ASSISTIVE DEVICE FOR PEOPLE WITH CEREBRAL PALSY

INTERACTION DESIGN PROJECT II
IN II - 70

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Assistive device for people with cerebral palsy

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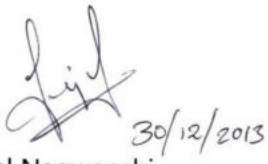
Declaration

I declare that this written submission represents my ideas and experience in my own words. This is an authentic record of my own work as requirements of Project II during the period of August 2013 to November 2013. I have adequately cited and referenced the original sources wherever external literature is used. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated any data in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute.



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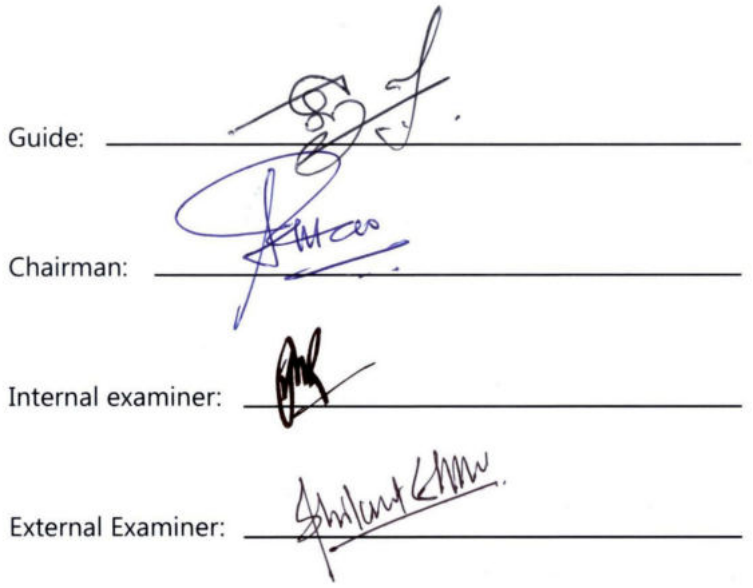
Approval sheet

The interaction design project II, entitled “assistive device for a people with cerebral palsy” by Sajal Nagwanshi is approved in partial fulfilment of requirements for award of the degree of Masters of Interaction design.



Acknowledgment

I had a profound experience while working with people with disabilities. I don't think so I would have had an opportunity to meet so many inspiring and hardworking people had I not worked with them. Throughout my project I met various people who have added tremendous amount of knowledge to me from the insights that they have gained through their experience. .

I would like to thank Dr.G.G.Ray for introducing me to this domain and motivating me to work for the benefit for people with disabilities. I would also like to thank Mrs. Ella D'Souza principal of Happy Hour Centre Khar, Mumbai, who gave insights from her life long years of experience of physiotherapy. I would like to thank Hemant , for co-operating throughout the test run of the project.

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Abstract

The objective of the project is to design an assistive device for people with cerebral palsy (CP). The primary objective of the device is to help people in communicating their basic needs to their care takers around them. Apart from communication, the device would also be used for training their motor skills, recreational activities and teaching various topics. The popular input devices like mouse or keyboard require fine motor skills to give input to computers which is not possible for people with spastic CP. The solution proposed here is a tangible device that is pressure sensitive. It takes the input signal of gross motor movement, like tapping of foot or hands and converts it into meaningful information. It can recognise the position and the pressure of fingers touching it. This device can be attached to any computer and be used for various applications. The solution describes how the users would interact with the device for applications of motor skill development, communication and recreational activities.

For the purpose of testing the concept, a person with Cerebral Palsy was chosen. He has quadriplegia and the only part of body which he has voluntarily control is his left toe. Therefore the present prototype of device was made to be operated by left toe.

Introduction

Background

The topic of people with disability was introduced while studying the subject 'Human factors in interaction design'. The subject talked about modelling human's behaviour and actions. The systems were classified into closed loop feedback system. A system which would self corrects itself while constantly comparing a desired value. A system is defined by inputs, processes and outputs. Any task which is taken by humans can be modelled by the system. As shown in the diagram (Image 1), a simple task of walking by human being can be modelled by a closed loop feedback model. Let's say, a person wants to move to a desired position then the error would be the difference between desired and current location. The Environment (static) would be roads, pillars, and dividers. Actuation is the motion of legs for walking and output is the change in position of that person. But there are some cases when this does not work as expected. Like a case of CP, in which the inputs i.e. the sensory organs may not function as expected or some maybe mentally challenged or with physical disability.

Cerebral palsy causes permanent damage to the brain and physical disabilities. The motor disorders may affect a child's ability to walk or perform manipulative tasks, and may make overall arm and leg movements slow or unsteady. In addition, the brain injury may cause other medical disorders, such as impaired intellectual development, seizures, and spinal deformities. It may also delay the growth of a child, effect vision, speech, hearing or behaviour. [2]

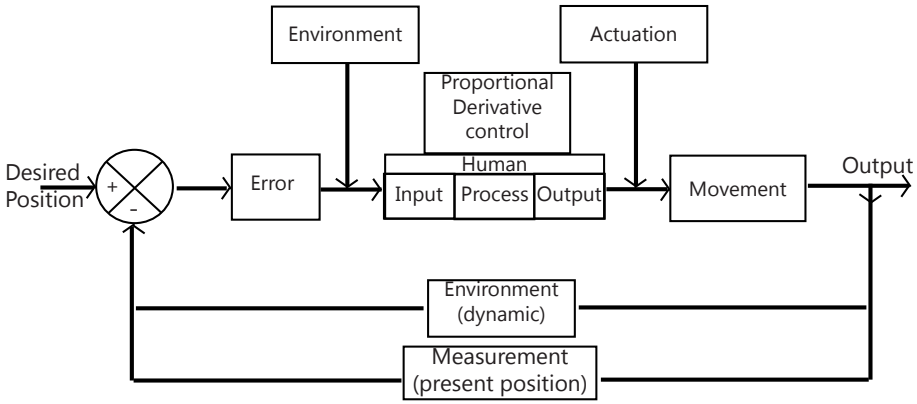


Image 1: A generalised diagram of motion of human being represented as a closed loop system with feedback

About Cerebral Palsy

Cerebral palsy (CP) refers to a group of permanent and non progressive brain dysfunctions that affect a patient's ability to move. It happens due to the defect in the neural system in brain resulting in non-cohesive uncontrolled neural discharge responsible for erratic muscle contraction of different parts of the body. CP is one of the most common causes of childhood physical disabilities, though the effects differ from person to person depending on severity. A child with severe CP may not be able to walk at all, causing them to seek continual assistance from the families, therapists, or assistive devices. On the other hand, a child with mild CP may have relatively little motor deficiency and not require much special support. [1]

The types of CP can be classified into:

A) According to the movement (tone) disorder

1. Spastic (Pyramidal) - Increased muscle tone with damage occurring at the Pyramidal Tract. The muscles become overactive when used and produce clumsy movement. Normal muscle works in pairs: When one contracts the others relax. Spastic muscles become active together and block affective movement. It Accounts for 70-80% of CP cases. Lesions to the brain's cerebral cortex are generally the cause of it.

2. Non-Spastic (Extra pyramidal) - decreased or fluctuating muscle tone divided into two categories:

(a) Hypotonic/ Ataxic - affects balance and coordination. It is the least common type of CP. This type of patient has poor muscle power poor balance, problem in depth perception and co-ordination. Damage to cerebellum is the cause.

(b) Dystonic/ Athetoid - characterized by continuous or intermittent muscle torsion and abnormal posturing. Fluctuating tone, leads difficulty in controlling tone and co-ordinating movement. They may have involuntary movement and are constantly in motion. It results from damage to Basal Ganglia.

3. Mixed - a child may have mixed symptoms from both categories.[2]

B) According to number of limbs affected:

1. Monoplegic — One limb
2. Paraplegic— Both legs
3. Hemiplegic — One arm and one leg on either side of the body
4. Quadriplegic — All four limbs

About assistive devices

The term assistive technology, also known as adaptive technology refers to any equipment, product or system which is either acquired commercially, modified, invented or customized, that is used to increase, maintain or improve functional capabilities of individuals with disabilities [4]. The most famous example of assistive device used as communicator is that of Stephen hawking's (image 2 and 3). These kind of assistive devices are known as Augmentative and Alternative Communication (AAC).

While no cure is known for any of the subtypes of CP, many of the capabilities of the person can be improved using a variety of methods. Orthotic devices and mechanical aids can help to improve mobility and posture, while speech therapy and communication aids, such as voice synthesizers and computers, can help to alleviate the affects of communication difficulties. Recently it has been observed that tablet computers and smart phones are being used to provide an inexpensive therapeutic device to engage children with disabilities through various therapy and rehabilitation apps. Also, there is increased feasibility and applicability of robotic solutions to physical problems and rehabilitative therapy for CP has begun to see some benefit. Robotic devices that assist in patient exercises during therapy sessions have been shown to increase positive outcomes, as well as providing other benefits. [1]

Image 2: Stephen Hawking with his AAC assistive device

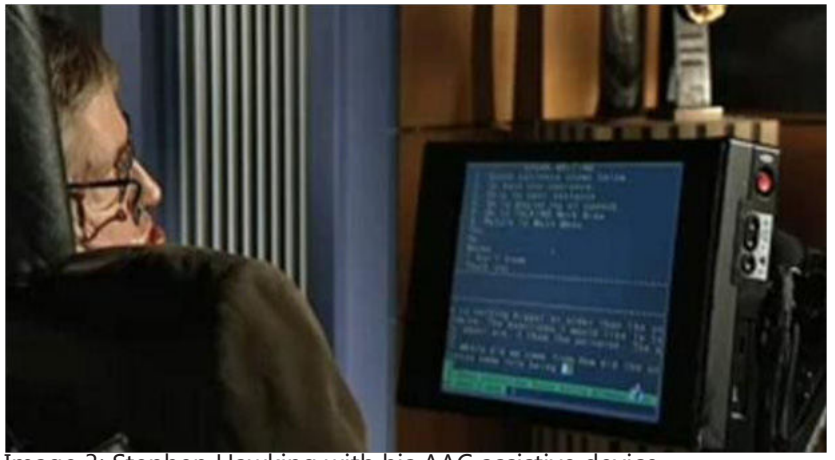


Image 3: Stephen Hawking with his AAC assistive device

Augmentative and Alternative Communication (AAC)

AAC includes all forms of communication that are not through oral medium and are used to express thoughts, needs, wants, and ideas. We all use AAC when we make facial expressions or gestures, use symbols or pictures or write. [5]
Those people who have speech impairment rely on AAC to communicate their needs. Special augmentative aids, such as picture and symbol communication boards and electronic devices, are available to help people express themselves. This helps them to increase their social interaction, performance, and expressions.

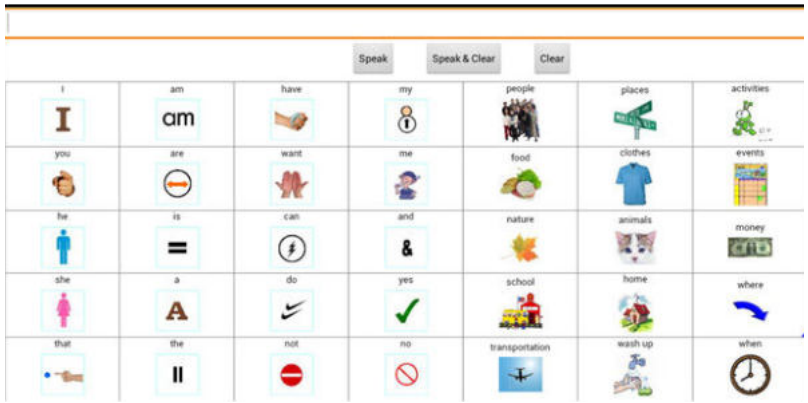


Image 4: Alexicom AAC application on Android platform

Picture exchange communication system (PECS)

PECS is a form of augmentative and alternative communication. It was developed in 1985 for individuals with autism spectrum disorder and related developmental disabilities.. [6]
PECS begins by teaching an individual to give a picture of a desired item to a "communicative partner", who immediately honours the exchange as a request. The system goes on to teach discrimination of pictures and how to put them together in sentences. In the more advanced phases, individuals are taught to answer questions and to comment.
The AAC apps available derive inspiration from this system, where the child selects an appropriate picture to express himself and the other person understands his thoughts by looking at picture or from auditory response from computer. An example of such an application is Alexicom's AAC (image 4).

Process Followed

1. User study

Observed 5 people who had cerebral palsy with speech disorders.

Interviewed: special educators, physiotherapists and parents to understand problems

2. Defining constraints

Selected a particular user to go ahead and solve communication problems.

Design issues for adaptive system, taking into account his physical disability.

3. Define system

A system that consists of input device, process and output.

Defining the problem statement.

4. Secondary research

Compare all the available adaptive technologies for people with cerebral palsy.

selected an appropriate app.

Looked for breakdowns

5. Prototype

Make working prototypes to demonstrate concepts

6. User testing

Test and the system on various parameters.

User study: Observations of people with Cerebral Palsy (CP)

1. Akshat Gambhir, 24, Male

Diagnosis: Athetoid CP with mild spasticity, multiple spastic contractions, currently wheel chair bound with problems in speech, epilepsy.
Dependency: Completely dependent on care takers
Health: Good physical health and personal hygiene
Social: Good interpersonal skills. He likes to interact with everyone and shows good participation in group therapy. But due to physical limitations he gets restricted with few activities.
Motivation: needs to be motivated
Activities: pasting paper bags, gifts envelope with help an aggarbatti packing
Treatment suggested
1. Joint flexing
2. To teach co-ordination movements
3. Trying to sit and balance
4. To improve speech, Om chanting, tongue exercise, breathing exercise. He can speak letters of the alphabets, days of weeks and months but not with clarity
5. Activities like cycling, pulley, putty and rowing.

Observations by Occupational therapists

1. He has history of CP. He is able to communicate his needs but it is difficult for people around him to understand him, especially if someone is new.
2. Conversation is very limited. Conversations are not initiated at all
3. During sessions, he explained that “papa loves him” but was unable to express himself in more detailed manner so as to why and how.
4. He needs more time to explore how to express emotions and relations

2. Rohit Gambhir, Age: 38 Male

Diagnosis: CP with Athetoid (severe), mental retardation, Epilepsy
Dependency: Completely dependent on care takers
Activities: pasting paper bags, gift envelope, gift envelope, aggarbatti counting.
Extra curricular activities: yoga, physiotherapy, painting.
Overall: Social but limited by speech. He likes painting and is enthusiastic to learn new activities but due to severity of his disability he is restricted.

Physiotherapist's suggestion
• Teach co-ordination movements with Proprioception (the sense of the relative position of neighbouring parts of the body and strength of effort being employed in movement.) [1]
• To improve speech by Om chanting, tongue exercise, mouth exercise and breathing exercise
• Voluntary control is poor
• Hand function not properly developed
• Tightness of both upper limbs, hip flexor and knee flexor

Recommendations
• Generalised mobilization and stretching exercises
• Overall motor development
• Proper positioning on wheel chair

3. Manisha, 34, Female

Diagnosis: Triplegic CP with mild spasticity, multiple spastic contractions, currently wheel chair bound,
Dependency: Partially dependent on care takers
Health: Good physical health and personal hygiene
Social: Good interpersonal skills. She likes to interact with everyone. She works in an MNC and also takes care of other students in centre.
Motivation: Highly motivated to work in an MNC
Activities: She works at reception of the office. She has problems while using keyboard and mouse due to pronation of hands.
Recommendations from physiotherapist: Regular physiotherapy to maintain flexibility, motivation and confidence.
Computer efficacy:
• She can type at a speed of 32 words per minute.
• She can operate mouse but the wire of the mouse gets entangled.
• For pressing the mouse button she has to align her hands in a specific way
• When given a task to open word processor, she was able to do it using a combination of keyboard and mouse commands. But mostly mouse.
•She faced problem while applying complex formulas in excel.
• She wanted to customise multiple key presses in key boards
Communication: Even though her speech is normal and can communicate well with others, she complains of epileptic seizure during which she can't communicate with others.

4. Ashwani, 35, Female

Diagnosis: Triplegic CP with spasticity, limited hand movement, unresponsive legs, multiple spastic contractions, currently wheel chair bound, spine support, problems in speech, weak eyesight
Dependency: Completely dependent on care takers
Health: Good physical health and personal hygiene
Social: Good interpersonal skills. She likes to interact with everyone. She enjoys doing activities at centre and as is friendly with others.

Motivation: Highly motivated to do activities at the centre
Activities: She likes painting diyas, pots etc. Even though a little help is needed from the care takers she does the job with efficacy. Packing Aggarbatti and counting.
Observations:
• She was able to paint the mud plate in fair amount of time efficiently.
• She could also pick up the paint brush by herself
• She could understand all the conversations and commands given to her and respond appropriately
• She could count till 50 but had problem in remembering the last counted number after 30
• She would salivate excessively

5. Hemant, 38, Male

Diagnosis: CP with mental retardation, spastic Quadriplegic, voluntarily control of left foot, speech impairment, Auditory agnosia

Dependency: Completely dependent on care takers and parents

Health: Good physical health and personal hygiene
Social: Good interpersonal skills. He likes to interact with everyone and shows good participation in group therapy. But due to physical limitations he gets restricted with few activities.
Motivation: high

He has Auditory agnosia due to which he is not able to differentiate between sounds and assign meaning to it.
For example if the teacher said 'C"A"T' is CAT he would not be able to understand. If CAT is written with a picture of cat beside it then he would be able to establish relation amongst it. Therefore to him, the spelling of words do not have unique sound to it but just shape of letters. Each letter has just the significance of it's shape but not of sound. Apart from that, he cannot focus his eyes on a particular point due to which he misses out some of the letters in middle of the word. He has constant jerky movement of his head while trying to read. For example he would spell cat as 'CT' and miss out A. Presently he is able to recognise 6 different words if he is shown it's picture.
Future: To train him in learn words and sentence formation.

Insights

1. People with CP have spasticity which hampers them in making fine motor movement. It is difficult for them to make precise controlled movement.
2. A person with CP has unique set of disability. To overcome that individual cases have be looked at separately. In order to come up with an assistive device a set of tools has to be developed which can be used by them as per their need.
3. A person with disability may have combinations of disability due to various reasons. People may have physical disability coupled with mental retardation.
4. Sometimes, a little modification in normal devices can lead to great benefit for people with disability, e.g. a key board with holes for key press.
5. For people with disability, working in a normal office environment is dream. If by any means they are able to do it, they would be satisfied.
6. CP treatment is an area that has begun to benefit greatly from emerging technologies. There are various AAC and therapeutic applications available on smart phones and tablet but their use is restricted to unavailability of suitable input device.
7. Developing therapy or tools for occupational therapy shall be beneficial for the students. As it helps them to work efficiently.

Design Ideas

1. A device that could help people with spasticity to practice linear motion, circular motion, figure 8 etc. These would help them in Occupational therapy, thereby making their work more productive.
2. A tangible device which can train them for alignment in 3D space. A tool which trains their spatial ability.
3. A simple way to respond as ‘yes’ and ‘no’.
4. If Multiple key press can be customised on a specific key it would help in operating complex functions in MS Excel

The issue of communication: past and present

Hemant at Happy hour's centre first started using picture list to communicate his needs. The care takers had a file of A4 sheets, which had categories and objects within them. The care taker would ask him his needs and he would respond by moving his leg to turn to page number first and then the object in that page. Thus the needs were communicated by PECS. Later on, a computer was developed to cater to this need. Professor G.G. Ray of Industrial Design Centre, IIT Bombay, in co-operation with Happy Hours Centre had developed a unique type of foot-operated personal computer-based communicating tool for him (Image 5). [7]

The input is through specially developed foot-operated switches in conjunction with specially developed software. The foot-operated keyboard and monitor are set on a sturdy wooden stand to enable the child to operate it with ease while seated in a wheelchair.

Image 5: Hemant using the communication system

Image 6: User interface of the system

The input in this case was a set of switches, mapped according to the interface. The process had two level of hierarchy i.e. Categories and objects. Six categories (feel, who, do, go, eat and drink) and the objects within each of them (Image 6). The output was visual i.e. The image of the item and text describing it.

Each of the categories in the interface was linked to sub categories and objects. The user had to press the button which was corresponding to the interface, which resulted in display of that specific item, thereby communicating his need to others around him (Image 7). The user has now been conditioned to the system and remembers each and every category very well. He can now effectively communicate with people around him. Even though he does not understand the word and it's spelling, he remembers the form of the letters and remembers the word. He is able to relate the switches on the input device with the user interface. It took him a month to train him with the present system.

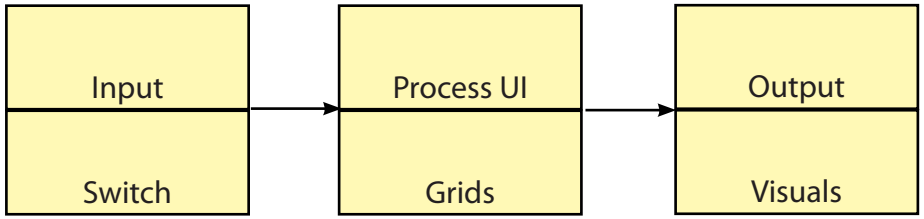


Image 7: The previous communication system

The vision for the system

The vision for the assistive technology for people with cerebral palsy is to have technology which is adaptive to their needs. In human computer interface model (Image 8) there is a constant link between actions and reactions from humans. The computer and humans exchange and process information simultaneously. If there is any break in the link, the process can not continue. In case of people with disability, the link may break at two point, one while giving input to computers due to physical disability and two, when processing information due to mental retardation. For both the conditions, the system should be adaptable and help them in achieving their goals.

About the first limitation, which is that of input devices, the larger vision is to have multiple alternative channels of input which can be selected based on an individual's needs (Image 9). Thus, by having alternative choices to popular input devices like mouse or keyboard the computer becomes more accessible to people with disabilities.

About the second limitation, which is the processing information part, then need to look at the specific application which are necessary to individuals. For example, a communication application, which is adaptive to individual's context. It could also help the person to develop his motor skills or for recreational activity.

Defining the system

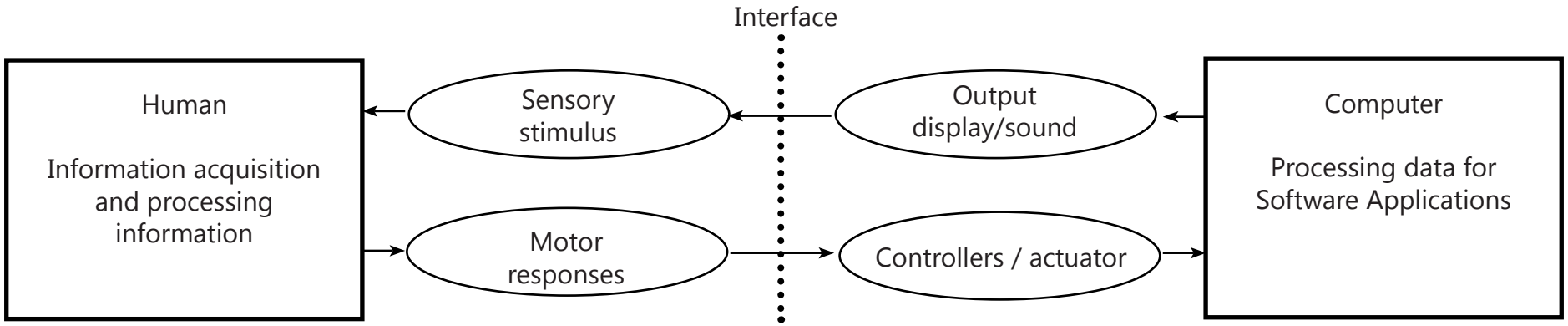


Image 8: Human computer interface model

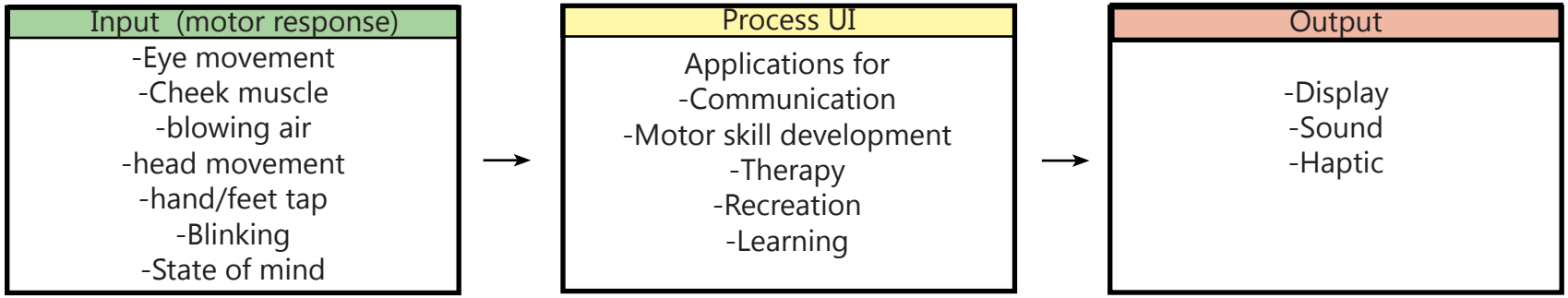


Image 9: The vision for assistive technology system for people with cerebral palsy

With the advent of minicomputers which are more capable than computers of past and smaller in size and developments of sensor, the whole system can be upgraded to add more functionality. The future vision is to make the device versatile so that it can be used for communication as well as therapy and recreational purposes. The system should be upgrade able and adaptive to the user's needs. It should be portable so that it's function is not dependent on the place where the system is installed.

An example of such system which was used for testing is a pocket sized minicomputer (Image 10) called 'Cubieboard', which has capability to run many such applications. It runs Android OS and applications supported by android. The OS can be upgraded and is of free of cost.

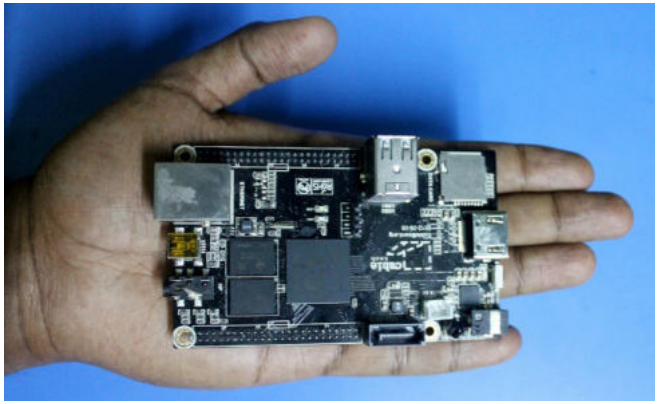


Image 10: The minicomputer Cubieboard

Input Device

Many people with spastic CP have pronation in hands or legs due to which they cannot point and touch a specific button or perform actions requiring fine motor movement. They do not have fine motor skills but have fair gross motor skills. Therefore, the challenge is to have a device which can convert these gross motor movements, like tapping by hands or foot into meaningful information for computers. Keeping this factor in mind a force based platform was thought of for converting the gross motor movement of the body into an input signal for the system. This also opens up possibility of the input device being used for functions other than communication.

The input device is a platform which is recognises force and the position of touch by the user (Image 11). This helps in getting more information from the user since it is an analogue signal (of value between 0 and 1024) compared to switch which just give information of off/on.

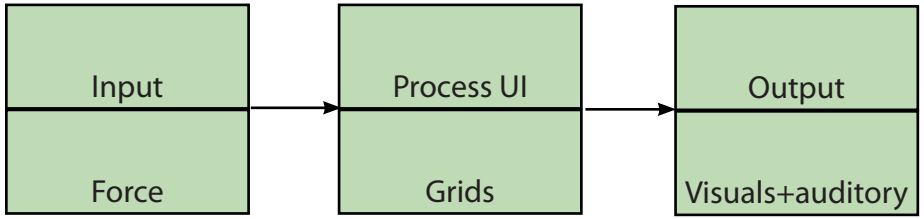


Image 11: The next planned communication system

Explorations

Earlier prototype of the input device consists of a grid of FSR (force sensitive resistor) sensors as shown in sketch (Image 12, 13, 14).These sensors are sensitive to force applied on it. It was chosen to be the medium to input information as the person can give taps through his foot or hand.

In the following sections various modes of interaction through this device is explored. The prototype models were made from smaller FSRs. Each grid was 10cm in width, according to the size of a foot. The structure of 3X3 matrix is followed as it is replicated in the interface as well.

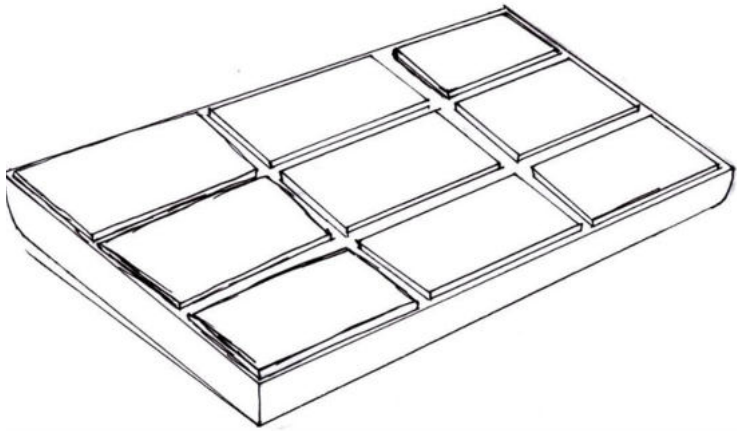


Image 13: Input device Concept 1 sketch

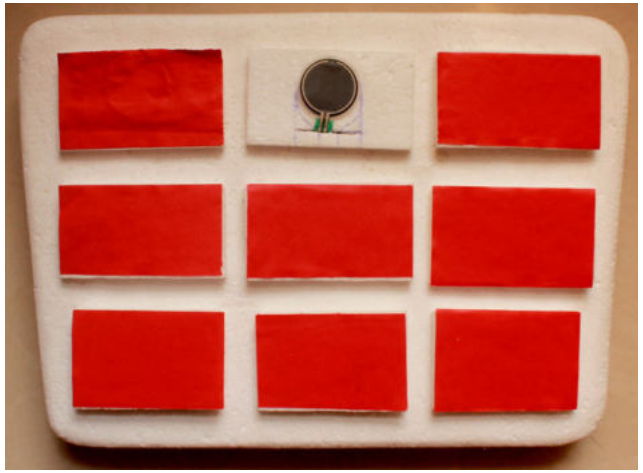


Image 12: Concept 1 prototype of input device

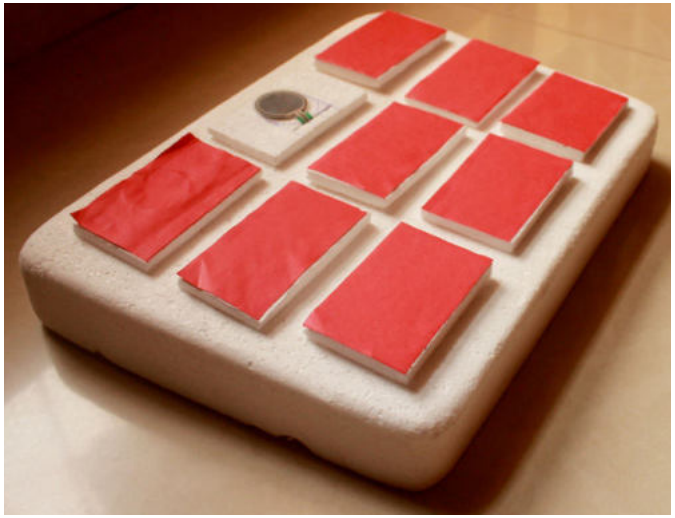


Image 14: Concept 1 working prototype with the FSR mounted

Final concept

The final concept for the input device consists of a grid of FSRs which has touchscreen mounted on it and above it are inter-changeable overlays as shown in sketch (Image 15). The bottom layer of sensor is to sense the pressure applied by the user. The touchscreen recognises the position of the touch and the over-lays helps the user to guide at right spot.
The device would be connected to a computer and can be used for various applications. The working prototype is shown in the following page (Image 18,19, 20, 21).

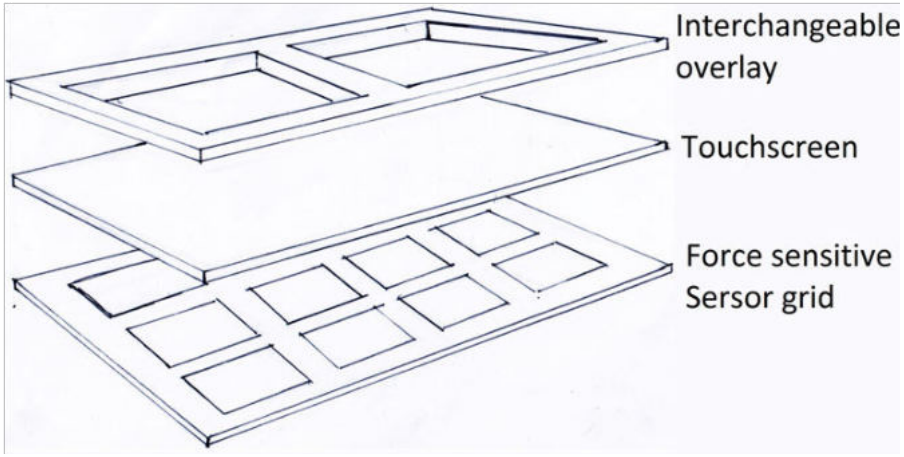


Image 15: Concept 2 sketch of input device

Inspiration

Key guards are used extensively by people who have spastic CP to operate computer keyboards (Image 16). It helps them to locate and press the right key since they have jerky motion and pronation. Taking the same idea forward, these kind of key guards can help them in using the new input device. For exam-ple, it could be for training them in linear or circular motion or using applications for learning simple concepts of maths or for communicating his basic needs. These interchangeable overlays would be complimenting the application's interface and would help the person to point and touch specific part on the input device. As Image 17 describes how the set of overlays would be part of the system.

Image 16: Key guard for keyboard

The system

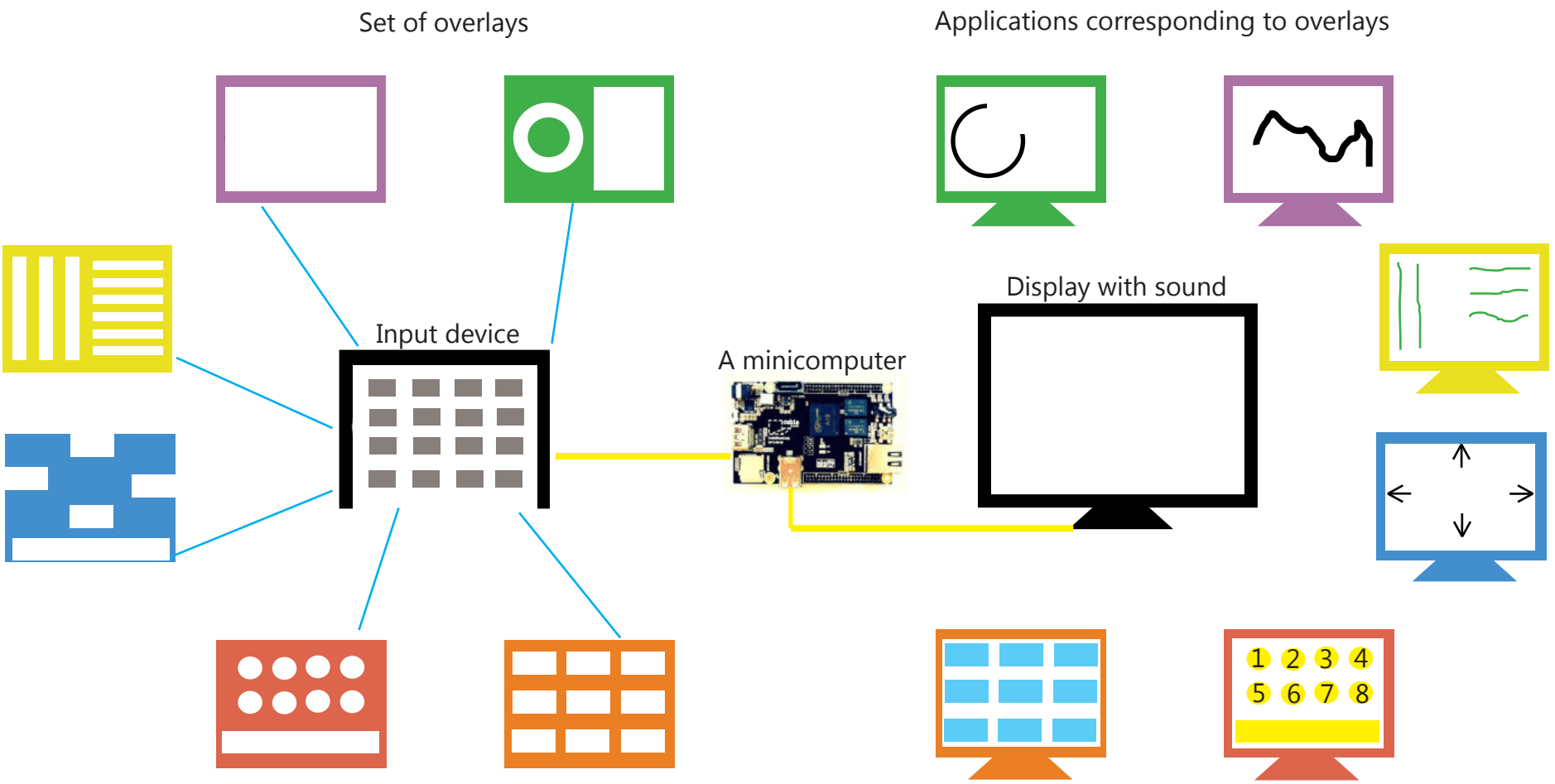


Image 17: The system includes a set of overlays, input device, minicomputer and display

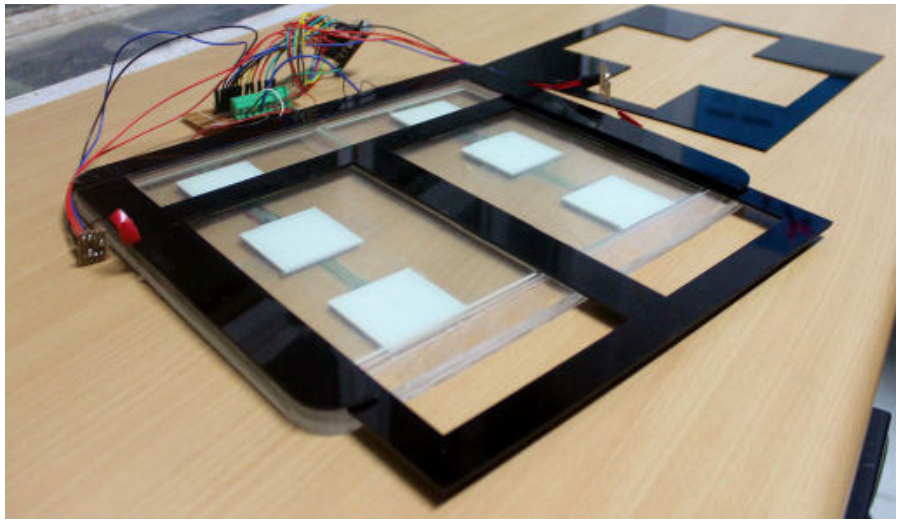


Image 18: Prototype of the device with two overlays

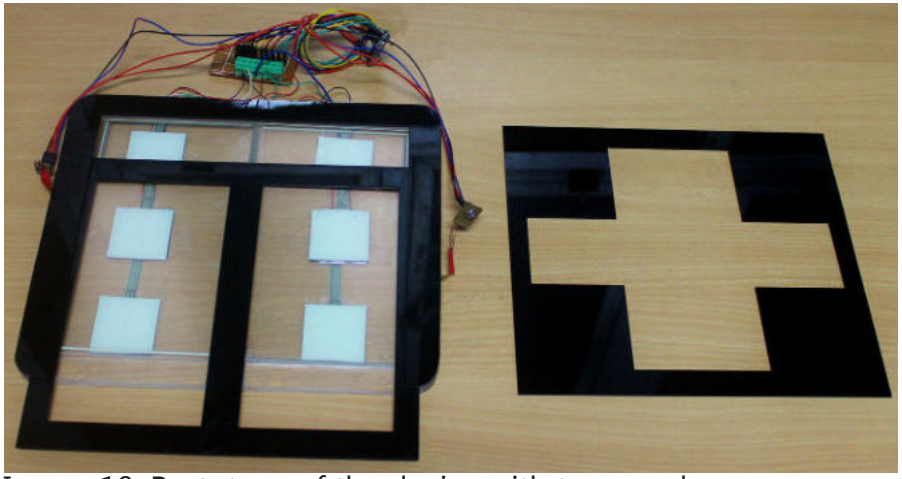


Image 19: Prototype of the device with two overlays

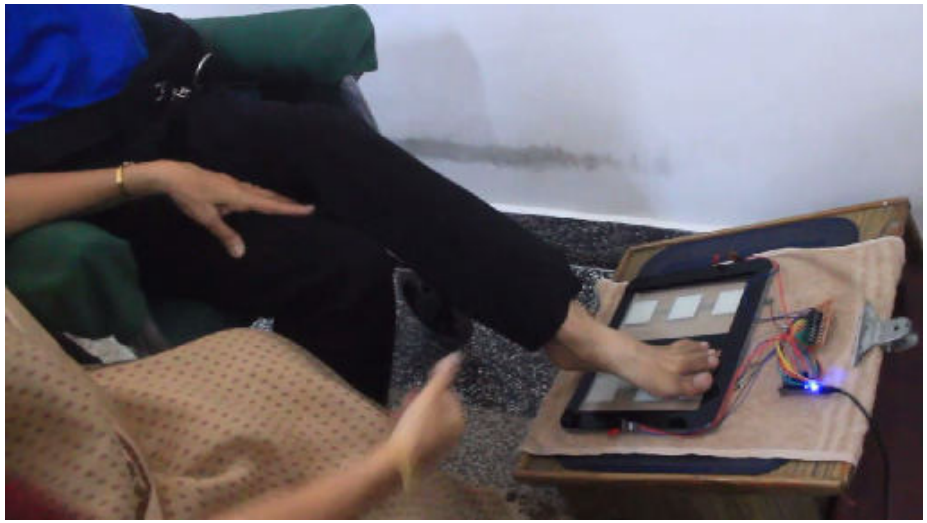


Image 20: Testing the prototype with users

Image 21: Testing the prototype with users

The Communication UI

The communication process is a type of AAC which is inspired from PECS. It is a grid based UI in which each element contains an object or an activity represented by visual and text. A comparison of all the freely available Apps concludes that all the Apps are based on grid based UI. This is due to it's easy scalability and ease of use. But the drawback is, it is made for touchscreen phones and tablets. There are no means to operate them if the person does not have normal motor skills of hands.

There is no contribution in this domain in the present project. But, future plan is to work on an original application which could incorporate best of all the features of the available apps and create a better experience.
The following is the plan for making a custom UI:

1. Study of all the available apps like Avaz (Image 22), Jabtalk (Image 23) etc.
2. Prepare a comparison chart of all the features. (Image 24)
3. Ranking them on basis of their features.
4. Selecting the most appropriate
5. Adapting the App to present requirement i.e. Note the current needs of the user and map them on the App
6. User testing and modification

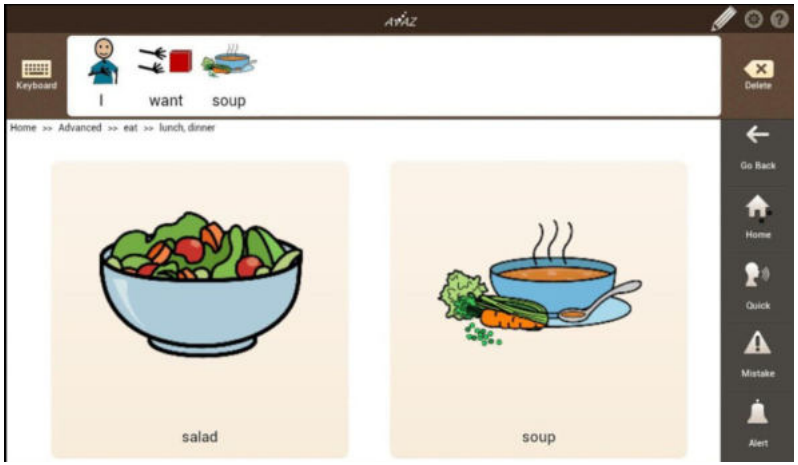


Image 22: Avaz AAC app for people with Autism disorder

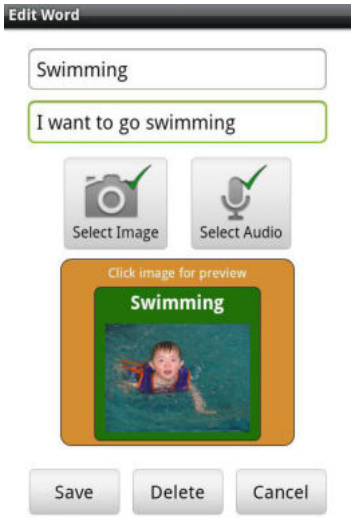


Image 23: Jab talk AAC app

Apps / Features	Speak Cepal	Pickto Plus	Vox4 All	AAC communicator	Alexicom	Youtalk	Jab talk	Avaz	Access4kids	Hemant's
Cost	Free	No	Free	Free	Free	Free	Free	No	Free	Free
Visual										
Tile/grid UI	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Customizable layout	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Customised visuals	Yes	Yes(3D avatar)	Yes	No	No	Yes	Yes	No	No	No
Visual library	No	1000 gestures	12000 widge	Yes	No	No	self clicked	Yes	No	Yes
Auditory										
Text to speech	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Multi lingual	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Sentence building	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Audio/voice selection	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
Customised message	Yes	Yes	Yes	Natural languag	No	Yes	Yes	Visual grammar	Yes	Yes
Optimized feedback										
Fast yes/no	No	No	Yes	No	No	Yes	No	No	No	No
Recent phrase in history	No	No	No	No	No	No	Yes	No	No	No
Haptic feedback	No	No	No	No	No	No	Yes	No	Yes	No
External hardware	No	No	No	No	Yes	No	No	No	Yes	Yes
Row/column scan	No	No	No	No	Yes	No	No	No	Yes	No
Support										
Support by developer	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	No
Tutorial videos	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No
Technical feature										
data backup	No	Yes	Yes	No	cloud	No	Yes	No	No	No
Access in built camera	No	Yes	No	No	Yes	Yes	Yes	No	No	No
Social media	No	Yes	No	No	No	No	No	No	No	No
Calender	No	Yes	No	No	No	No	No	No	No	No
Printer	No	Yes	No	No	No	No	No	No	No	No

Image 24: Comparison chart of various android Applications available as AAC

Communicating through AAC

Since the UI is grid based, there can be limited ways in which an element from the grid can be chosen. There are two main tasks in this process, i.e. Navigation and selection. If there are N elements in the grid then, there can be N number ways of navigating the elements from the grid. For the selection of the elements a separate input division is kept.

For example if there are 12 elements, arranged in 3 rows and 4 columns. There could be 12 channels of navigating through the grids. The minimum being 1 input (button)W and the maximum being 12. In the first prototype, only 1 input division was used, but it was unsuccessful (Image 25).

In the next prototype, four division of input is being tried (Image 27). They correspond to the four directions to navigate through the grids i.e. Up, down, Left and right. The selection is done through separate division at the bottom. A custom made UI is being used for prototyping purpose. The elements are arranged on 3X4 matrix. Any element when selected is highlighted in the bottom row.(Image 26 shows an image of apple being selected)

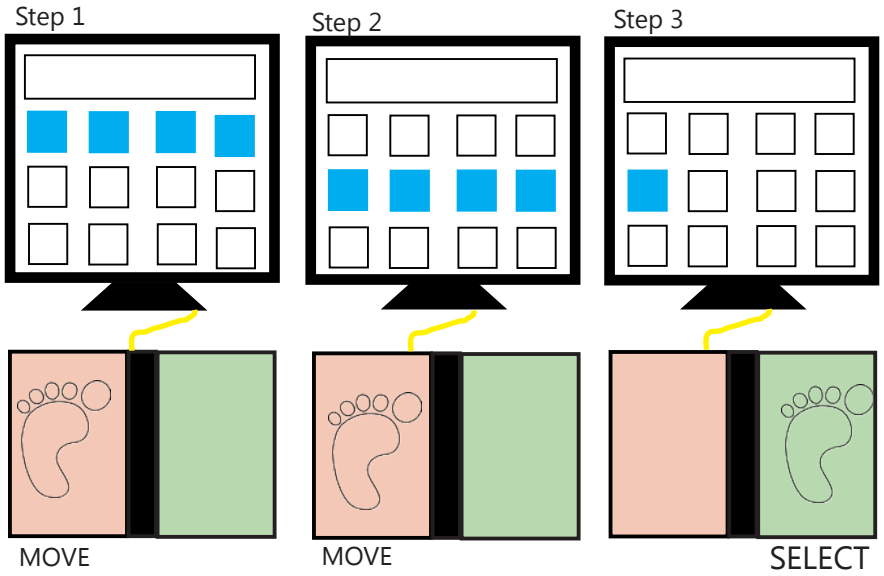


Image 25: navigating and selection process with previous prototype

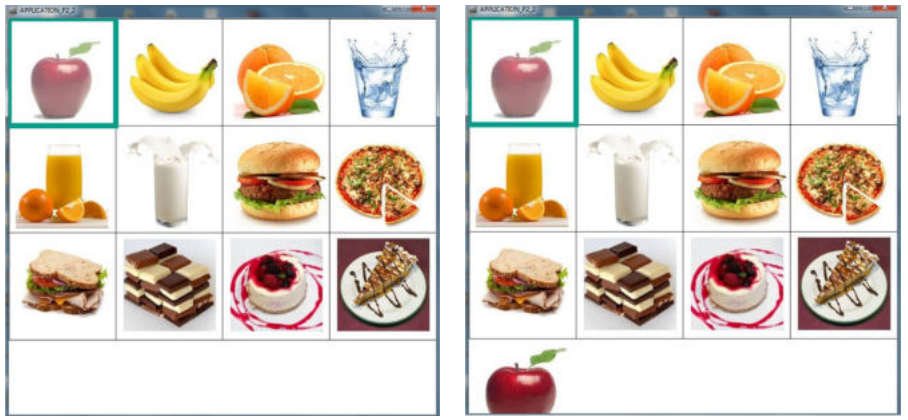


Image 26: A custom made UI to test navigation and selection process with the prototype of input device.

Interaction with device

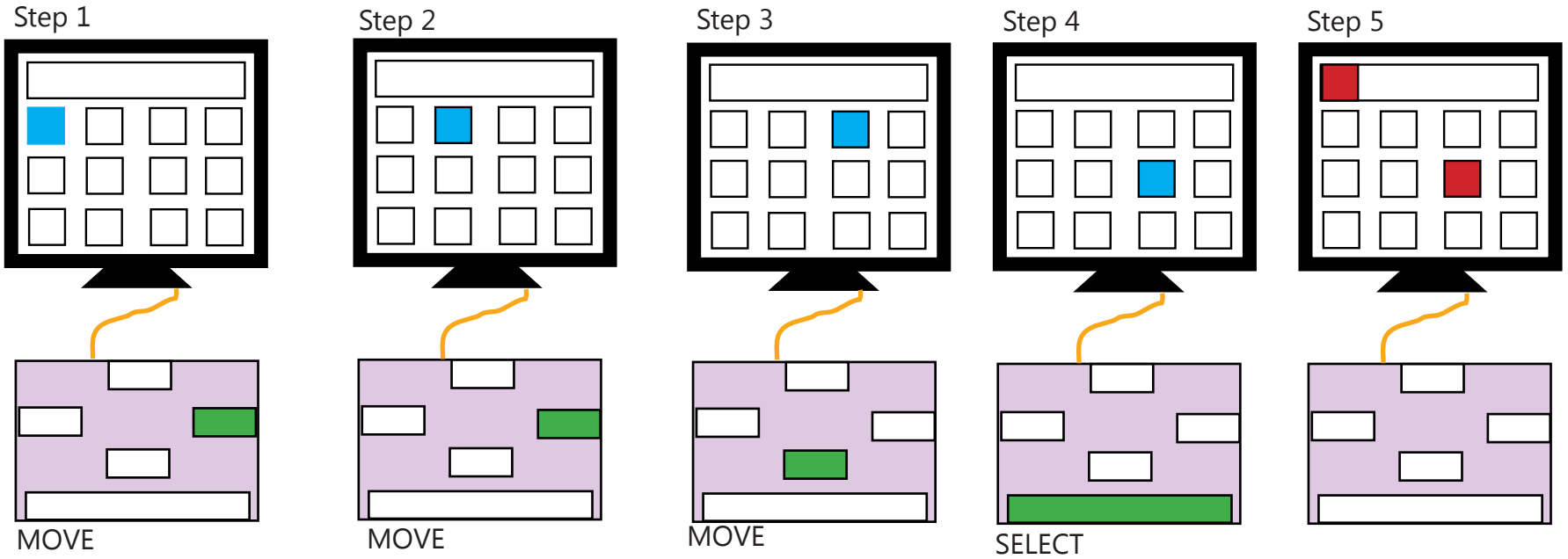


Image 27: In the user interface the blocks refer to pictures of objects. Below is the input device with overlay of four divisions, left, right, up and down. The bottom part is to select

The Process UI is a picture grid based system, which can have any number of categories, sub categories and objects within them. It also supports sentence building option. It is scalable and customizable. The text and pictures can be added and replaced any number of times. The output can be taken on any screen and it also supports Text to speech. The user has to select his desired object from the grid.

The user has two main tasks, navigation and selection. Presently in the input device there are two parts device, four for direction and one for selection. At initial state, the cursor points to the first element. When right area is tapped the cursor moves one by one to next element. The user taps move until the cursor points the desired element and then he taps select area. Once the element is selected it is shown above. (Image 27)

Applications of the input device

The final concept for the input device consists of a grid of FSRs The input device with force as input parameter is versatile and can be used for various purposes apart from the communication. There are three broad categories where the input device can be helpful for people with cerebral palsy.

i) Therapeutic device: There is a desperate need for devices which can help children to develop motor skills and co-ordination skill development. Currently this is being taught by educators for children with special need. The problem is, there aren't many teachers available for such schools and teachers can't spend a lot of time with each of them. The teacher cannot remember the exact level at which the student was last month or last year. This is where this device can come in. This device would not require a teacher to attend to it. It can also record data of each activity by student so that their progress can be tracked. Image 28 shows longitudinal study of force applied by the user over a period of several months. This data is particularly helpful for physiotherapists as the amount of **force is directly proportional to muscle strength**. A negative trend in this graph would mean decrease in muscle tone. If such an information is available to physiotherapist, he/she would be able to suggest appropriate treatment for the individual.

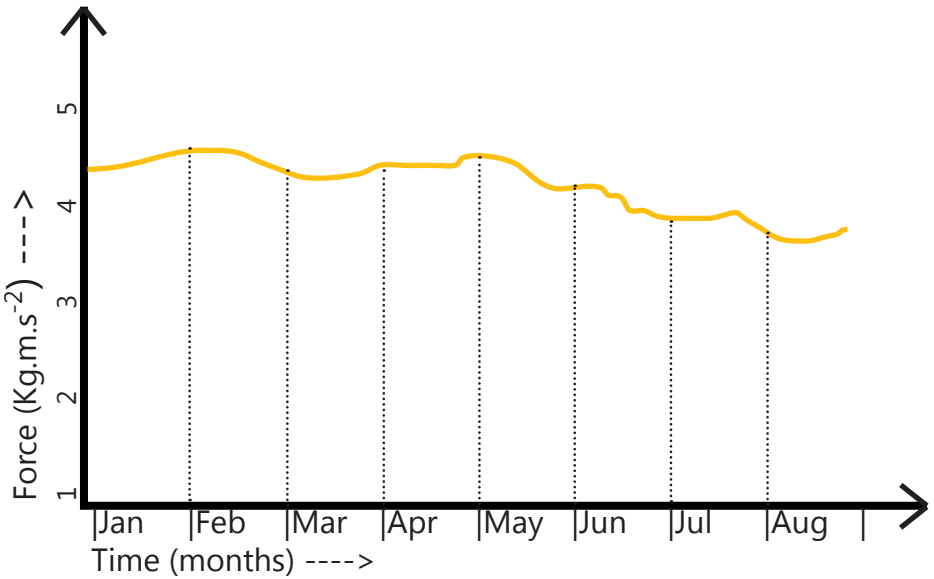


Image 28: The graph showing the amount of force applied by user on a period eight months

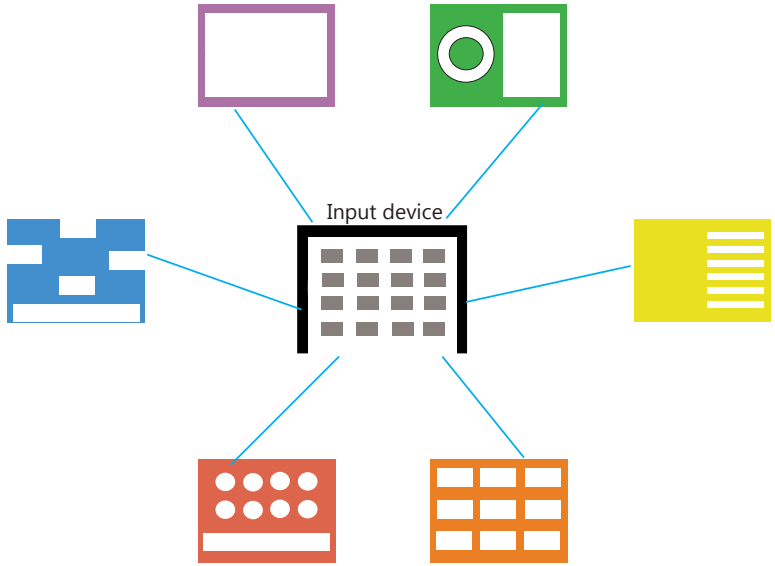
This will also help teacher to get to know if the level of skill of the child has improved or not. The children can themselves initiate these activities and be involved in it.
One of the example of such application is drawing (Image 30,31), Here, the person draws by applying force on the input device. The tone of colour is proportional to the force applied by the person.

ii) Learning tool: The children at the school learn simple concepts of maths, language and science by the tools developed for nursery children. Some of the concepts which are necessary for the person are learning alphabets to spell, numbers, sense of direction, spatial ability etc. An example application would be direction, which helps him to recognise what is left,right, up and down. Something similar to the DDR (Dance dance revolution) game, where the player has to step on a platform on floor according to the direction being displayed at screen (Image 29).

iii) Recreation and games: One of the problems that special schools face is what should the children do at their leisure time. Presently all their recreational activity requires the teacher's presence. That's where this system can come in, apart from being assistive device it can also train them through medium of games.
A simple application could be of drawing (Image 30 and 31). Here, the weight of the lines are dependent on the force applied. Similarly various other shapes can be made depending on the input, like the radius of the circle or sides of polygon is dependent on force

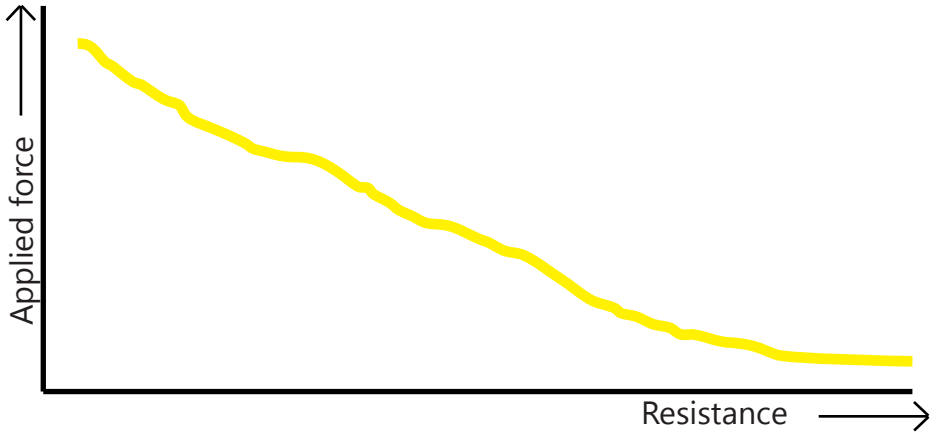
Image 29 : Children playing DDR

Why force as an input?



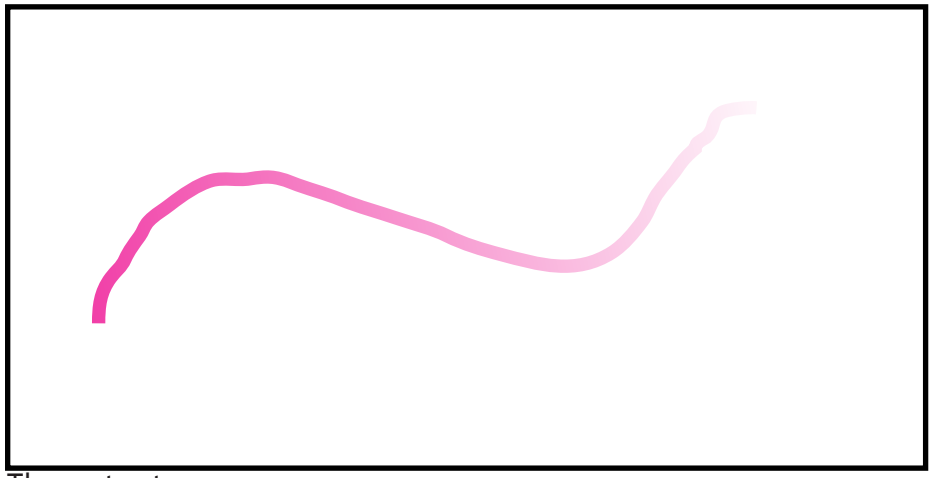
The reasons why force is taken as an input signal are:
1. It is analog and ranges between value of 0-1024 unlike a switch which is just binary. Therefore it can still have functions of a switch but with a lot more control options.
2. It gives an opportunity to calibrate device according to Individual's physical ability.
3. It would help physiotherapist to have longitudinal study of an individual's muscle strength. This will help in assessing his health and suggesting therapy over a long period of time.
4. Force as an input gives advantage of having applications which can help in developing motor skills, e.g. drawing.

Applications of the input device : Recreation

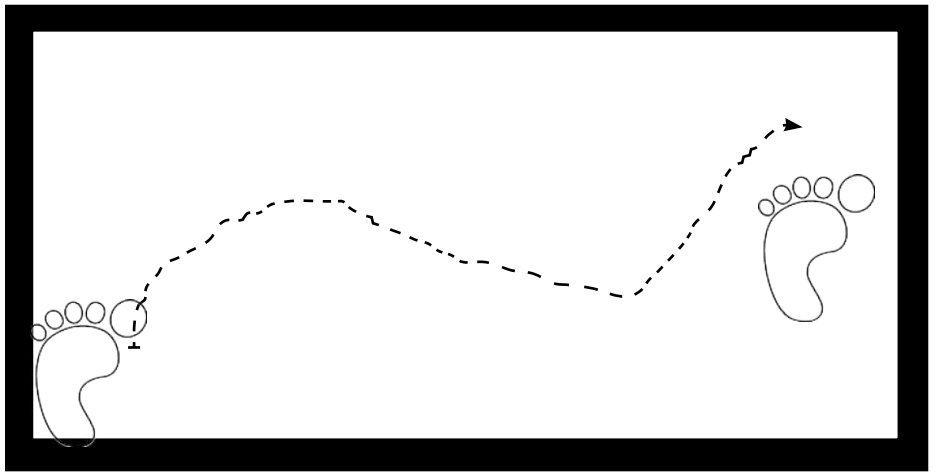


Tone of colors are dependent on applied force

Image 30: Example of drawing application with the input device

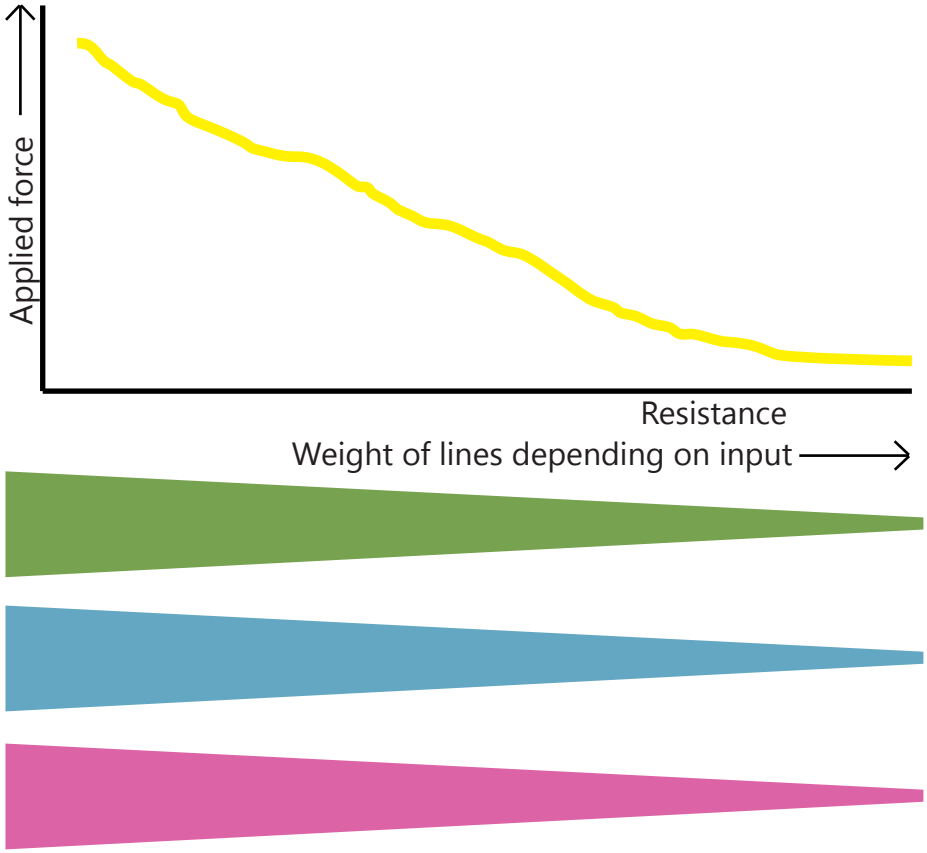


The output on screen



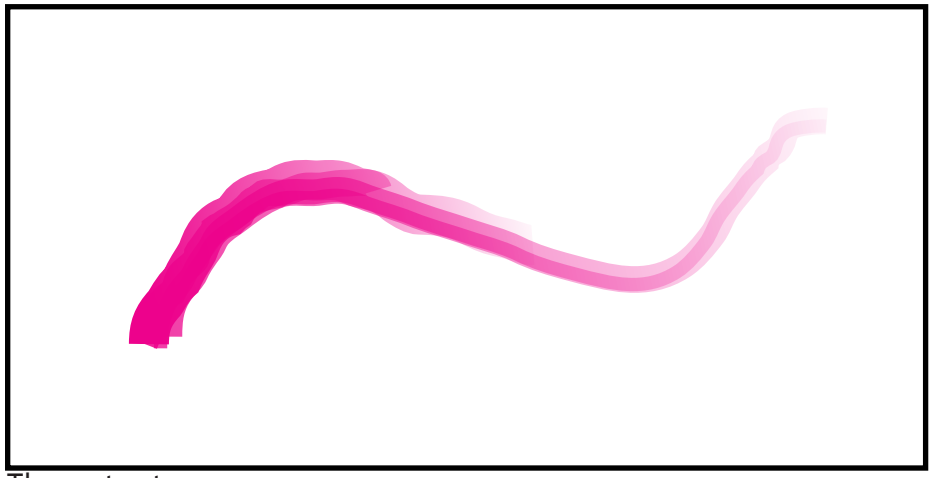
The input on the device. Drawing with feet.

Applications of the input device : Recreation

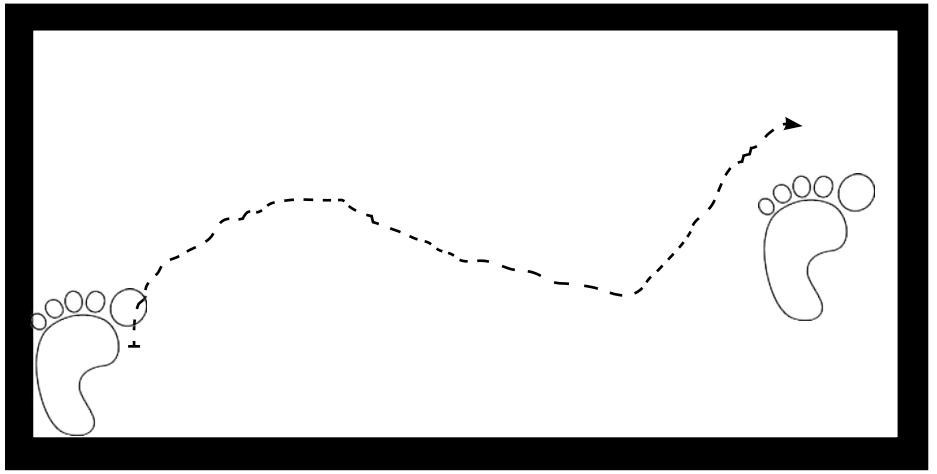


Width of lines are dependent on applied force

Image 31: Example of drawing application with the input device



The output on screen



The input on the device. Drawing with feet.

The system installation

After analysing the constraints and the needs of the user, the present section illustrates the placing of the system which includes the input device, display and computer . The input device is a force sensitive platform, the output is a LCD screen which also has speakers to give visual as well as auditory feedback (Image 12). A Minicomputer is mounted on the wheelchair thereby making the whole system portable. The images describe how the system would be installed. The calculation of height and angle of output as well as input devices are to be done while installing the system. The front, isometric and side view of the system planned is shown below (Image 32,33,34)

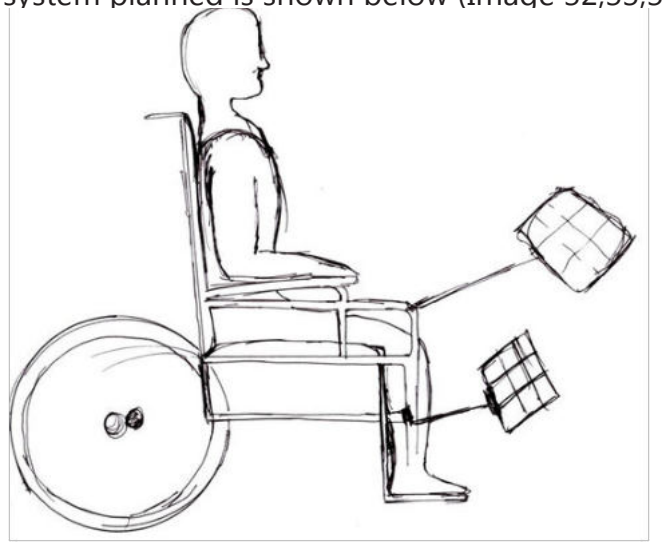


Image 32: Concept sketch of system

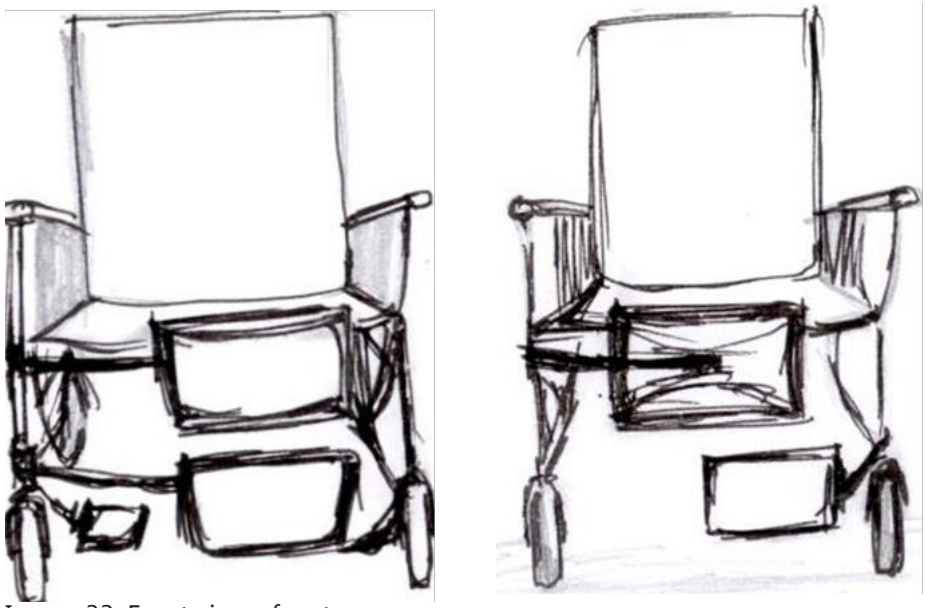


Image 33: Front view of system

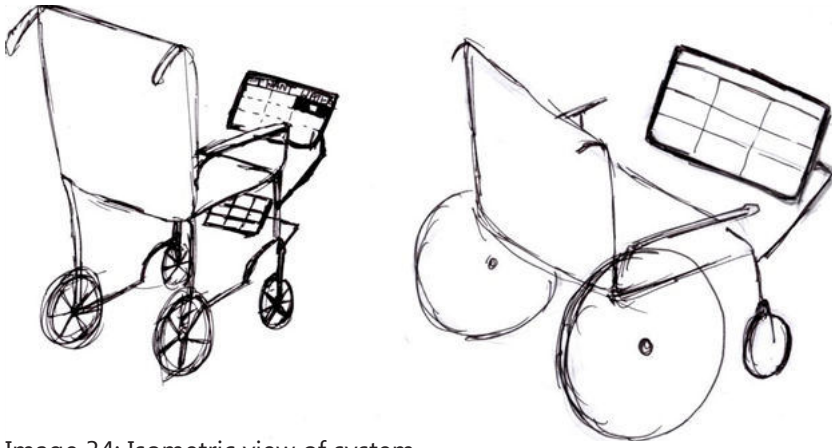
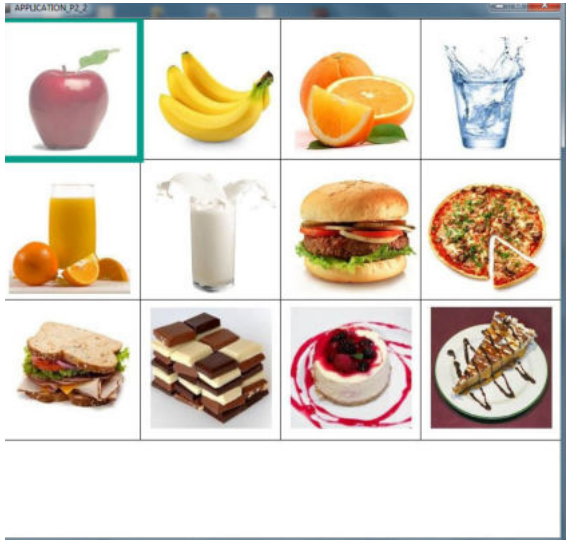


Image 34: Isometric view of system

Evaluation

The next step is to evaluate the input device for it's effectiveness in the communication process. A custom made UI is being used for the testing. The parameters on which the device would be evaluated are:
i) If the chosen method of navigation and selection is effective or not.
ii) Efficiency : To optimise navigation
iii) Ergonomics: If the device is usable and the dimensions appropriate keeping in mind the physical constraints



Task
1. To select a particular element from the grid of elements.

Method: Navigating by arrow keys

Number of times task executed = 3

Success = 1

Feedback from teacher:
1. Can the navigation be much more simpler.
2. The sensitivity of the device has to be improved.
3. The idea of overlay is helpful.
4. It would take him a month to learn a new system.

Evaluation

Task 2: The input device used as recreational tool.
Two children with CP were given the input device to play a simple game.

Objective: to check response

Feedback :
1. The device requires a lot of pressure to be activated.
2. There should be some kind of feedback mechanism to tell if the response is noted by computer.
3. The overlay is helpful and provides clear demarcation.

Feedback from Faculty

Appreciation
1. The topic taken up was complex and decent amount of work has been done to develop a solution.
2. The product is versatile and its versatility has to be made more prominent.
3. In future, there could a study of long press vs. Short press and other mode of interaction with the device.
4. The device could also be tested by keeping it on different positions.

Areas to improve upon:
1. The report could have been better organized.
2. Secondary research could have been more thorough.
3. Sketches could have been detailed out.
4. There could have been demarcation on contribution on HCI front as well as product design front.

Next step

i) To demonstrate the input device's function in regards to it's force sensing capacity.
ii) Test sample applications for teaching and recreation purpose. For example spatial ability, numbers, distance etc.
iii) Help in creating social interaction by means of multi-player games.
iv) Presently their recreational activity is dependent on care takers, if it can be done through this system then it would be of much help to children as well as care takers.

Learnings from project

1. Learning about human factors in design
2. Working for social cause is full filling.
3. Applying previous knowledge to solve the problem.
4. Learnt about problems faced by people with disabilities and their family members.
5. Being patient with your ideas. To be ready to change ideas if the outcome is not favourable.

References

[1] Published in: Proceedings of the 5th International Conference on Pervasive Technologies Related to Assistive Environments by Christopher McMurrough, Shahina Ferdous, Alexandros Papangelis, Angie Boisselle, Fillia Makedon Heracleia. A Survey of Assistive Devices for Cerebral Palsy Patients. 2011
[2] Manual for training of physiotherapist, 2010
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[6] http://www.pecsusa.com/pecs.php
[7] http://www.zoominfo.com/CachedPage/?archive_id=0&page_id=1048633298&page_url=//www.gulfnews.com/Articles/World-NF.asp?ArticleID=156801&page_last_updated=2005-03-19T01:26:04&firstName=G.G.&lastName=Ray

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