence' can be developed which can eventually perform a set of tasks without the user's direct involvement. This awareness of the user by the machine will lead to predicting certain activities that user is going to perform, thereby reducing the time between intention and outcome not only to zero but in negative!

//Brain Computer Interface (BCI) _____

Another way of reducing the amount of interaction or the difficulties related with it is to directly control these devices just like the way our brain controls the voluntary movement of hands and limbs. Thereby achieving a true state of symbiosis. It might sound impossible but the technology is already under development which allows the usage of brain signals to be detected and directed into meaningful control of objects in virtual and even in real world. Brain Computer interfaces as they are called, have already reached to such a sophistication that humans can control and play games just by mind control (Citation). Recently, a full paragraph was typed into the computer just by thinking. (CITATION). These devices are called electroencephalograph (EEG) headsets with external electrodes that rest on your forehead or head to measure the signals.(the glasses that were doing this). The trick lies in the fact, that brain emits a unique electrical signal every time it observes different things, and by enough training brain signals can be translated into meanings. For example imagining the letter "A" will produce a unique signal which can be translated into alphabet A into the computer through a interpreting algorithm. With more practice, accuracy increases, which is similar to learning curve for any other interface.

HOW

//Machine To Machine Dialogue

Apart from the dialogue between man and computer, the computer needs to have a dialogue and communication with other computers that exist in the environment. Thereby wearables will become a way of interacting with other objects and devices, hence reducing a lot of fruitless interaction that we do in order to achieve simple tasks through other objects. Let us imagine a real world situation, the daily activity of going to the office, checking in the office, then moving onto your cabin/cubicle... turning on the computer, accessing your account, opening your emails, other social websites. Going through your appointments, today's schedule and a myriad of other activities that happen.

A lot of time/resources is wasted in doing repetitive tasks, tasks that don't require much thought process but consume considerable effort and time. How can wearable technology change that? A simple way could be putting an identity chip worn on your body or embedded in your body. This chip is able to talk with other technologically enhanced objects in the environment. As soon as you enter or open the door to your office, the door acts as an enhanced device which registers your presence, and sends a signal to your office cabin. The sensors worn on your body measure your physical state, the temperature, and probably also know the exact point you left reading the newspaper. Now this door acts as a digital gateway, an invisible dialogue interface between man and the computers. As you pass through the door,

the electronics worn on your body talk to the electronics in the door, and it prepares your cabin. Based on your temperature state it adjusts the air conditioner temperature, based on your stress level it can change the colour of room and even play the music that soothes your mood, from your personal playlist itself. It switches on the computer, and prepares your email list, projects the important tasks and your schedules on the wall. It also displays the news from the point you left and similarly contextual data. So when you enter your room, you can directly sit and go straight to your task. And that's where the promise of wearable tech and embedding sensors in our environment can take us. Wearable devices need to talk to not only humans but a myriad of other devices embedded in the environment. This will lead to elimination of a lot of repetitive input required from the user front. So the interaction with the number of devices decreases, thereby decreasing the pointless cognitive load of mechanical tasks. So now one is multitasking but in a way that doesn't intrude into your daily life, but still understands you and does a lot of jobs which otherwise would have required my attention and feedback, hence my overall cognitive load.

The man and machines become one, and part of a singular system, and in order to achieve the perfect symbiosis, the interaction between the two needs to be natural, and with least possible friction and confusion. Wearables cannot afford to use older ways of communicating with computers. Wearables cannot depend on just one

mode of communication method. Humans use multiple ways to interact with each other, and communicate using more than one mode to do so. Human interactions are multi-modal, we can be talking, gesturing, looking and drawing at the same time to communicate some idea to a friend. We might be engaging in all five senses while exchanging ideas and thoughts with each other. Humans also know which mode to use for different situations. This is the basis of natural interaction, and wearable computers need to understand and respond, enable and support this multi-modal way of communicating. Wearable devices have the possibility of stimulating and talking to all our senses because they are placed on our bodies, and that should help wearable makers to grow beyond the screen which is extremely dependant on just one sense, i.e. of vision. Other senses as input and output devices should be utilised.

The promise of a seamless world where humans become hosts of technology and simultaneously living in both the virtual and physical worlds is only possible with an efficient way of dialogue between man and machine and with other machines.

HOW

//Adaptation

//Cognition (relative usefulness ease of use needs, meaning making) //Social //Culture //Identity //Privacy //Demographics

//Cognitive barriers

Whenever humans augment themselves through the use of a tool and technology, there are various factors that come into play during adapting themselves to that particular technology and its ways. There are stigmas and cognitive barriers that restrict acceptance of such technology. Cognition is the process of knowing, learning and perceiving something. It is the adaptation to a new thing. It affects our knowledge, our behaviour and our performance as a person in world. And when it comes to learning a new technology a user will do it only if it is accepted by the him/her in the first place. This acceptance depends on a lot of factors and is moulded by their perception about the technology's :

1. **Relative advantage** (the degree to which the innovation is more satisfactory than previous alternatives)
2. **Compatibility** (the degree to which the innovation is consistent with needs, existing norms and values held by adopters)
3. **Complexity** (the difficulty a consumer has in understanding and learning to use an innovation, including integrating it with other owned artifacts)
4. **Trial ability** (the extent to which the innovation maybe tested on a limited scale before the decision to adopt or reject is made)
5. **Observability** (the degree to which the innovation is visible and communicable to others)

(Everett M. Rogers defined these markers in his book *Diffusion of Innovations*.)

// Complexity

While compatibility is more of a social and culturally influenced cognitive factor (discussed later), Complexity is a personal cognitive barrier while adapting to a new technology. *"The complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption."* (Rogers) How much more useful (relative) or easy is the new technology compared to the older one decides its acceptance among the masses. If a system is found to/thought to be complex, users tend to start losing their confidence in using that tech, and even get worried over its use due to the fear of doing something wrong and causing some damage. For example, A neighborhood shopkeeper was afraid of using a computer, and could never learn how to maintain his accounts on the computer, the primary purpose he bought the computer for. This was around 8 years ago. The computer ended up being used as a gaming machine for his 6 year old kid. When I recently met him, he was fiddling his fingers through the touch screen of a big tablet powered by Google's open source operating system platform. I was surprised, and asked that if he has overcome his stigma to use computers. Here was his reply: "No, not at all, I still don't know how to use a computer or a laptop, but yes this tablet is easier and much more hassle free. I just have to open the related app and start using the app, not dealing with the tons of menus, icons, and hidden functions which I won't be ever using. And then I can just take it with easily everywhere, and enter the required data, and see it all processed nicely"

Moreover he switched to the tablet after he saw his partner who shared the same stigma towards computers was using it to manage his shop accounts. His perception of that tool and its 'perceived ease of use' made him try the technology and it didn't disappoint. Also the technology 'seemed perceptibly useful' in enhancing the way he could do his accounts, compared over the current method of using calculator, a pen and a diary.

In the survey It was found that people rated the ease of use of smartphones over desktop or laptop computers to do similar tasks as 8 out of 10. This explains why smartphones became such a universally accepted technology.

Majority of the wearable devices are utilising smartphones and the ease and familiarity of app ecosystem to drive interactions and control with the product. Though users might find it easy to adapt, the problem arises when one realises that a lot of function that these devices do can also be handled by the smartphones alone, rendering these devices relatively less important.

This is where wearable device makers need to be bold, and experiment with new, wild possibilities that only computers worn on body can provide. Natural multi-modal interactions that are possible with wearable devices needs to be explored and developed, so as to decrease the dependence on screen based interactions, which are simple but constantly becoming populated with unnecessary steps, causing reduced attention, distraction and exertion on eyes and fingers.

HOW

// Relative Advantage// Needs //Meaningfulness

Wearable computers are still not properly known or understood, and one of the reasons is that they do not seem to be perceptibly useful over existing tech. They don't seem to make much meaning to the users or satisfy their needs. They simply fail to justify their existence. Most of the current and even upcoming wearable devices are trying to create a need which is not there.

A month with a fitness tracker revealed a simple truth, I actually do not need it. Yes it is an interesting way of tracking my calories and heart rate, but what do I do about it? It tells me I slept, and a little about the quality of sleep, it tells me the calories burned and kms walked, but all this information is something that I already have an idea about. Yes the tracker quantifies this information into nicely visualised number chart and makes me achieve a goal thereby making me feel good about self, but the novelty wears away soon. Under pressure for work and tight schedules, the goalkeeping is suddenly missed on a certain day and one realises they didn't miss the device at all. It fails to form a habit. This is the reason that almost half of the users who bought fitness trackers stopped using them within an year of purchase(CITE RESEARCH). Interestingly most of the smartphones also have this ability to track your steps taken built in and one does not need to wear another device for the same task. Smartwatches are more useful than fitness trackers because they not only provide basic fitness tracking but also help to bypass the activity of taking the phone

out every time a notification comes, or when you want to change the song , accept or reject the calls. These devices do peel off a lot of necessary functions and make them easily accessible just through a glance. A week with Motorola 360 smartwatch did help me in reducing the number of times I took the phone out and the watch acted as a better way of following through my schedule and tasks. But there were a lot of times I had to end up taking the phone out, after fiddling with the watch for quite a few minutes to do a certain task (e.g. finding location on maps or replying to a message) At times I was confused whether I should just use the watch or take my phone out for a better experience, and i ended up using-both. It was a mixed experience and eventually I didn't miss the watch much except for rare moments when I couldn't take my phone out because of the disruption it might cause in current activity. Google's Glass is another device that tries to repeat the functions of a phone in order to make them available for instant consumption reducing the lag of taking the phone out, typing the password hundred times a day. Having critical information right in your visual field is definitely welcome, but the point is what defines critical information? The experience of navigating through real world guided by maps is seamless & fabulous on Glass, but a constant array of notifications of Facebook statuses which tells me what my friend is having for lunch, is not. Once in a while I do see a important message or call that I was waiting for, but there is a lot of noise for that. And that's where google Glass fails. It depends heavily on smartphone & internet

to be useful. All these devices are capable and have potential but as of now they are hardly essential. Most of the tasks and use cases that these devices provide, give them just a slight edge over doing the same tasks on a smartphone, which is not enough to convince people to adapt or switch to them.

//Grow beyond Smartphones

Wearables have to stop trying to become accessory to smart phones and start catering to some of the real and existing needs, that no other device caters to. Smartphones became a widely accepted devices due to one primary reason, they were reinvented avatars of something everyone was already carrying for years, the dumb phone, which fulfilled the real need for communication in a way no other device had throughout the history. Even today, the ability to make calls remains the most used function of the phone. Wearable devices provide no such compelling use scenario. Also, a lot of uses and functions contemporary wearables are trying to cater to, like monitoring your sleep etc, can better be done through other devices in the world of internet of things. Why wear a device to monitor your sleep? , when your sensor enabled pillow/mattress can do it. Why wear a device to correct your posture when the chair you sit upon can track it and correct it.

Wearable devices need to find specialised areas and scenarios which require the object to be worn on the body in order to function, and not unnecessarily burden the body.

HOW

//Human Needs & Use Case Scenarios _____

Understanding true human needs and finding suitable clauses for use of wearable technology in those scenarios is the direction wearable makers need to take. Contemporary wearables are desirable but not actually needed, thereby still being limited to a few early adopters and enthusiasts.

Abraham Maslow laid out the extent of human needs in an hierarchical order, in his theory of human motivation. It is interesting to look at this hierarchy to understand how humans give importance to different needs. The Maslow's pyramid places physiological needs at the bottom indicating that these are the most basic needs for a human. Physiological needs are the ones that a human requires for survival, such as air for breathing, food, water, shelter, clothing and sleep. Only when these needs are taken care of, the requirement for higher needs for safety of health, money, family and social stability become important, followed by the needs of love & belonging, then need for self esteem and finally the self actualisation. This chart is a useful reminder for checking which level of need is the product aiming to cater for, and the profile of the user that will attend to that need. Wearable computers reside directly onto the body itself, for long usage times and hence can cater to all these type of needs in meaningful ways. Fitness trackers seem to cater to the need of health safety and even the physiological needs, both of them being the basic needs but still have not managed to capture the imagination of people.

Is there something else that is causing fitness trackers to fail? On a careful observation it is revealed that though fitness trackers have the potential to cater to deeper needs, their under explored capability has caused them to become accessories rather than important devices. The reason is that these trackers are not providing the users with meaningful information, which will inspire the user to take a suitable action. Wearable health monitors measure a lot of vitals, and can do that throughout 24/7. That is a lot of high resolution data being collected, but not being properly analysed to generate meaningful insights.

//The Fourth Layer : Meaningful Data _____

The hardware devices are one layer of the whole system which collect data. Processing this data as a quantifiable number of burnt calories or steps taken is the next layer. This information when presented to the user on a smartphone in appealing graphics is the visualization layer which tries to make some meaning out of the processed data, such as how many hours I was in deep sleep and how much I was disturbed. But an average user doesn't know what to make out of this information. He/she might try to make up for the loss of sleep by sleeping more, but due to lack of any feedback, it will be an exercise in futility. To make this data make more sense and cater to deeper need of health safety, there needs to be another layer to this system, i.e. the action taking layer. *"This is the information presented in a context, in such a way where it would be obvious and intuitive which actions to take as a result of seeing the information"* (melanie swan)

Instead of telling users what they already know or have an idea about, these devices need to tell meaningful insights derived from this data. By analyzing particular data stream such as heart rate, over months, and finding anomalies in that, user can be informed whether his/her heart is healthy or whether there is something to worry about. There is a lot of data streams that are being generated through these devices, not only lot of data but new types of data. Data which was never recorded in so much detail and over such a long period of time. This data can be about anything ranging from your location, your favorite food places, your last vacation, your vitals, etc. . This Data is digital gold in terms of its vast possibilities. The data is generated by your activity in both , the virtual and real world. With wearables it is possible to get data from thousands and possibly millions of users continuously for days and months, which can be recorded and used to find patterns. These patterns can be analysed by doctors/scientists/psychologists to understand the sleep, health conditions, habits & behaviors, preferences and choices etc which can provide a deep insight into finding and improving the lifestyle choices we make, to live better healthier and happier lives. In case of an epidemic this data can help to understand the way and spread of the contagious disease and control it informatively. Consider a wearable device which can analyse the pollution levels of air and water. Collecting data from all the users throughout an area will give a high resolution map of the conditions and hence initiating proper action to combat that.

HOW

Such data can establish a general health index of the zone, and over the years, by learning from patterns recognised might help in understanding numerous health conditions, their causes and can even predict the outbreak of diseases in advance. This will help the medical facilities to be prepared and fight the disease better. It is also possible to compare and relate multiple different streams of data like heart rate and glucose levels, and discover entirely new relationships among these variables.

All this data has to make such sense, to tell personalized stories to individuals, to researchers, about themselves, their health, their state of being, their town's state of being. This is possible by understanding this data, finding patterns through algorithms, research and observation. Based on this layer, the devices can help in predicting the future health condition based on current habits and body condition. This will help in preventing diseases before they occur.

“Owners of wearable technology, like the upcoming Apple Watch or Microsoft Band, are the most vital part of the product ecosystem because they generate valuable information each time they wear their devices. Yet they also pay for the privilege. Brands should rethink their value proposition, make wearable devices free, and monetize the data, or risk losing out on the possibility of mass-market adoption.”

This data generated is so valuable that Frogs Design's creative chief officer Hans Neubert says wearable devices should be provided free, and people should be paid for the access to their data. We are becoming valuable data clusters, the digital shadow that we cast while using wearables and other devices can be used to generate a profile. Apart from health predictions, based on this profile, extremely personalized content and advertisements can be catered to you. With more people wearing these devices, these datasets will become better, more accurate and deep.

//Targetting Specific Users _____

Another approach, for wearable devices is to create products for usage and needs of a specific set of users and not for masses in general. For example focusing on taking care of elder people and developing wearable devices that help them live more confident and independent lives might be well accepted and perceived to be relatively much more useful over current systems by them. Wearables can detect falls, strokes, remind to take medicines, help the failing memory by reminding particular things, people and faces, can detect sugar levels and other vitals and send all this data to a doctor or a person in care of the elderly. Provided they are easy to use and disguised as normal garments, elder people will switch to such products.

Another example would be using the biophysical monitoring offered by the health trackers to specific people

such as pilots, military, fire fighters, F1 racers, mountain climbers etc. because they undergo a lot of stress and fatigue and continuous biophysical monitoring may help in improving their performance and save them from damaging their bodies.

While devices like Google Glass may have been rejected by the masses for various reasons, it can be used in less stringent conditions where fashion, privacy and entertainment is not that important. For example, security and police personnel can use in various situations like identification of criminals through facial recognition, scanning number plates, recording interrogations and analyzing the facial expressions of the victim. During a raid, a device like Glass can stream the live footage to the command center, and get clearer instructions specially when handling bomb disposal or unfamiliar situations, etc. Wearables are also in a fantastic position to help become extra senses for handicapped people.

“We have realized the need [for] and benefit of wearables, now we just need to let the designs, applications, and technologies evolve, similar to cavemen realizing that clubs, spears, and wheels could be great tools but not realizing that those tools would become the catalyst of humanity. We are on the cusp of the largest disruption of mankind that history has ever seen; wearables are a necessary blip on this revolutionary trajectory.”
Gigaom Research

HOW

//Social & Cultural Compatibility

Smartbands, smartwatches and current range of smart-glasses are still a transitional technology, and with passage of time they will give away to more advanced and mature forms of wearable technology. The interesting thing is there is suitable infrastructure to come up with wearable devices that can make a difference in people's lives. Its time for wearable industry to think beyond the smartphone dependent products, stop trying to make one product for all, and start providing more sensible feedback and insight through their wearable products.

“True human needs should constitute the heart of smart clothing and affiliated domains because technologies are meant to serve people wherever and whenever available, permeating physical, social, and digital worlds.”

(duval)

Considering real needs and finding the set of users that those needs respond to, will help in catering to that niche through wearable technology. These particular set of people will start perceiving such specialized products catered to them as relatively useful and advantageous over current technology and will start adapting to it. With the help of an efficient dialogue between the devices and the user, the ease of use can also be achieved. This will lead to a acceptance and evolution of wearable technology and is the direction that wearables need to

Adapting to a new technology or idea is also driven by what is acceptable and compatible by societal rules and cultural values. Majority of the people confirm to these standards and are influenced by social scenarios that they are in. Their choices about things is influenced by their friends, mates and coworkers. (72% users said that their behaviour and choices are influenced by their friends and close ones) Culture and its values about behaviour and code of conduct influences what is done, thought and felt by the people. Wearable computers are one of the most personal form of technology till date. Residing on our bodies and mediating our interactions with everything else, they might become intruding and might break the existing paradigms of society. This might be opposed by the society leading to a rejection of the technology. Wearable things define your identity to the society and we already saw how they need to be fashionably acceptable too. There are various rules that each society follows in terms of what is acceptable and what is not in context of fashion.

“ The mounting of a device directly onto the body, in a constant-wear paradigm, necessarily includes the visual appearance of the device in the individual's displayed identity. Because of this, technological innovation in the form of body-worn devices must adhere to the methods and pace of social assimilation of other body-worn articles, such as apparel and accessories.”

Remember the bluetooth headsets? They have been a very useful piece of technology, enabling to let the

phone remain in pockets, allowing hands free and wire-free access to calls and music. No matter how useful or even how gorgeous they looked, they never took off with the masses due to a perceived common perception that anyone wearing them is always ready or even desperate to make or take the calls. This was labelled as uncool by the societal norms and only people who actually needed to make and receive a lot of calls as part of their job became its users. e.g. sales person, contractors etc.

A lot of wearable tech even today is considered to be too novel and only reserved for nerds and geeks. (user survey) A part of this perception lies because until recently these devices were a much visible addition to the physical identity, and most of the times they looked big, shabby and technical. Though with the miniaturization, wearable tech has started disguising itself in daily wear, still wearing a fitness tracker continuously throughout the day is considered odd by the people. The user is still considered as an early adopter rather than a normal user of technology. A light stroll through mall with Google Glass on, caused me to be the subject of all sorts of glances. From the ones that seemed excited about it to ones that made me feel that I am wearing something weird and look creepy. Google Glass was perceived as a threat to privacy by societies worldwide, majorly due to the camera that adorns it. Even though a voice command (which can be heard) is required to activate it, and there is a visible light which blinks when recording is under process, people were still unsure whether they are

being recorded invisibly or not. (CITE USER RESEARCH RESULTS). This concern was so elevated that the society came up with a term ‘Glassholes’ to refer to google glass users. Even before its launch to the public, a lot of cafes and places banned the use of Google Glass. Maybe it's still too early for such advanced technological additions to our bodies, and removing just the camera from the device would have made it more acceptable or maybe its just a matter of time to adapt to them. A lot of technologies that were once considered odd were accepted by the society gradually. There was a time when wearing earphones or using smartphones during walking or eating dinner was considered as an act of rudeness or rebellion by that individual, due to the disconnect with the world that earphones or smartphones created. Over the years, the culture of using earphones and smartphones seeped in and became accepted by the society as a means of personal entertainment and communication. Its 2015, and people can be seen using wearing earphones and glued to their smartphones everywhere, including the library that I am working at, which would have been an impossible scenario just a few years ago.

It is important to consider what kind of a social message is conveyed when one starts wearing a particular device, and design process should include understanding the particular culture and compatibility with the society.

HOW

// Currently there is a lack of a coherent vision which considers all these factors in creating wearable products. There needs to be a humanistic approach to the direction that wearable computing is headed to. Wearable computing devices hold the potential to make us truly super humans, but it will become possible only when we understand the issues and shortcomings. //

//Inferences

Understanding problems plaguing wearable devices today, following observations and directions can be utilised for development of wearable computing devices :

// Ultimately, invisibles rather than wearables will cause mass acceptance of such products, by overcoming various stigmas that come up when a device becomes a visible addition to the body.

// Till then, Wearables need to disguise as daily wear accessories and must consider the fashion aspect, giving choices of colour, style and sizes.

// Modularity of device and clothing will help in allowing more choices with the same tech.

//Body has a limited space , wearable devices should not cater to just a few parts of the body. They need not compete but supplement each other. Selection of alternative suitable position on a body for better and easier performance should be considered.

// Durability , Price and Life Cycle of products that become a part of smart clothing should be considered

//Technology still needs to overcome a lot of factors, battery capacity needs to be improved and so are the alternative technologies for interfacing with wearable devices.

//Wearable devices need to stop using older computing interface paradigms such as touch screens. They need to enable Multi Modal, multi sensory interaction, with the device. The interactions have to be minimal, devices have to become context aware, taking attention when user wants to or it is deemed important

//Alternative interaction methods using sense of touch, audio, smell and direct brain electrical activity (Brain Computer Interfaces) should be developed and utilised.

//Devices should communicate to each other and able to understand and collaborate with each other in order to reduce repetition of functions and also to create a more aware and responsive environment of use for the user.

//Wearables should stop becoming Phone Repeaters, if they had to do so, they should make the functionality so that there is no confusion of use between phone and the device, and there is perceptible advantage over the phones.

//Wearable devices gather a lot of data but doesn't make any sense of that data. This data should be put to pattern recognition and anomaly detection algorithms to discover interesting and meaningful insights which cause the user to take an Action.

//Everybody has unique characteristics and their preferences, needs and wishes which might make it really difficult to create one device that suits all. That may be possible probably only when technology matures and becomes invisible inside our clothes and skin completely. It is useful to think of specific users and target their specialised needs. Give these users a huge relative advantage over existing tools and methods and the wearable products will see success.

//Due to the wide variety of culture and social norms, wearable devices should try to create designs that are responsive to these two factors. It is important to consider what kind of a social message is conveyed when one starts wearing a particular device, One product for people all around the world won't work, and before targeting the users, their social and cultural stigmas about clothing and technology needs to be understood.

// Wearable devices need to find specialised areas and scenarios which require the object to be worn on the body in order to function, and not unnecessarily burden the body.

// True human needs should constitute the heart of smart clothing and affiliated domains because technologies are meant to serve people

EXPERIMENT

//Experiment Aims

During the research, it was realised that wearables need to find meaningful use case scenarios, which are only possible with wearable device. The next part of the project was to experiment with an idea about such a product. As part of project, this product should embody the research findings, and attempt to show how wearables can make a difference to various people's lives. Another criteria that became important for the idea selection was the ability to prototype faster, hence allowing testing with the possible users and understanding its viability.

To understand the needs and wishes of people exploring wearable device possibilities, two simple questions were put to the users during the survey:

- 1. What could be the most amazing use of the wearables?**
- 2. Have you ever thought of a certain tool/object that you wished/wanted you could have possibly carried with you all the time? Or worn it?**

Among the options given for the first question, the most voted use was "learning new things" followed by the "access to instant information" and "doing things on the move". This insight became an important criteria for finding related use case scenarios. And though I expected users to vote for "augmented or virtual reality" as the most preferred one, the answer was much more deeper and thoughtful in un-

derstanding possibilities of wearable tech. Replies to the second question were even more interesting and crazy. Among the 100+ replies, that people typed in response to this question some of them are :

"I wish I could carry a device which captures as I draw in my mind and then save it",

"I want to carry a camera with all the lenses", " something which can capture my thoughts, ideas and colours and wildest of imagination, before it fades away from my limited accessible memory",

"Shoes that change according to the ground. Becomes like a trekking shoe ,floater or a rock climbing shoe or slippers when required.",

"Painting tools, measuring tape",

"Something that gives me real time data of health and nutrition",

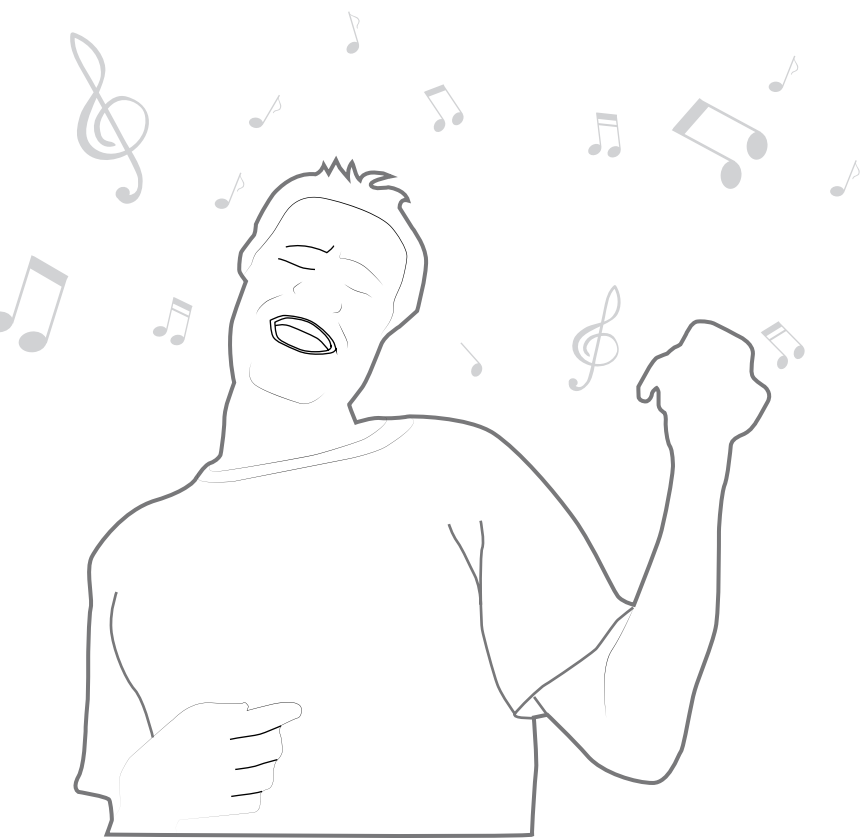
"i would like to wear a t shirt that changes its graphics to my own or selectable illustrations" "

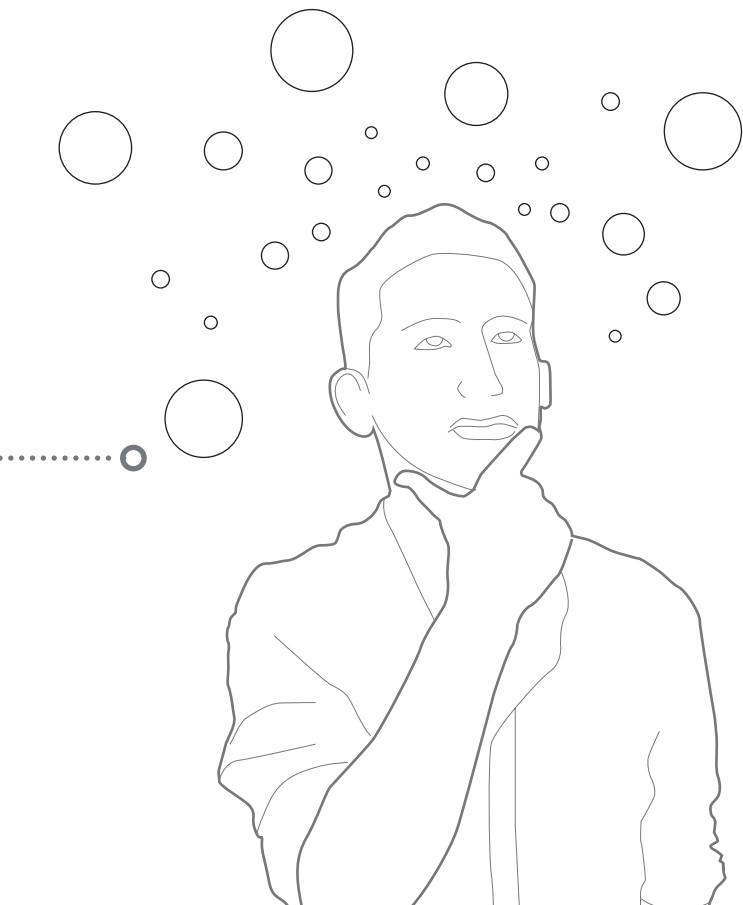
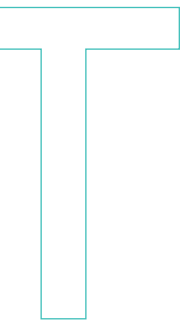
a screen that pops up anywhere so I can watch things or play games anywhere and it has to orient itself to my eyes, so that even when I lie down on bed I can enjoy watching" ,

"something that helps me in my creativity"

and the list goes on to ninety more responses.

EXPERIMENT





//A Journey to Memory Loss & Music

Based on these responses and research findings, I started looking for possible ideas about the product. A lot of possible scenarios were explored such as elders healthcare, museum experience, office productivity, learning in schools, intimacy, etc. all of these scenarios either were too futuristic, difficult to prototype in a limited time span or being already available. At the very end of the survey, while I was travelling to Google's Office at Bangalore, to try out Google Glass, I met a guy. Studying to be a lawyer like his father, his heart was in music, his area of interest being "instrumental piano compositions", which piqued my interest. I asked him whether I could listen to some of his creations, to which he said "I wish I could play for you here, it's not the same listening over a music player". And as the discussion went on about music, and I listened to his tracks which were beautiful by the way, one thing caught my attention. He said "just a few moments ago, I was humming a new tune while feeling the air passing through my hairs and body (he was standing at the train gate, which is highly dangerous and not recommended) and now I have lost it, it was so good but I cannot just remember it, I wish I was at my piano".

I almost forgot about this incident, until I saw one of the responses to the second question, the response was "a portable piano". This triggered the above conversation and it led to an array of possible ideas and case scenarios.

"Can I make music anywhere?"

"Can I never miss a tune that comes to my head?"

"Can I perform my music anywhere?"

And very soon, I started discussing the possibilities of these questions with people who play music, specially the keyboard, and they resonated with the problem of losing a lot of amazing tunes that they have in their head while travelling, in bed or somewhere they were unable to access their keyboard. One of them even used a piano app on his tablet device to compose music on the fly, but was unsatisfied by the whole experience. An idea of a device that one can wear on his/her hands, which allows him/her to create music on the fly, in air, anywhere and everywhere was born. Over the observations and discussions that followed with musicians, it was discovered that with proper haptic feedback to the fingers, the device can also help in learning piano, which personally I have been secretly wishing for years.

This idea had the necessary quotients for a simple but effective wearable product. It reduced the gap between the thought of a tune, and being able to create it. Secondly, this was an idea only possible with a wearable device which you can wear on your hands all the time, and lastly it allowed the possibility to learn something new and get better at it. Moreover it was not targeted at the masses but for a specific set of users, who found the perception of the device very useful as over the current options of either no such existing products or using means like touchscreen apps etc to achieve similar results.



Problem/Need

Every one resonated with the problem of losing a lot of amazing tunes that they have in their head while walking, travelling, being unable to access the instrument

Experiment Brief

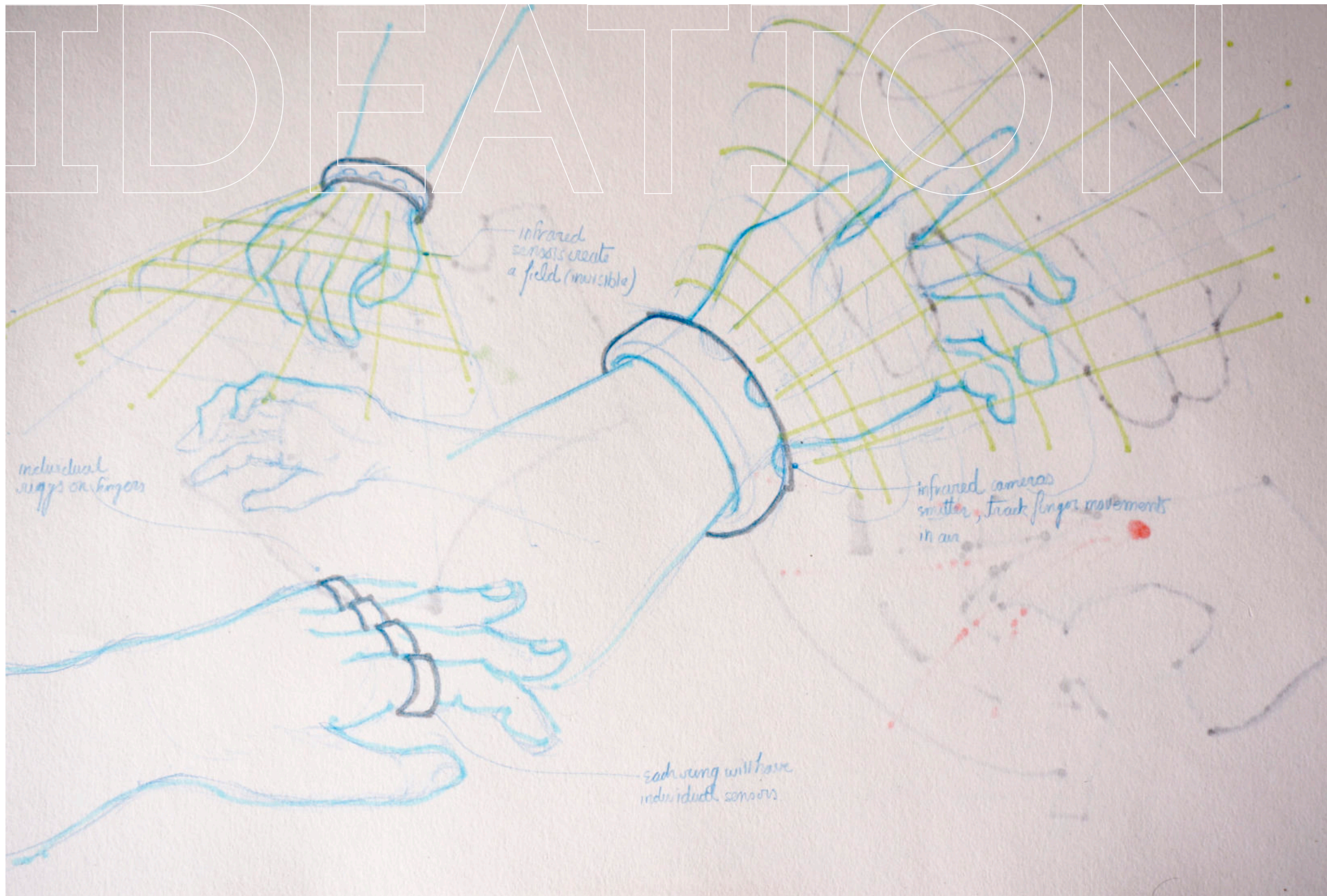
Envisioning a wearable device which allows to create music from the vicinity of the body, i.e. through hands, anywhere and anytime.

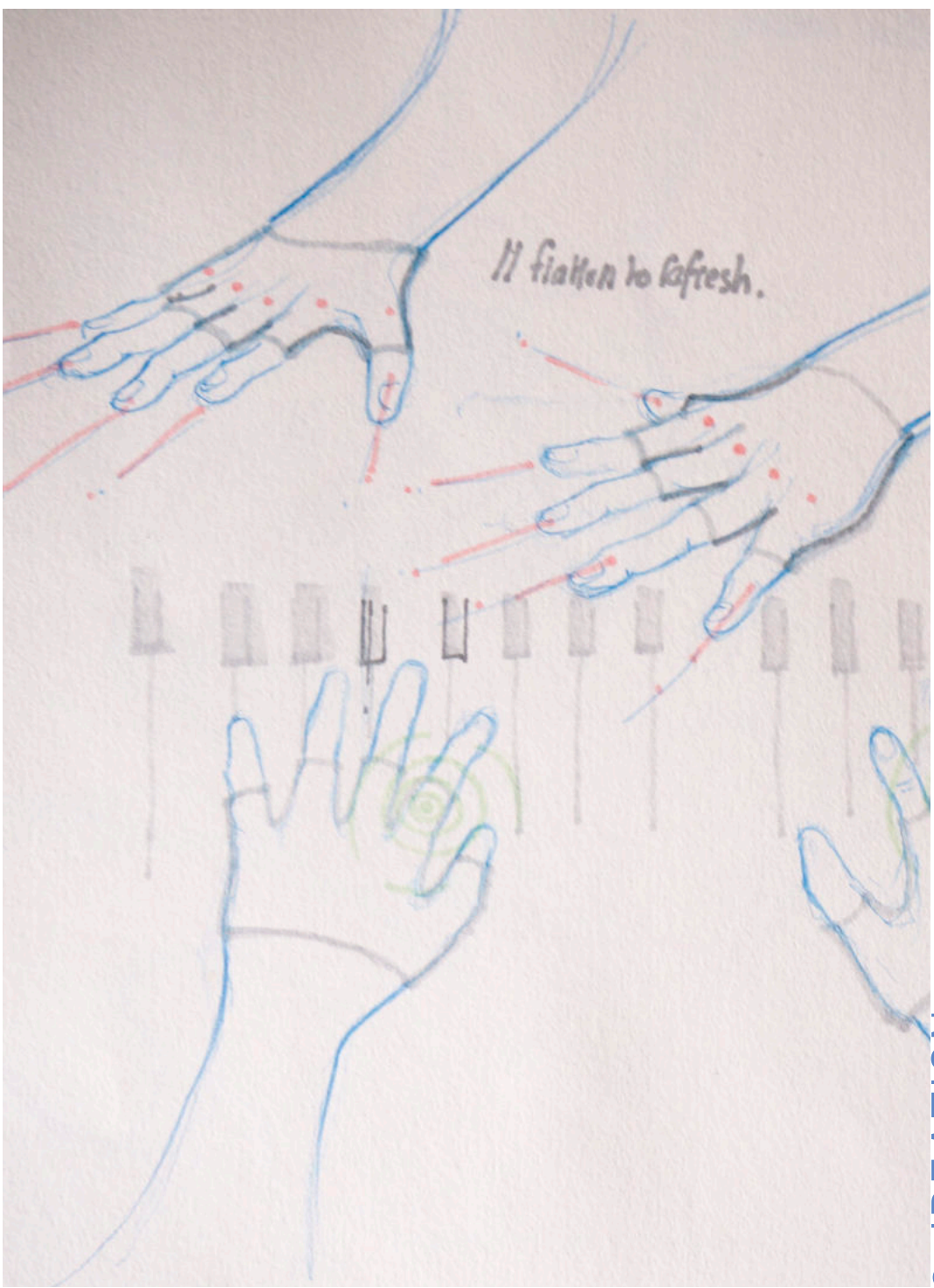
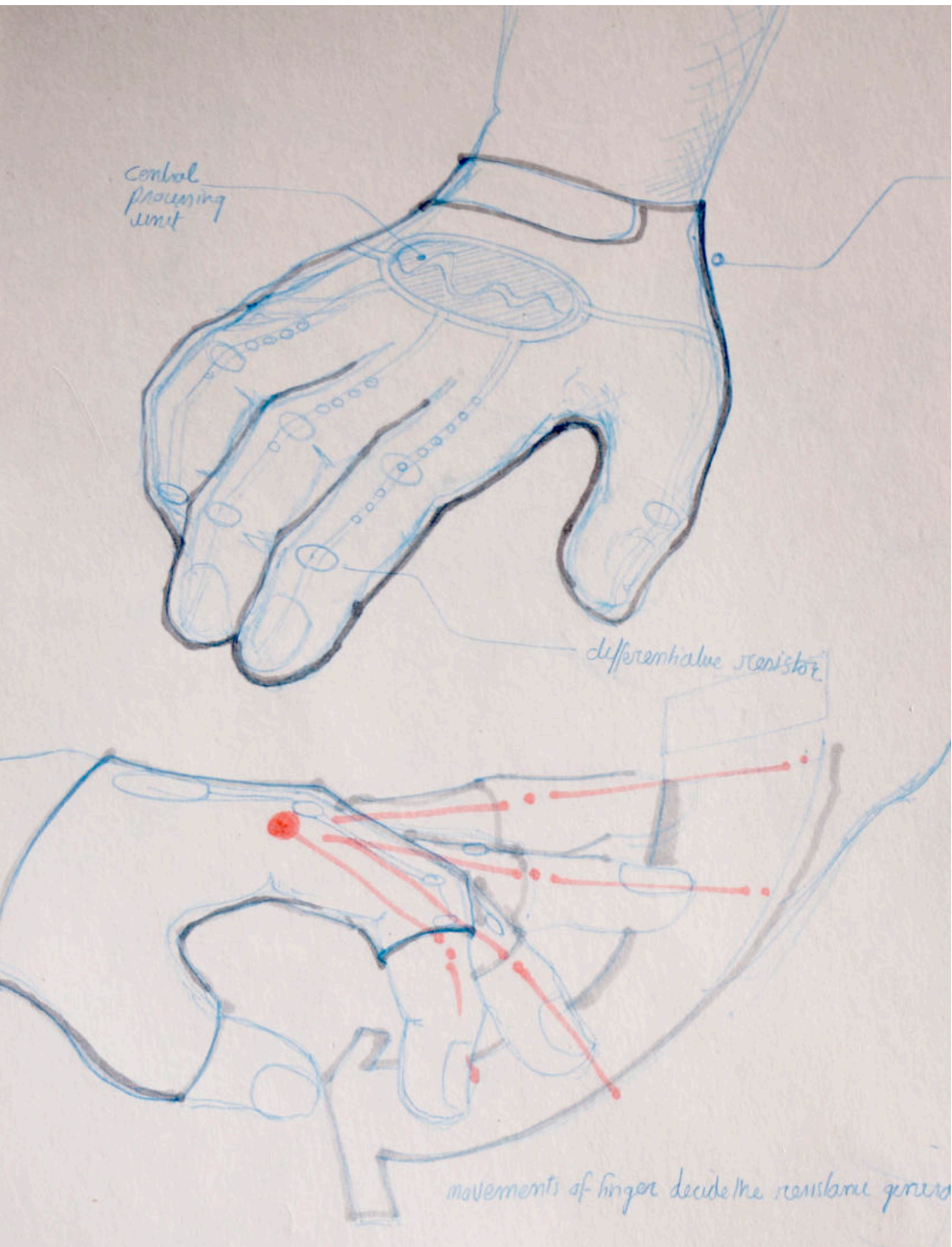


//What It Does ?

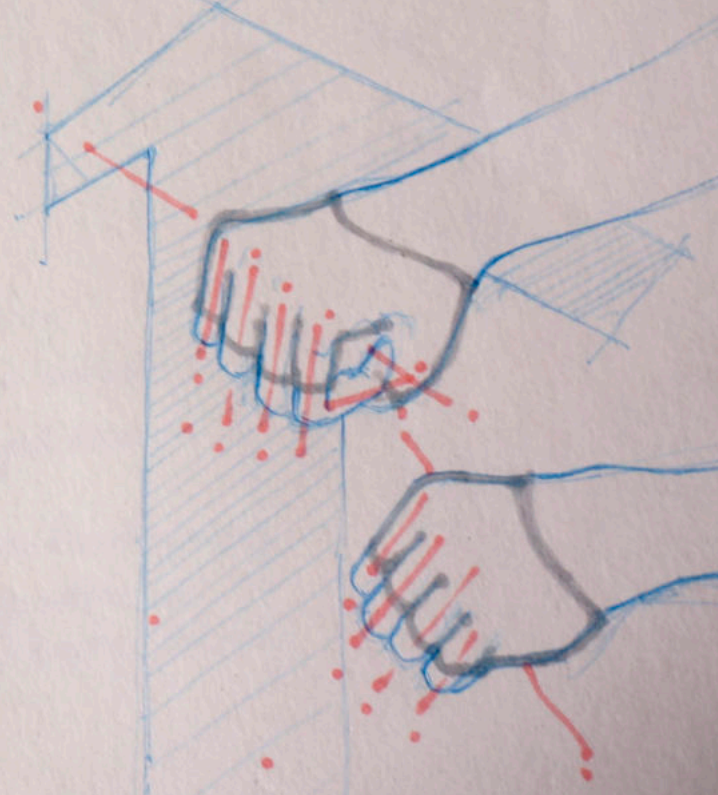
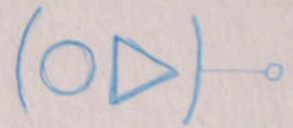
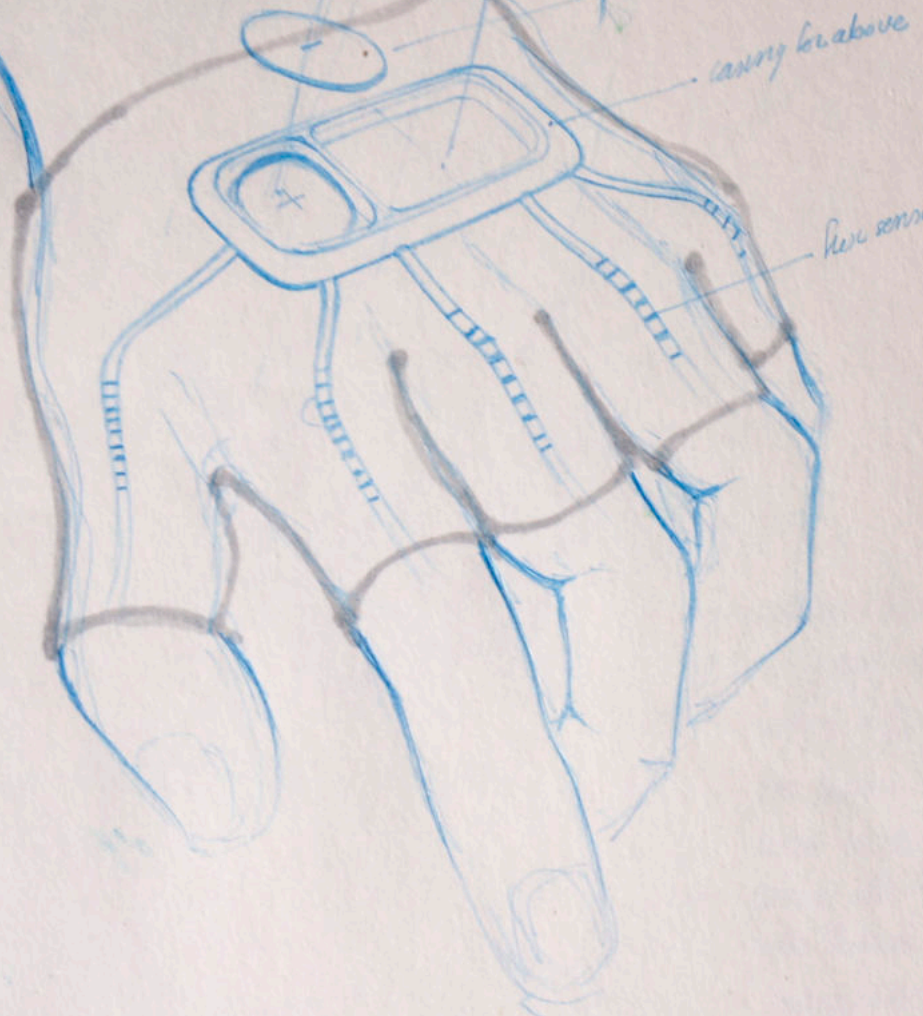
The Product is a glove which you wear on your hand. Its a simple device, which allows the musicians, to record and create, tunes anytime, from anywhere. This allows for a reduction in the gap between imagination of tune in head and making it in real world. The gloves can be used to make music in any position an situation. It allows music professionals to work on their tunes on the fly while travelling. Even when you are at a crowded place, no one will recognise that you are doing something with the glove. The bone conduction technology allows you to listen to the sound being created as well as keeping the ear free for real world navigation. Through a computer software/ smartphone application, users can choose what sound/ tones to assign to different fingers. A total of 10 tones are possible. During research and discussion with musicians, it was found that 8 tones are enough to create the essence of any music composition. A range of set of tones can be stored on the device and used to create compositions. It also helps in learning piano for the novice users, and for professionals to get better at particular tunes. When you play over the piano, the computer software creates a key code for fingers according to the time and tone they need to be pressed, and while practising it sends a vibratory feedback to the finger which has to push down the key to create a particular sound. This helps in building muscle memory of the user, thereby allowing him/her to get better at playing that tune, by practising and learning from the haptic feedback.

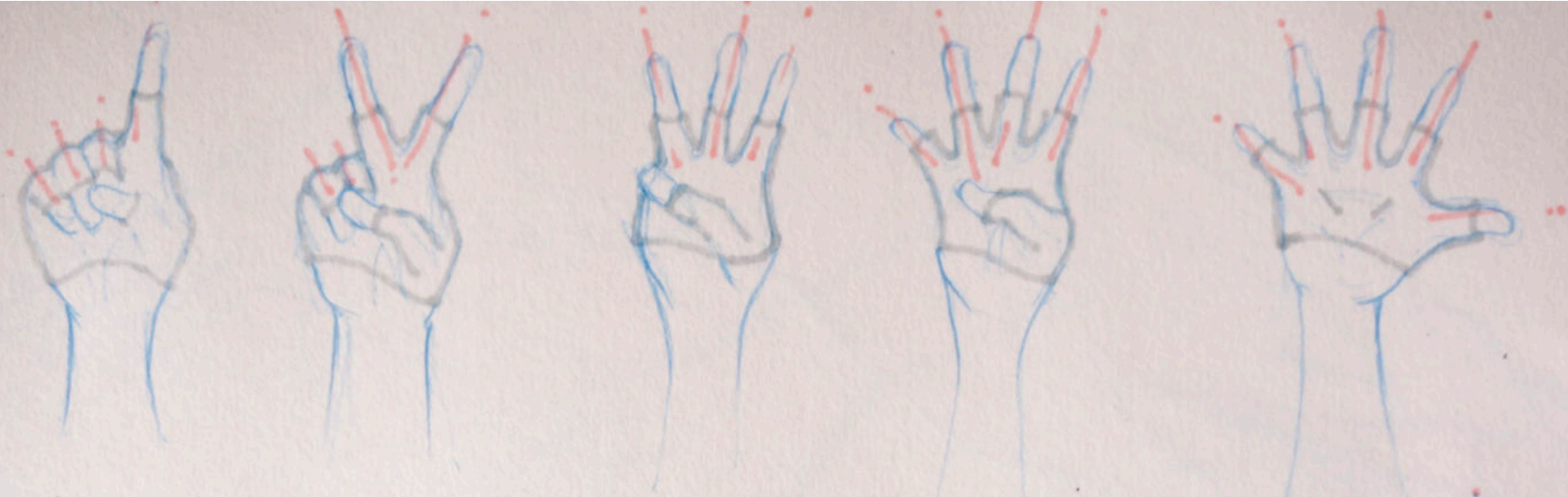
IDEATION



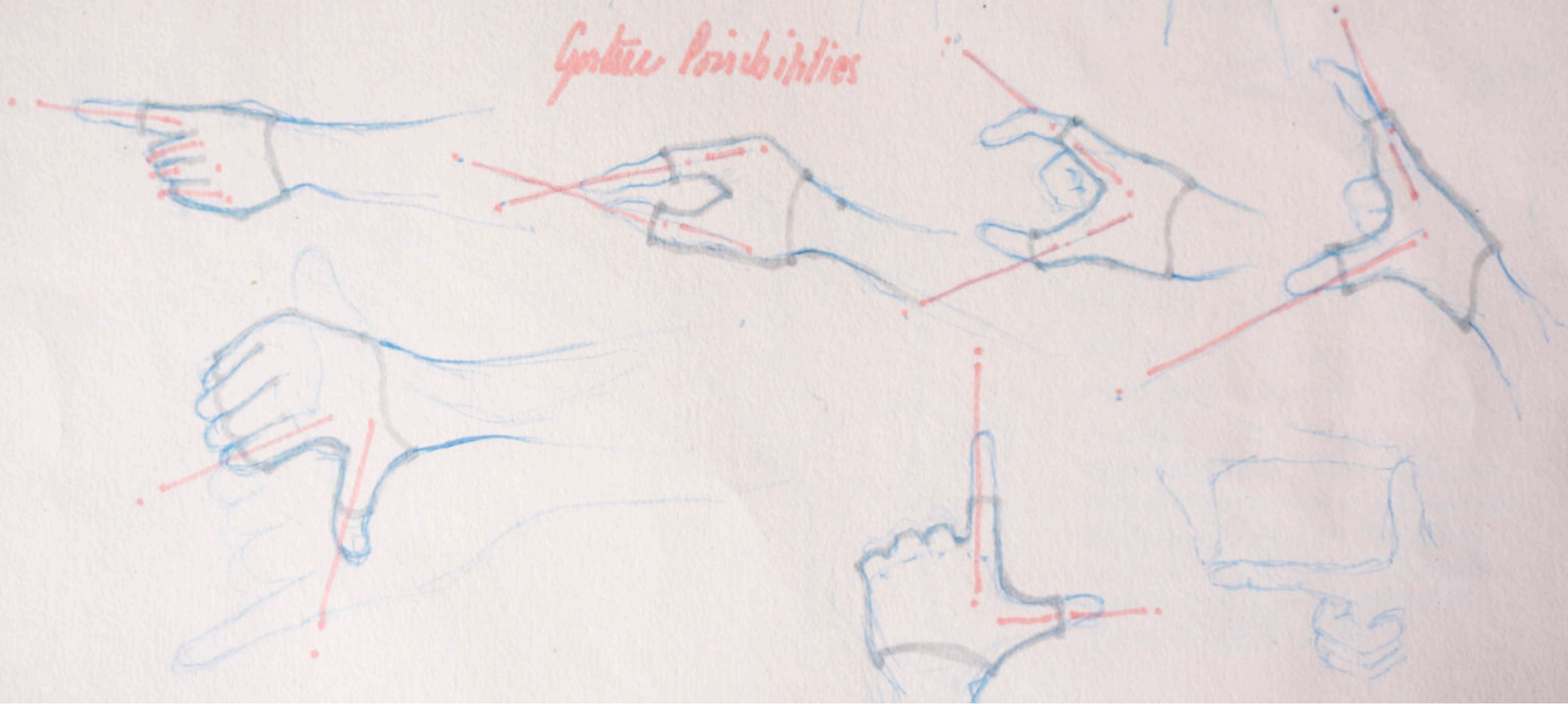


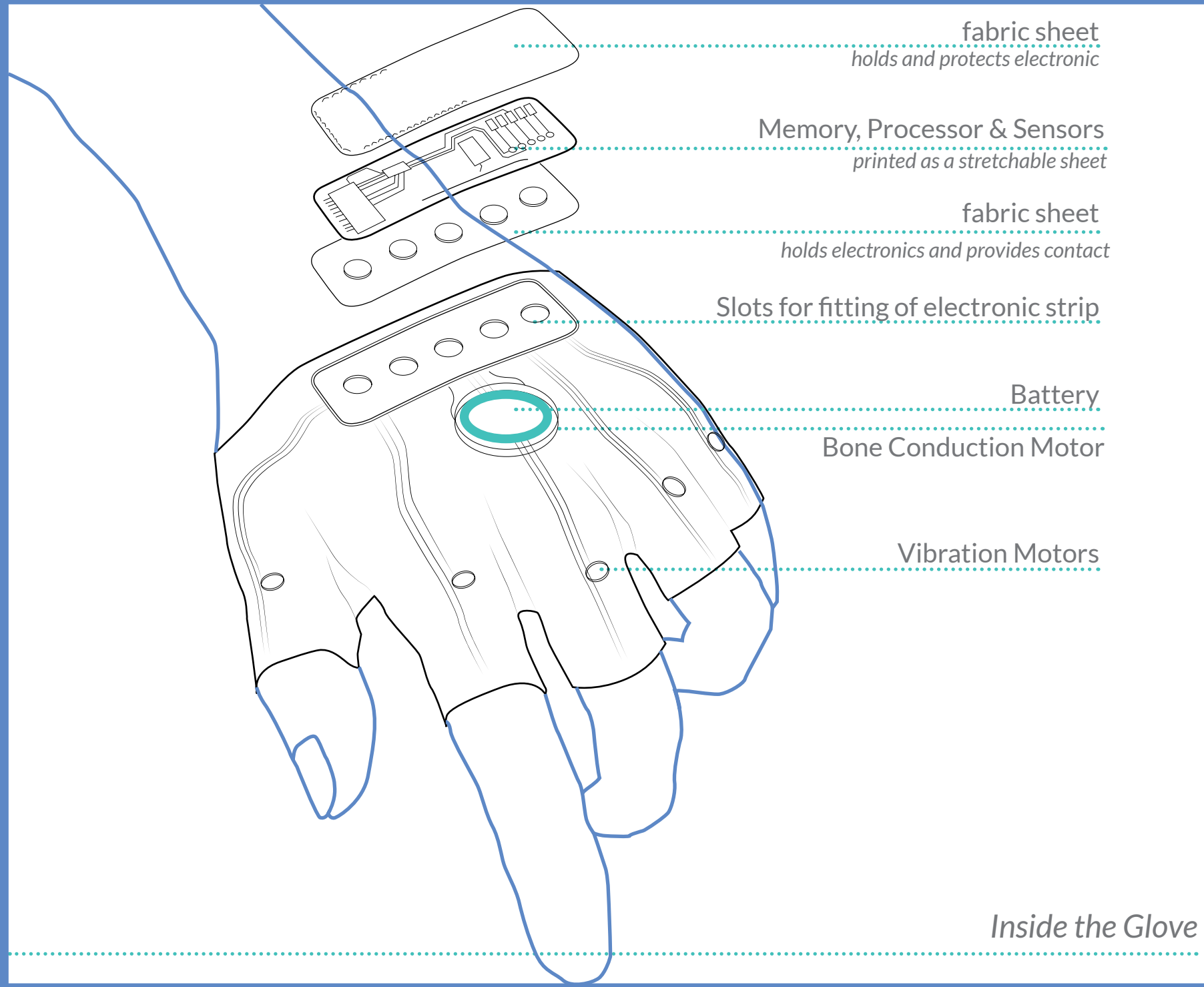
IDEATION





Gesture Possibilities





fabric sheet
holds and protects electronic

Memory, Processor & Sensors
printed as a stretchable sheet

fabric sheet
holds electronics and provides contact

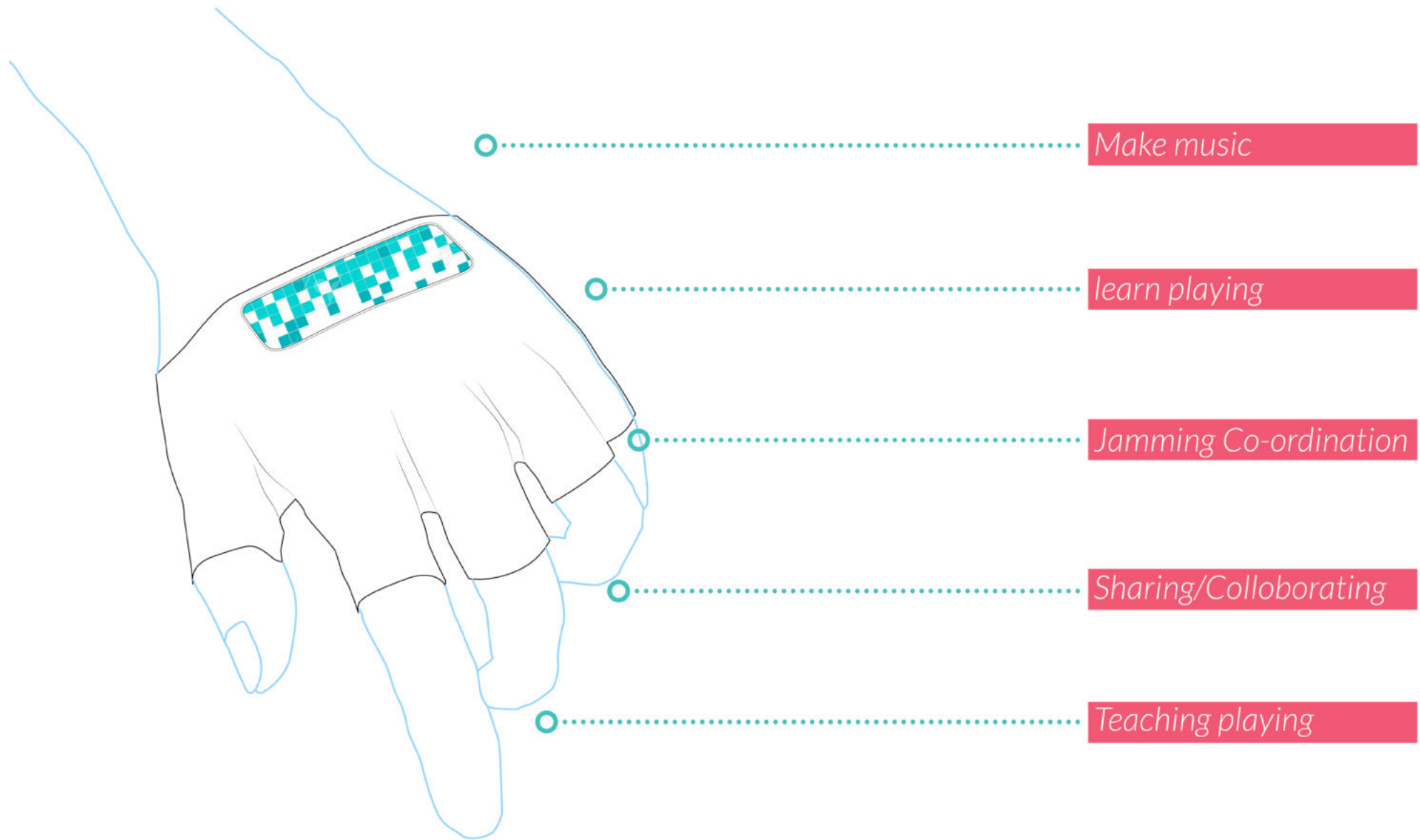
Slots for fitting of electronic strip

Battery
Bone Conduction Motor

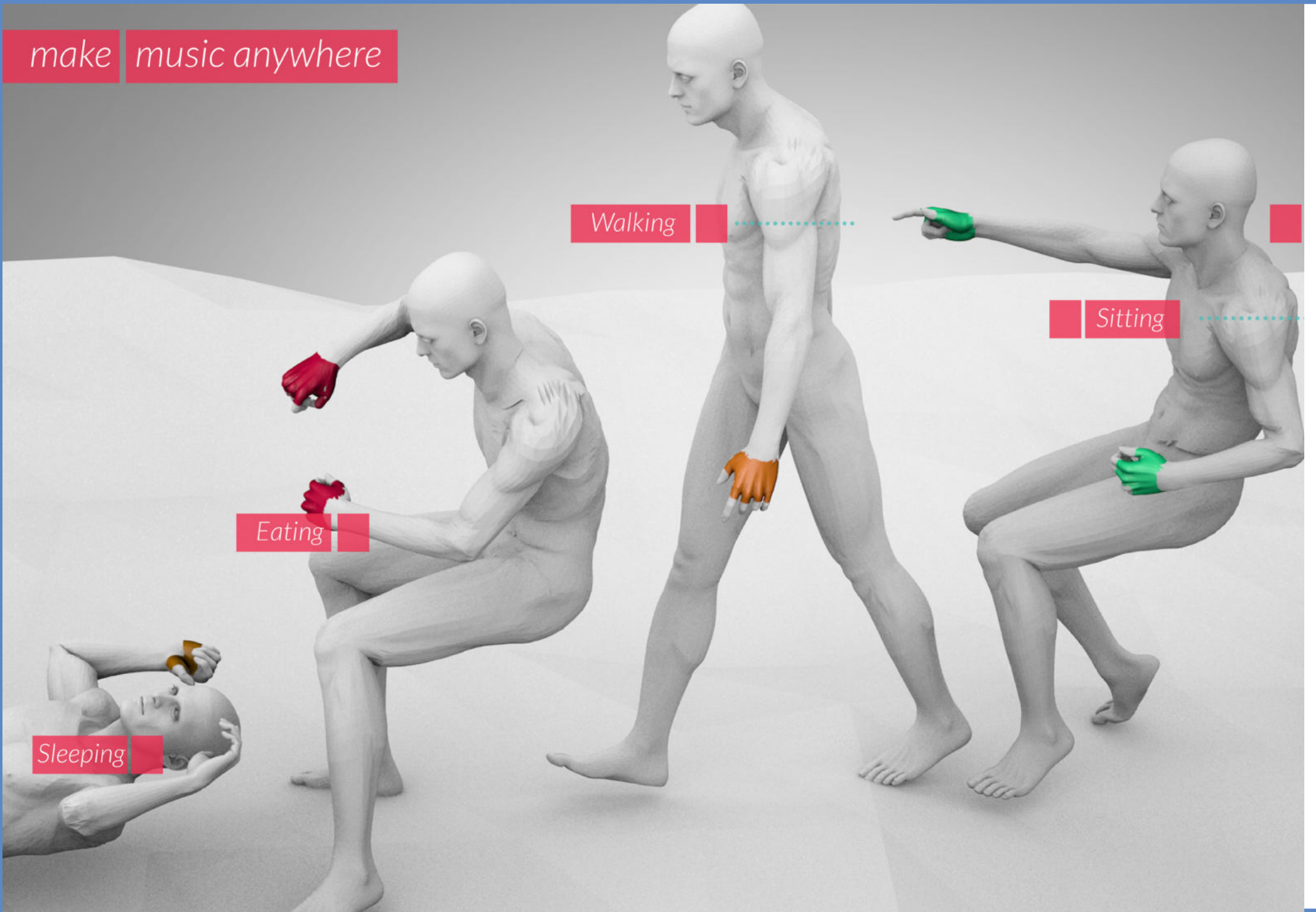
Vibration Motors

Inside the Glove

What does it do?



make music anywhere



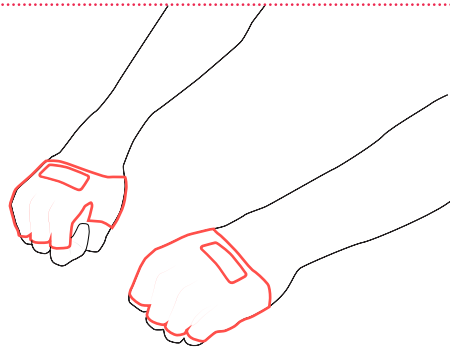
Walking


Sitting

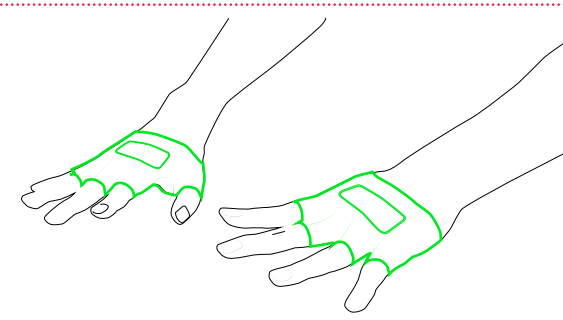
Eating


Sleeping

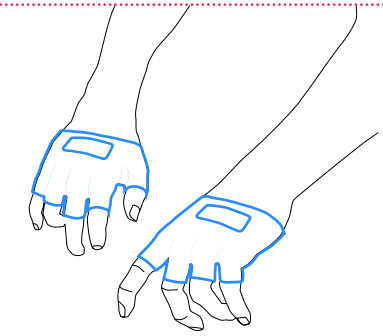
make music



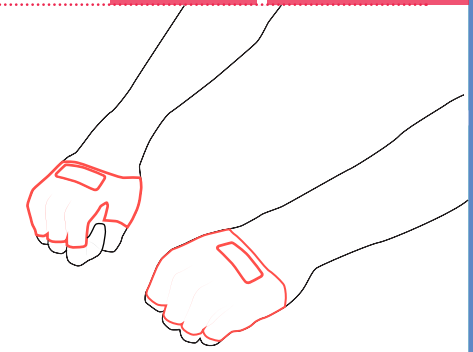
 Clench your hands to go to the base menu and then make the choice.




 Open all the fingers flat (5 fingers) which registers as making music command.



start playing the music and it will start recording



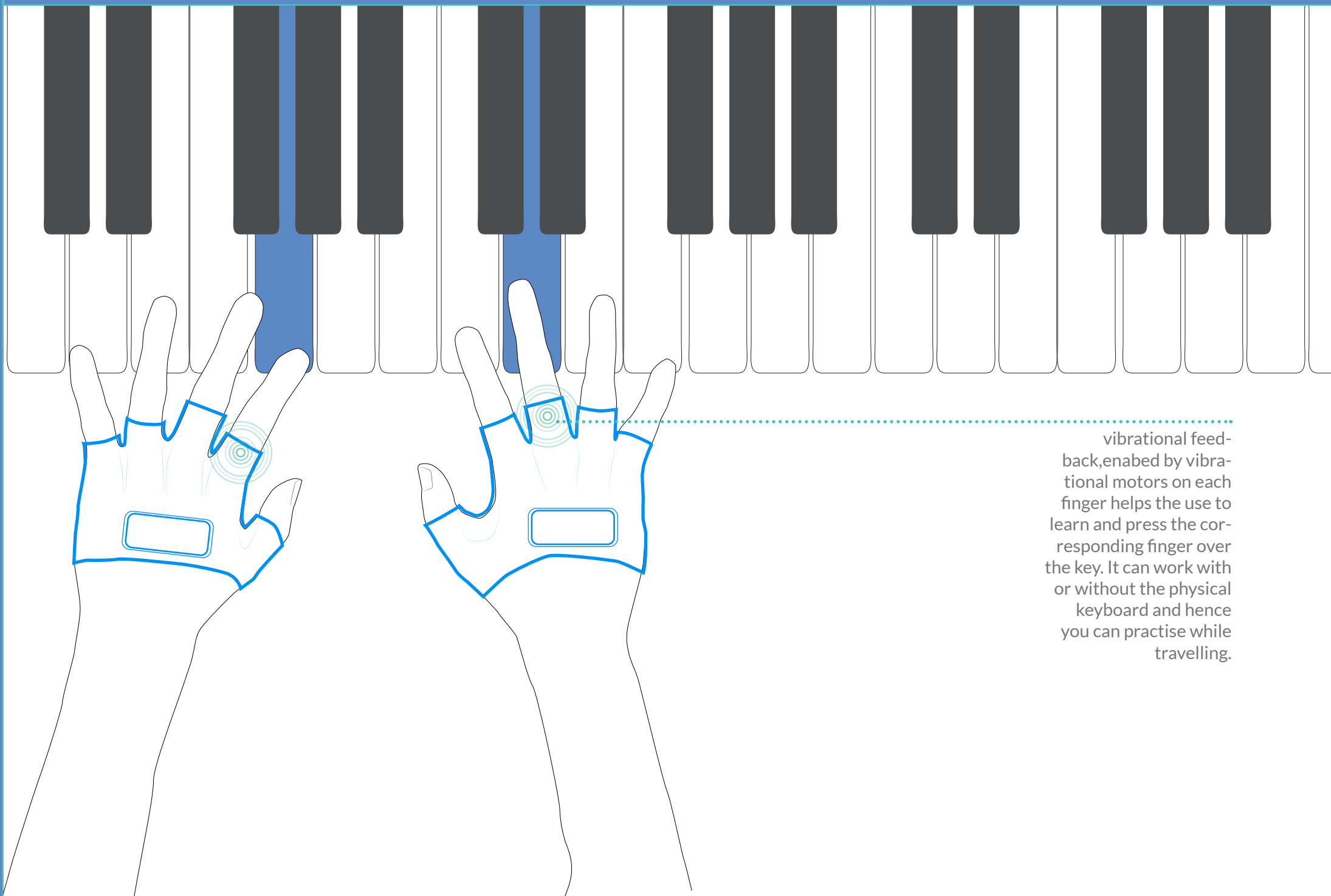
 Clench your hands again when you are done recording the tune and the device will save it automatically.



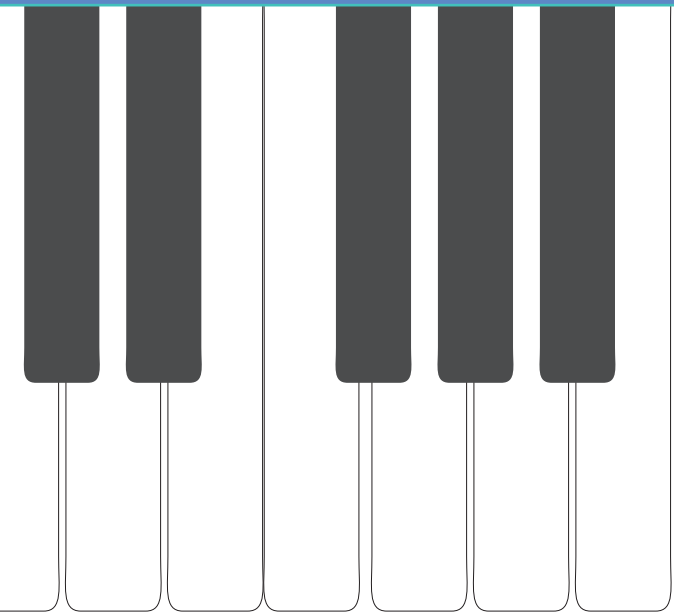
Next time you hold the phone with gloves on, the nfc will allow the devices to get n sync automatically and all the songs will be transferred to the phone.



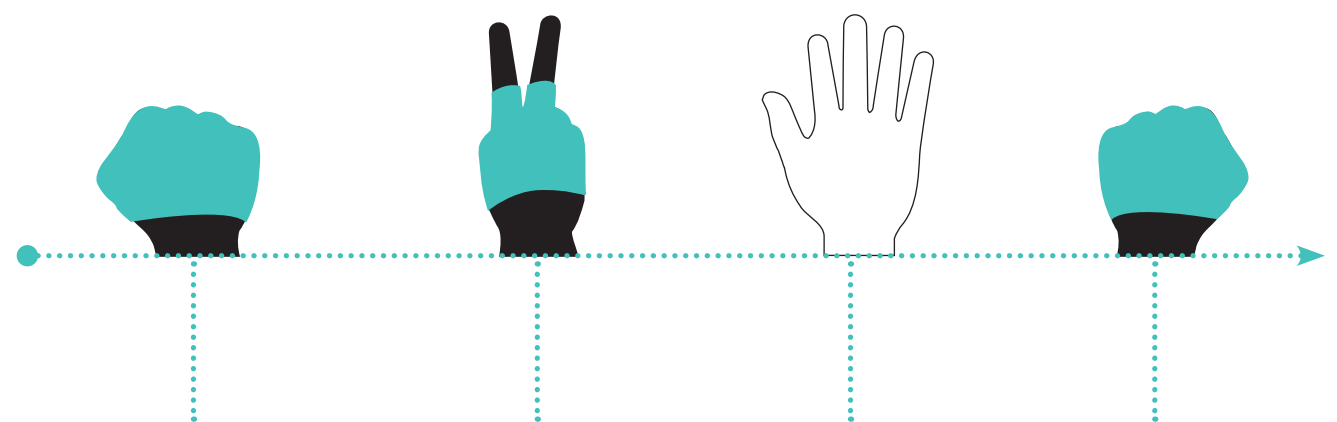
With a companion app you can browse through the compositions, play them, edit them, delete them etc.



vibrational feedback, enabled by vibrational motors on each finger helps the user to learn and press the corresponding finger over the key. It can work with or without the physical keyboard and hence you can practise while travelling.



Sync the song/tune to be learned and sync it with the device. All the midi notes are transformed into vibrational key and finger combinations.



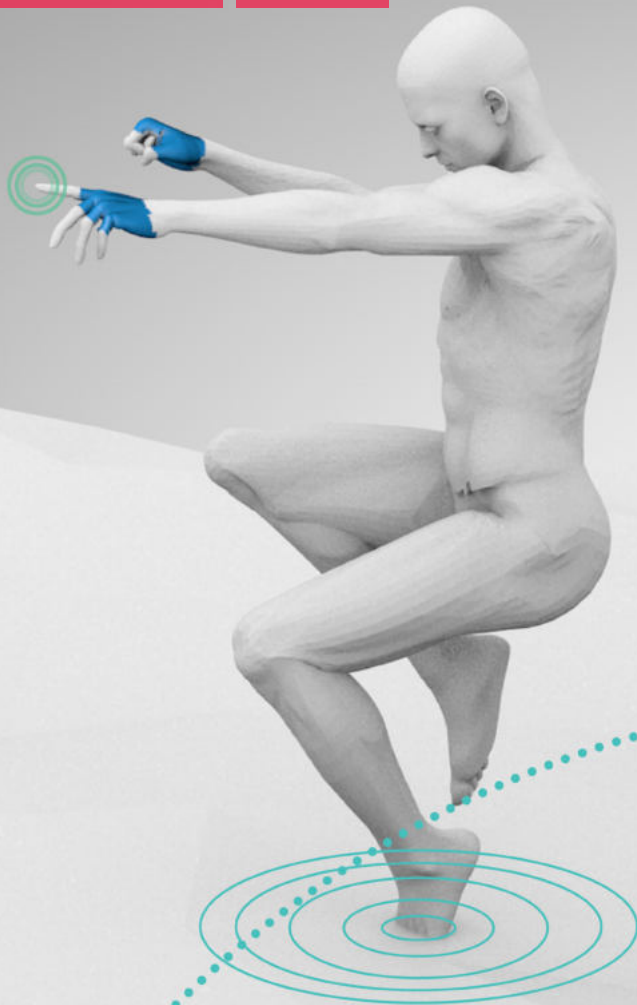
base menu/
device activation

selecting second
function i.e.
learning music

use this to re-
start practising
the tune afresh

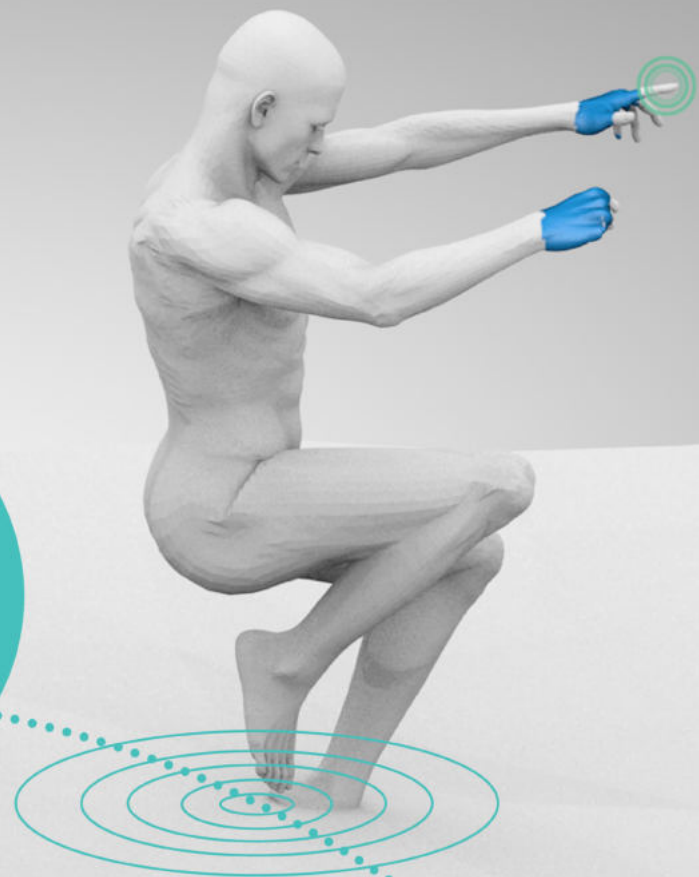
base menu/hold for
3 seconds to turn off
the device. (all vibra-
tions indicate that)

distance learn music



Through Borders

a teacher at one end plays the musical tone, the same tone is synced to the other device, and the learner feels the vibrations in the same fingers that the teacher is playing.





The connection between two users is achieved through smartphone.

the teacher end



base menu/
device activation



four fingers to start
live, real time shar-
ing mode

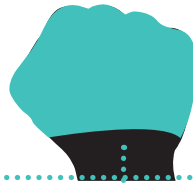


use this to restart
practising the tune
afresh



base menu/hold for
3 seconds to turn
off the device. (all
vibrators indicate
that)

the student end



base menu/
device activation

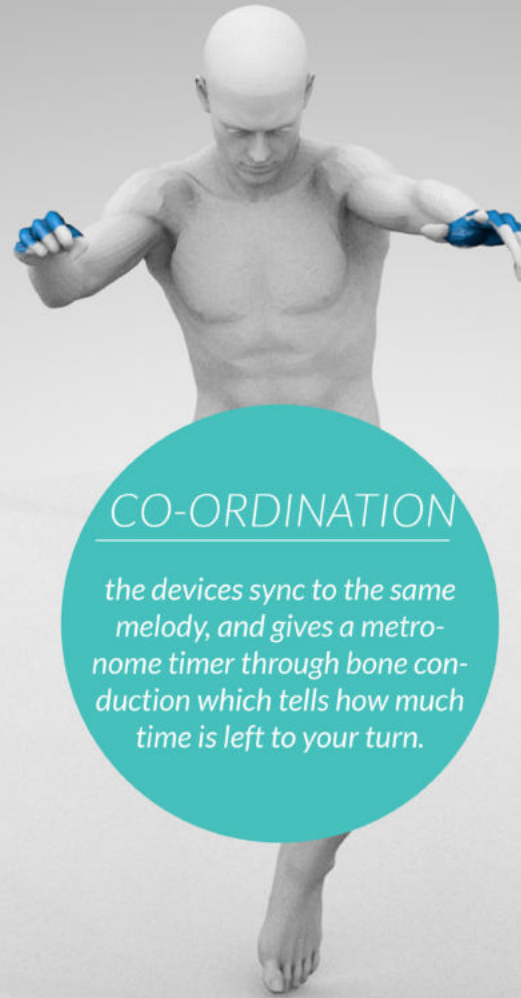


the student does
this gesture to send
a alert to the teach-
er that its ready

the teacher controls
the refreshing and
other things

jam

music

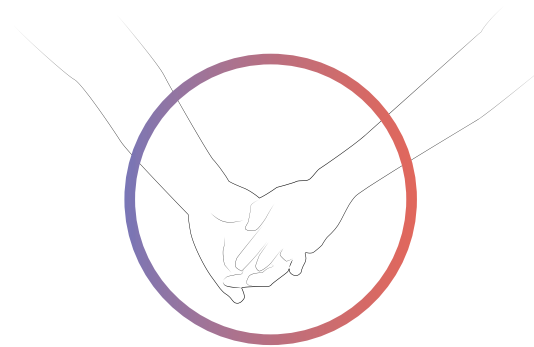


CO-ORDINATION

the devices sync to the same melody, and gives a metronome timer through bone conduction which tells how much time is left to your turn.



The song /composition to be jammed is synced with the glove, by one member. Each jammers' part is designated and tagged with proper timing information.



All the members who are going to jam, hold their hands, to sync the song and start jamming the session together.

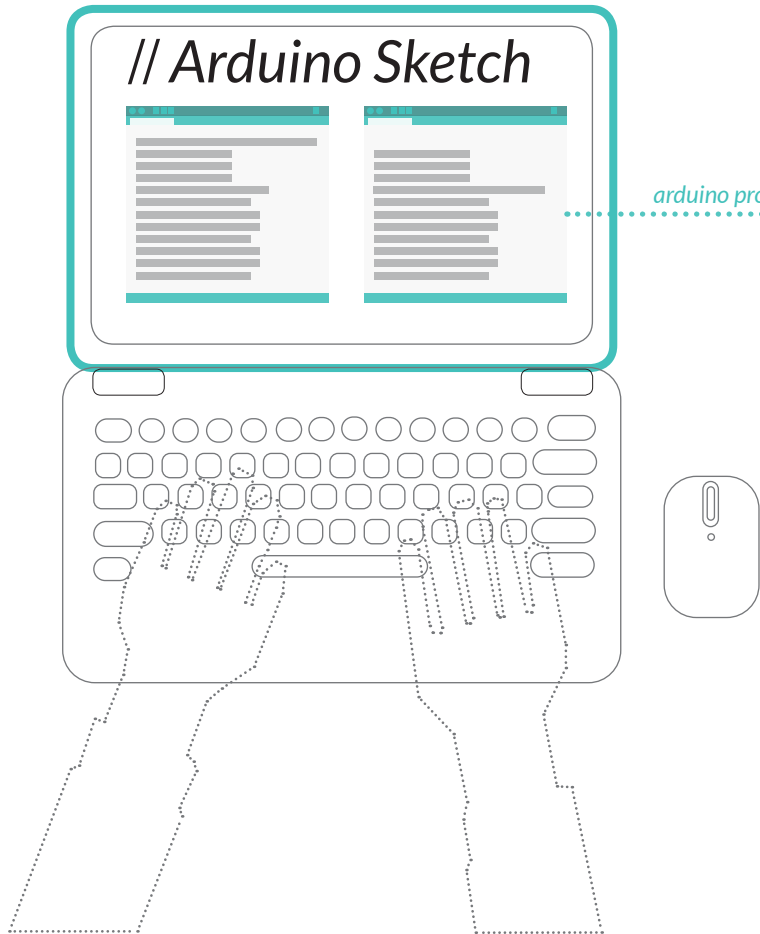


members do this gesture as a way to show everything is ready and good to go, when the last member has done this gesture, jamming starts.



base menu/ hold for 3 seconds to turn off the device. (all vibrators indicate that)

PROTOTYP

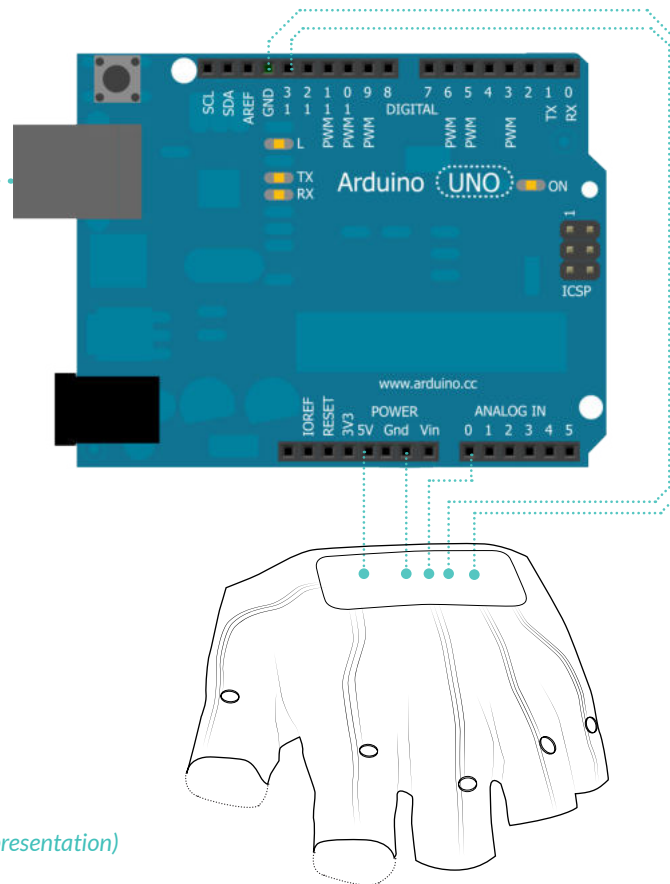


arduino programming interface

```
//project 3
#include "pitches.h"
int value, buzzer = 10, notes[] = {NOTE_C4, NOTE_D4, NOTE_E4, NOTE_F4, NOTE_G4};
void setup() {
  pinMode(buzzer, OUTPUT);
  Serial.begin(9600);
}
void loop() {
  for (int i = 0; i < 5; i++) {
    value = analogRead(i);
    for (int j = 0; j < 9; j++) {
      value = value + analogRead(i);
    }
    Serial.print(value / 10);
    Serial.print('\t');
    while (value / 10 < 30) {
      tone(buzzer, notes[i]);
      value = analogRead(i);
      for (int j = 0; j < 9; j++) {
        value = value + analogRead(i);
      }
    }
  }
  noTone(buzzer);
  Serial.println();
}
```

ING

Uploading to board



Schematic Sketch (only for visual presentation)

//Prototyping the Device

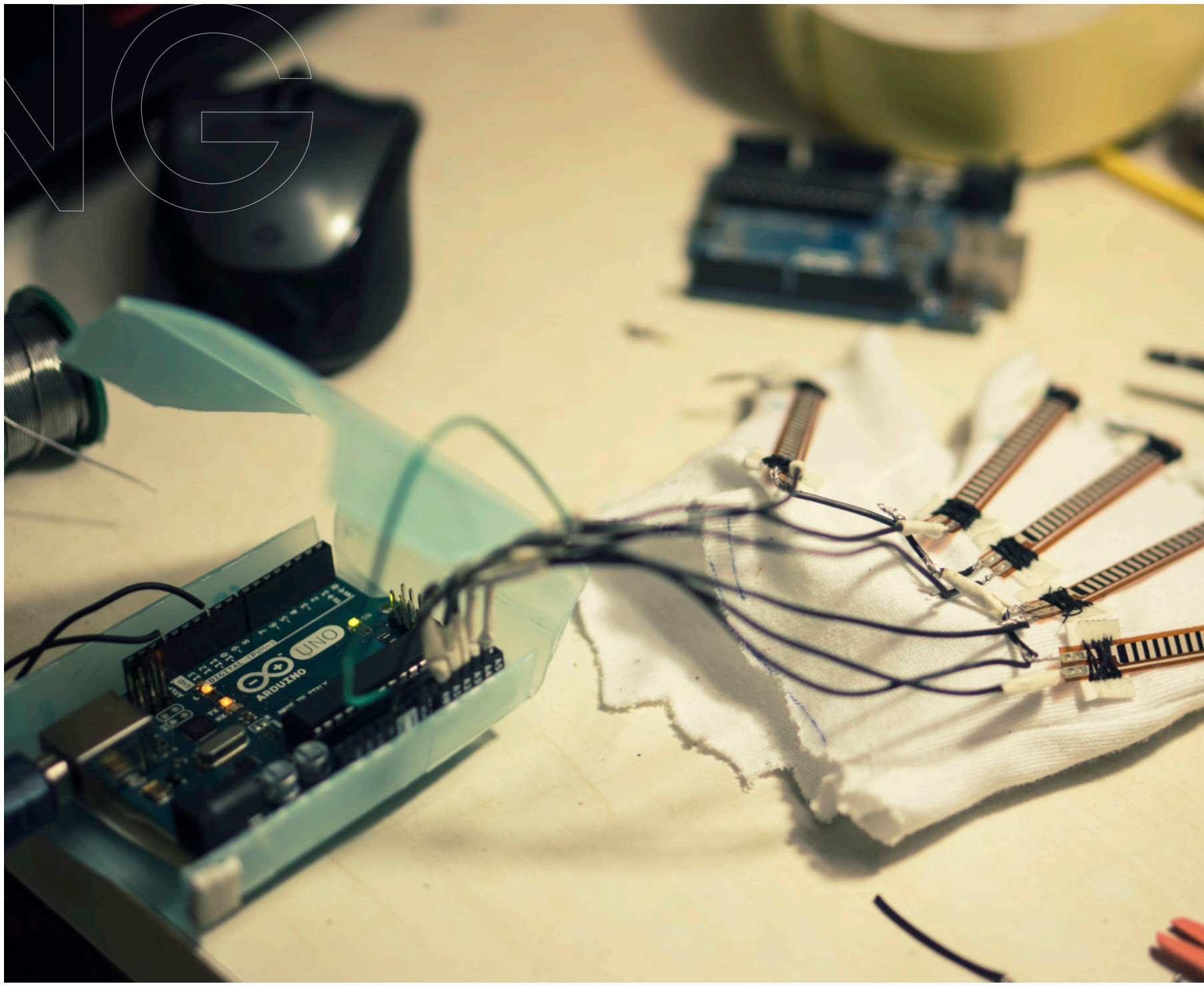
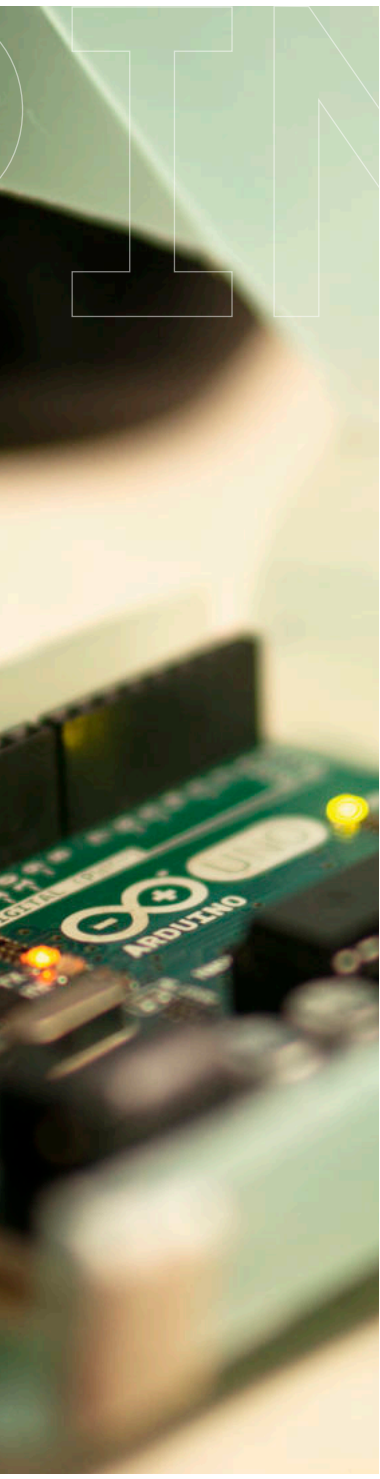
In order to try the idea with the users, and gauge the success of the experiment, prototyping a working device was important. The device was prototyped over a period of one month including several failures and revisions.

The Arduino Uno was chosen as a platform for running the device logic on account of its smooth learning curve, versatility and low price point.

The coding is done on the arduino program interface which is based on "processing". The code once free of bugs is uploaded to the arduino board connected to the computer and the board can then function wirelessly. The code was revised around 12 times before it started working. Version one of the code is shown here, alongside, which works with a single hand glove with five inputs from the fingers. As the fingers are bent, the code generates a preset tone value (second line of the code defines this) which is then sent to the buzzer/ speaker.

The next version of the device which includes sending a vibration feedback to the individual finger as per the defined tone value, requires further development of this code and is under process.

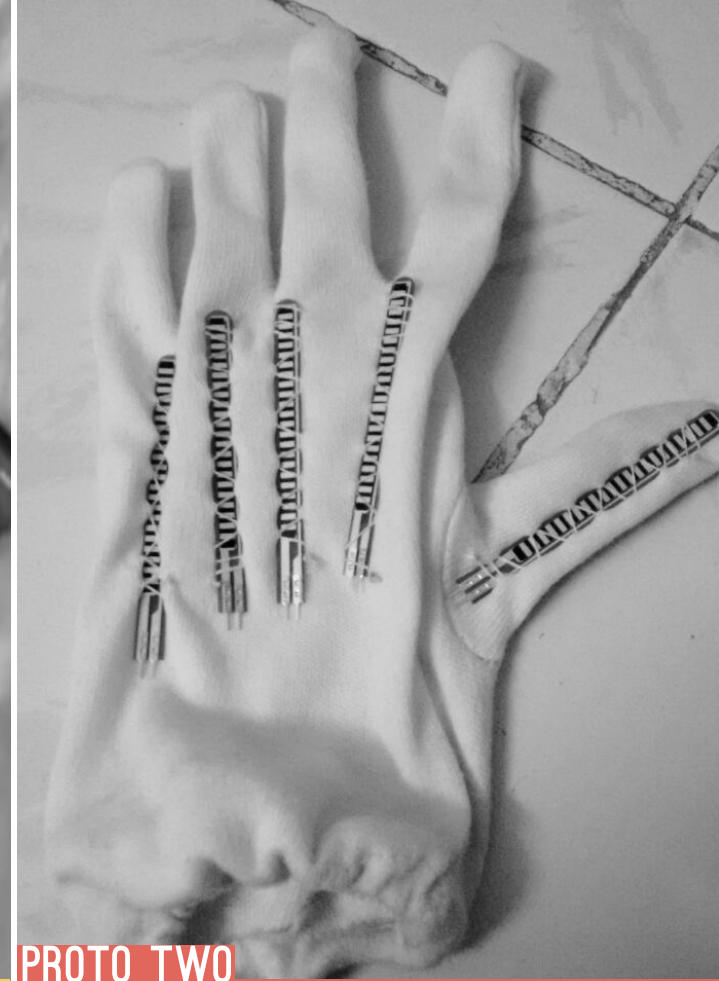




PROTOTYP

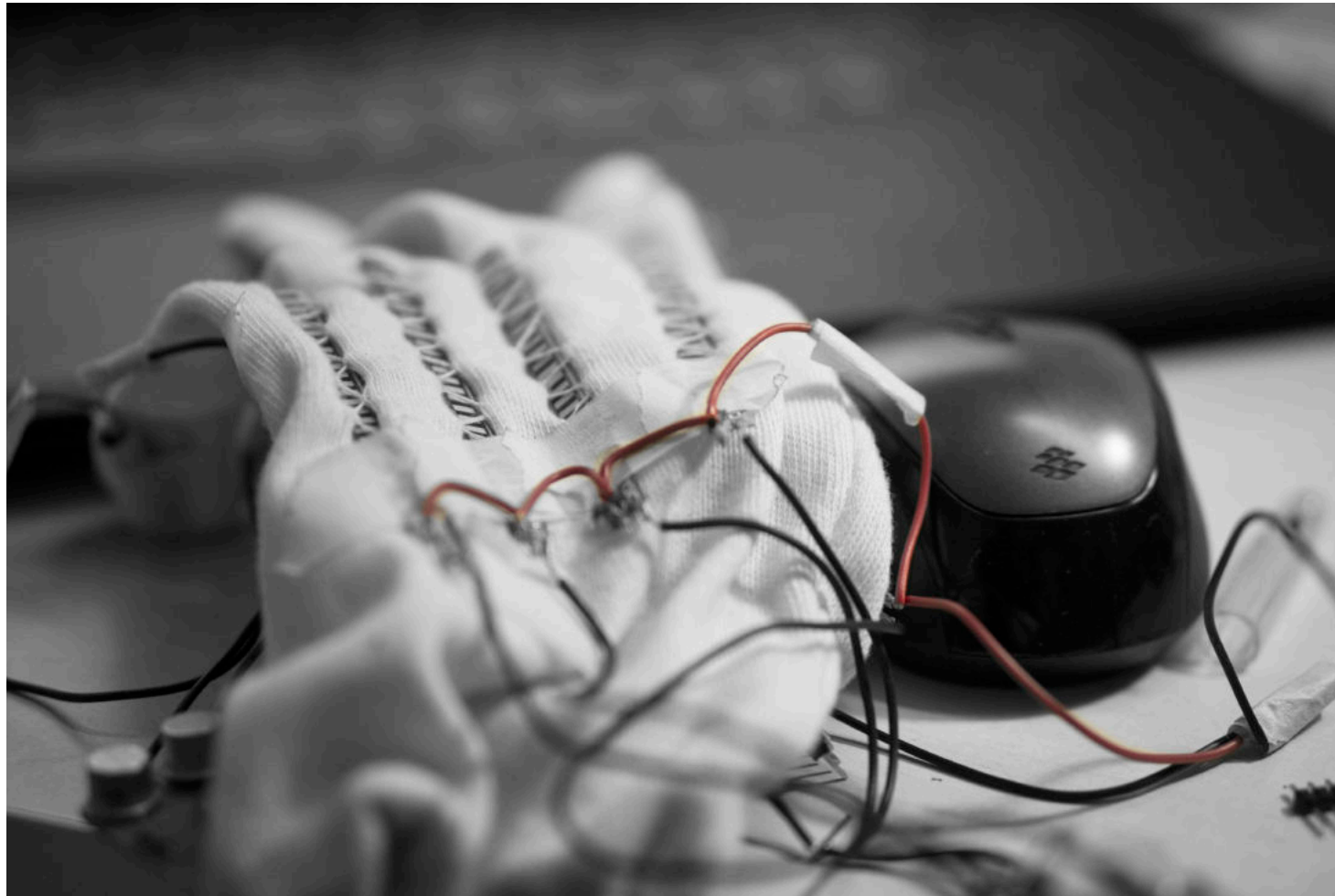


PROTO ONE



PROTO TWO

E



PROTOTYPE ONE

The first prototype was constructed out of copper plates, where a mechanical joint between them allowed for varying resistance values as one folds the fingers. Connecting the plates with the arduino and playing with it around a week with the whole setup allowed for successful note reproduction.

//image source: author

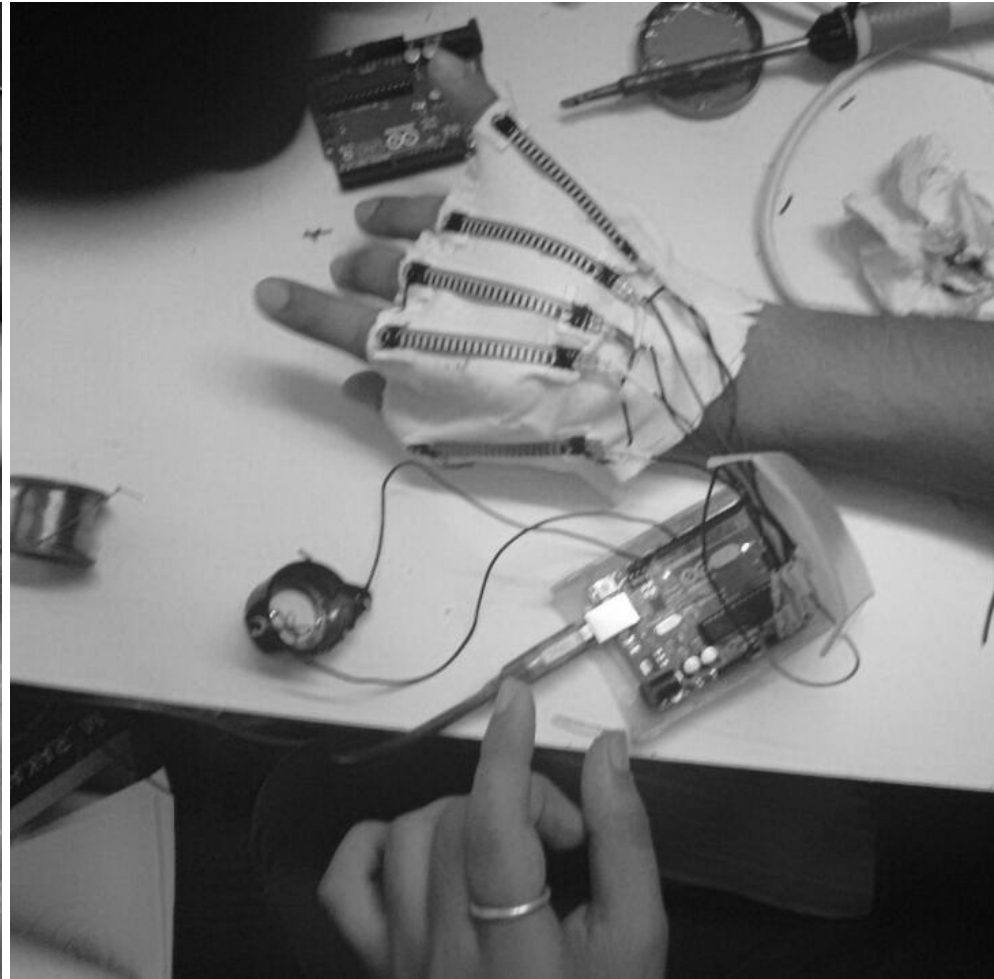
PROTOTYPE TWO

During the development of the first prototype, I learned about the existence of flex sensors, which are sensors which produce varying resistance values as they are flexed or bent. These sensors were acquired and the copper chips were replaced. This allowed for a neater and more reliable product.

//image source: author

//image source: author

PROTOTYP



PROTO THREE



PROTO THREE

The third prototype was about cleaning up the circuitry, removing all un-necessary components and wires and make the whole arrangement easily wearable and reliable for testing by users. The arduino board was fixed onto a strap which was worn on the wrist making the whole arrangement considerable wearable and self sustained.

This was the prototype that was demonstrated and tested bny the users. Another prototype including the vibrator motors to enable learning function was under development during the authoring of this report.

//all image source : author

SURVEY

// Music Makers Involved



Ram Prasad Sedouram

// Semi-Professional Musician
// Prefers Keyboard

[//soundcloud.com/ramprasad-sedouram](https://soundcloud.com/ramprasad-sedouram)



Zash Ansari

// Hobbyist Guitarist
// Keyboard player



Joshua Mathew

// Multi Instrument hobbyist
// Prefers Guitar

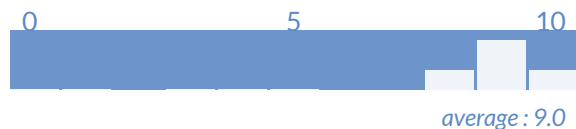


Akshay Murthy

// Professional Musician
// Prefers Keyboard

[//soundcloud.com/amtracks](https://soundcloud.com/amtracks)

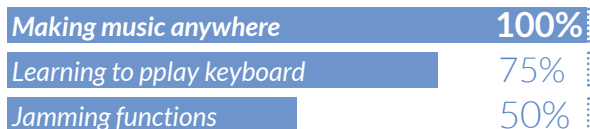
Q1 How much relatively useful will this device be, in comparison to whatever you are using now? (scale 1 to 10)



Q2 What of the following functions you like the most?



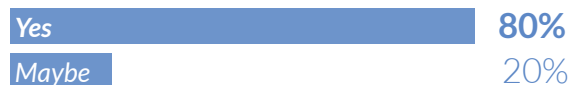
Q3 Do you think wearing this device will make you uncomfortable in any way?



Q5 On a scale of 1 to 10 rate the ease of use of the device:



Q6 Do you think this will be a valauable addition to your music kit ?



Q7 Would you like to buy it?



Q8 If yes, how much price would you like to pay for it ?



//Testing the idea with users

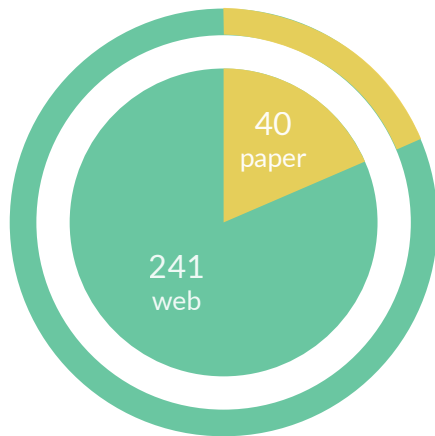
The whole experiment was done under constant discussions with people who create music, both professional and casual. A lot of ideas were refined and improvised resulting from these discussions. When the prototype was ready, it was demonstrated live and through video to ten of the users to guage their response. A survey was done from these users to understand the succes of the experimental wear-able device.

Overall the users were very enthusiastic about the product and it showed in the relative usefulness score of 9/10 of the product. They were also interested in getting involved with the development of the project further, and even investing their time and money with it. The next direction for this experiment tries to accomodate fashion style and uniqueness factor by collaborating with fashion designers.

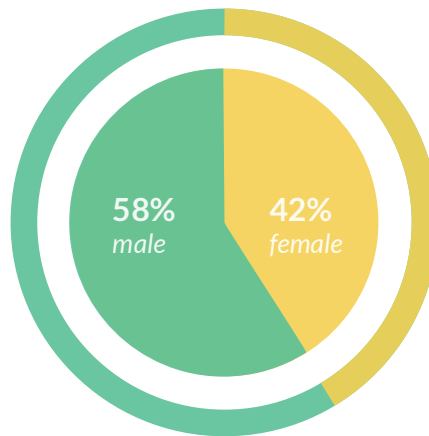
This experiment and its success approved a few of the inference points that resulted from the prior research. Wear-ables can aim towards niche and specific areas of usage and focused user set rather than trying to appeal to everyone. Using new technology like bone conducting in a novel way and devising new and simpleinteraction methods will cause the devices to be accepted well by the targeted users.

APPENDIX

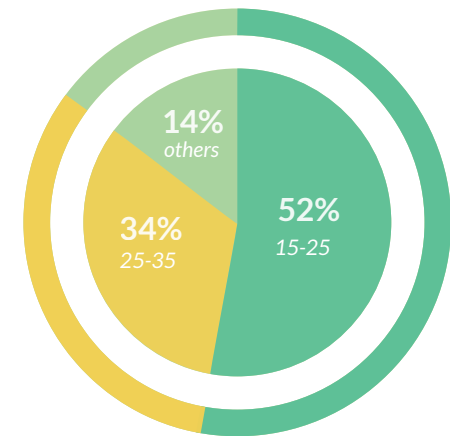
// Demographics



// user responses



// gender demograph



// age demograph

//USER SURVEY//

To understand the people, their mental state while using technology and choosing things they put over their bodies, this survey was conducted. Divided into two sets of questions namely “fashion and wearability” and “technology and behaviour”, they consisted of a total of 45 questions (including demographic information)

Over the duration of the project, a total of 281 responses were collected. The initial survey was done in person with almost 40 users. Later the survey was put online to get more responses in the limited time of the project. The surveys are still live and continue to grow in user responses. here are the links:

1. Wearables and Fashion

<https://rahul35.typeform.com/to/J2S4I7>

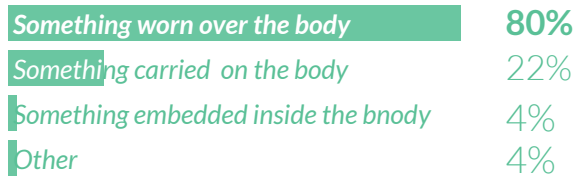
2. Technology and Behaviour

<https://rahul35.typeform.com/to/AUqmFf>

The broad user group helped in attaining useful insights which were more reliable and hence used to derive various inferences during the research.

APPENDIX

Q1 What do you think Wearable means?



Q2 How Important is something you wear, for your identity? (scale 1 to 10)

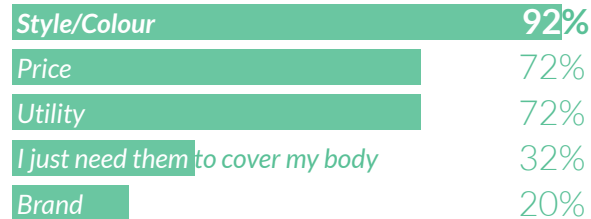


Q3 When you buy something, how much importance do you give to how it would look on you?

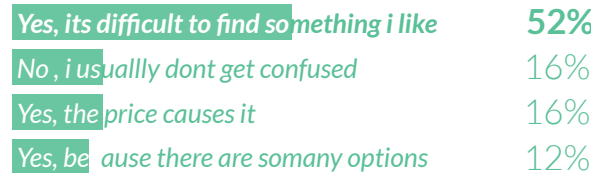


Maximum people have given 7 out of 10 as the importance factor. While the over all average comes to 7.8

Q4 What amongst these, matters to you in choosing things you wear?



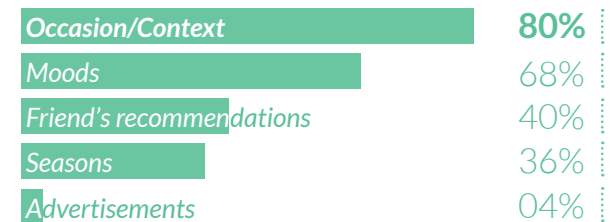
Q5 Do you find yourself confused, when buying things to wear?



Q6 How important is it for you to try out the wearable (clothing/accessory) on yourself before buying it?



Q7 What effects/influences your choice of things you buy to wear?



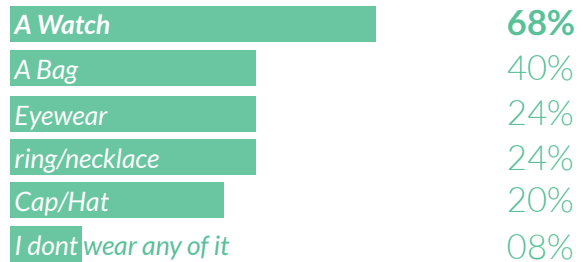
Q8 Would you buy a wearable piece(clothing/accessory) if one of your friend has the same one?



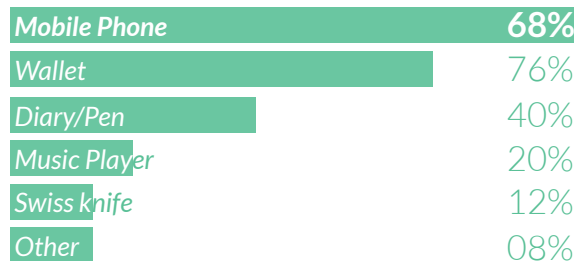
Q9 Do you wear/prefer to wear something that is not generally worn in your environment/culture? (to create a unique identity of yourself)



Q10 Do you wear some/any of these accessories on a daily basis?



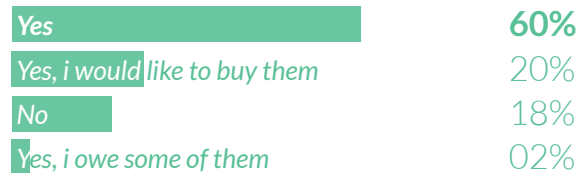
Q11 What are the objects/tools/ you carry with yourself, in your pockets/close to body?



Q12 Will you be interested in a device which does more than just being a passive accessory?



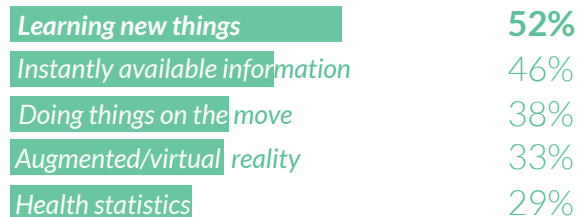
Q13 Have you heard about wearable devices like Fitbit fitness tracker, Apple Watch ,Oculus Rift or Google Glass?



Q14 What would you like to buy among these devices?



Q15 What do you think can be the most amazing use of a computer worn on your body?



//Question SET ONE//

Fashion & Wearables

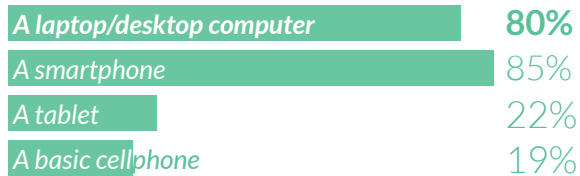
Set one of the survey included fifteen questions (featured with results alongside) which try to understand the perspective of the users towards fashion, importance of things worn on body and their expectations out of wearable computers.

The results helped in comparing with the wearable products and whether they are able to cater to these needs and psyche of the users. A lot of wearable devices failed on many fronts such as not being available in multiple styles and colours, which for most of the users is the leading criteria to choose things they put onto their bodies.

This also helped in understanding what users expect from the next generation of wearable devices. they want to be able to learn new things and access the information even more faster.

APPENDIX

Q1 Which of these devices you own?



Q2 Which of these devices, you spend the maximum time with?



Q3 How much you consider the visual appeal of the computing device (the fashionable aspect of it) before buying it?



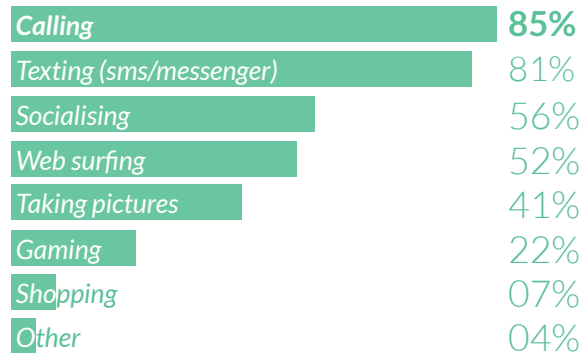
Q4 Do you think your mobile phone has/can replace your computer?



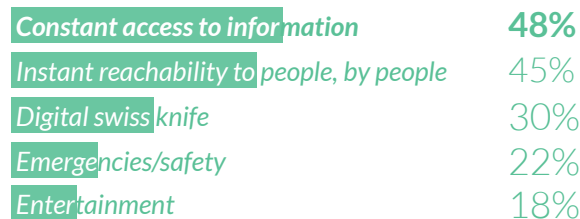
Q5 How much using a smartphone is easier than using a laptop/desktop computer?



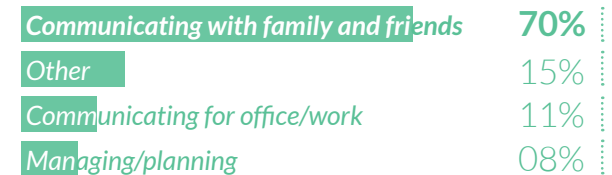
Q6 What do you use your phone mostly for?



Q7 What is the best thing about smartphones?



Q8 How according to you, your cellphone has made a significant contribution to life?



Q9 Do you use your smartphone as an encyclopedia/ indispensable source of information?



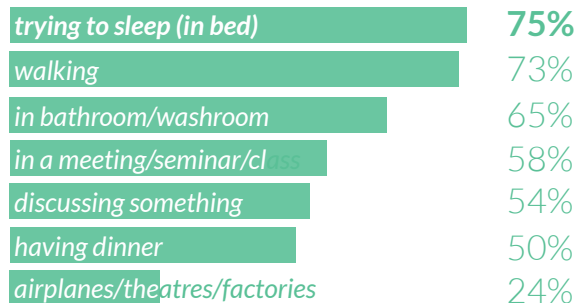
Q10 Do you think it sort of enhances/augments your memory?



Q11 How much do you think your cellphone has improved your ability to learn new things?



Q12 Have you done any of the following?
engaged on your smartphone while:



Q13 Do you think your cellphone has become an important part of your life, and you wont be able to live without it?



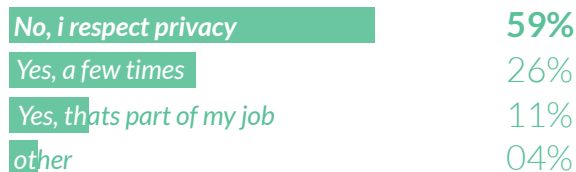
Q14 How many times you think, you check you mobile phone in an hour?



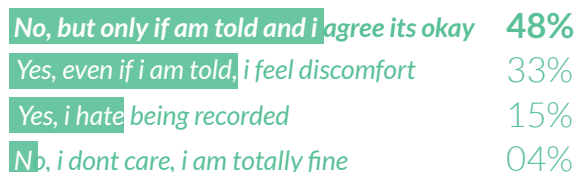
Q15 Do you find checking your phone, even when there is no call, vibration or notification?



Q15 Have you taken pictures of somebody unknown, on your cellphone without their information?



Q16 Do you feel uncomfortable with the act of being recorded in any way (picture/video) ?



//Question SET TWO//

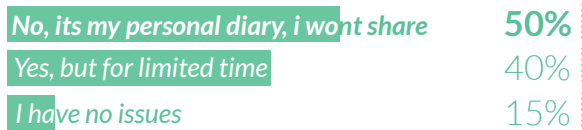
Technology & Wearables

Set two of the survey included 25 questions (featured with results alongside) which try to understand the perspective of the users towards technology, computing in the contemporary scenario. Understanding how people use their smartphone, which is closest to being a wearable device and has been becoming the de-facto device for accessing information and doing things in the recent years.

The results helped in understanding the realtion and behaviour of the humans with technology, how it changes and what are the problems people are facing with the current generation technology. The survey results can be used to avoid pitfalls and creating interactions which result in a more productive usage of technolgy while minimising the ill effects of it.

APPENDIX

Q16 Do you feel comfortable sharing your phone with some one?



Q17 Have you used your phone to kill boredom ?



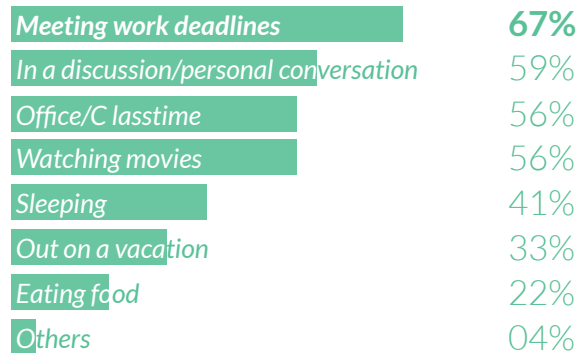
Q18 Have you used your phone to avoid certain situations, people and conversations?



Q18 Do you think your phone causes you to not be able to enjoy the moment/life as it happens?



Q19 When is time/time periods that you have specifically avoided/silent your smartphone until it is very urgent?



Q20 Has your cellphone made it difficult to:



Q21 What has caused frustration, while using your cellphone?



Q22 Have you panicked/generally panic when your cellphone is low on battery?



Q23 Do you think a smart phone is a wearable computer?



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