AR/VR in the area of healthcare

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Interaction Design - P1 Internship Project Report 2018

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Finally, I would like to express my gratitude to Prof. Venkatesh and Prof. Jayesh for helping me with study materials and suggestions even on email conversations despite their schedules.

Content

1

Introduction to Philips Healthcare

Philips healthcare focuses on three driving principles which are—

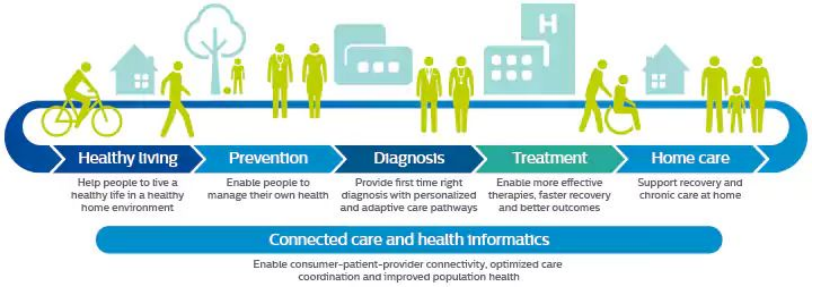
1. Humanizing Technology
   When technology is natural to use and delightful to experience it becomes a liberating factor that enriches people's lives, stimulates their senses and extends their capabilities. We always aim to bridge the gap between human interaction and cutting-edge innovation.
2. Holistic Care
   Design for entire care ecosystems, bringing personal and professional healthcare ever closer to each other. Shake up existing paradigms and ways of delivering care to offer experiences superior to those currently available. **Always think and act with sustainability and durability in mind.**
3. Radical Empathy
   People are unique, complex, multi-faceted and ever-changing - so we put ourselves in their shoes to truly understand their functional, emotional and aspirational needs. By connecting with them on a fundamental level we help them maximize their potential.

Philips healthcare continuum

With growing focus on healthy living and prevention, people are looking for ways to proactively monitor and manage their health both in home and community settings. Healthcare is now no more limited to hospitals but is considered as a continuous continuum that spans in every part of a person's life journey. There is great value in more integrated forms of healthcare which is connected and supports faster diagnosis and treatment at any time. Visualizing healthcare as a continuum enables unlocking gains and efficiency and drive innovations that help deliver a good patient experience, improved healthcare outcomes, affordable cost of care and improved work life of care providers.

The value of a patient is created over the full cycle of care - from the pre-hospital phase, their time in hospital, as they prepare to go home and recovery period at home.

[1]



[1] *Image Source:* https://www.philips.com/a-w/about/company/our-strategy/our-strategic-focus.html

The major verticals under Philips Healthcare are the following —

PCMS - Primary Care and Monitoring Systems
DI - Digital Imaging Systems
HI - Healthcare Informatics
IG - Innovation group
Serviceability

Innovation Program

The annual innovation program in PIC is managed in 6 stages as adopted from Adobe Kickbox[2]. These are—

1. Inception
2. Ideate
3. Improve
4. Investigate
5. Iterate
6. Infiltrate

[2] *Weblink: https://kickbox.adobe.com/*

2

Co-create Methodology

Philips approaches its projects with a methodology called the co-create methodology. The co-create methodology facilitates a human-centric approach to innovation. Its core-beliefs are centred around participation of all the active stakeholders and bringing together an interdisciplinary team for a broader perspective and knowledge base when it comes to problem solving. Thus co-creation helps in building smart, value-creating solutions.
The co-create process identifies the key requirements of the overall project goal and divides the approach into four phases —

1. **Discover**
   Before diving into problem solving, it is important to explore and understand the wider context of the challenge. Here's where we must be completely immersed in user's world and look for inspiration and ideas. Gather all the existing data, meet and observe stakeholders and identify the key insights to come up with an experience flow or a journey map.

2. **Frame**
   Framing is defining the opportunity area or challenge based on the Discover phase outcomes. It is crucial for spotting the key considerations of the challenge, identifying gaps and revealing new perspectives and envisioning the possible desired future reality by asking "what ifs".

3. **Ideate**
   Ideate phase is about finding creative ways to achieve the possible desired future that was envisioned in the framing process - brainstorming into diversity and then converging the most promising ideas. We look for leading directions and develop solutions.

4. **Build**
   This is the prototyping phase where ideas are quickly built to simulate the experience or behaviour of the solution. It's a learning phase and several iterations may be required. Insights and learnings received from here can be taken into consideration by restarting from the Discover phase again.

[3]

[3] *Image Source:* *https://www.philips.com/c-dam/corporate/cocreatorlab/methodology/cocreator-logo.jpg*

3. A.

Discover

AR/VR Landscape

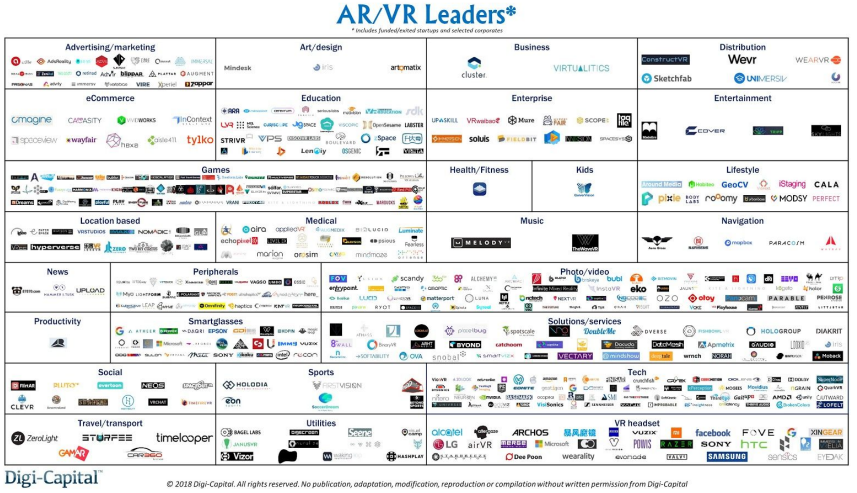
The history of AR/VR begins with the first actual VR head-mounted display created by Computer scientist Ivan Sutherland. But the technology stayed dormant until the recent years with the development of Oculus rift and other pioneers of modern era of AR/VR. With the HMD becoming more portable infused with the benefits of mobile technology, new innovative ideas have started to come alive - mostly driven by our ideas of the future in various science fiction novels and literature.

Currently the AR/VR industry has expanded enormously spreading itself over various sectors to name a few - Advertising marketing, art/design, health/fitness, entertainment, smart wearables, medical devices solution/services etc.

Nomenclature

Virtuality continuum

The concept of a “virtuality continuum” relates to the mixture of classes of objects presented in any particular display situation, where real environments, are shown at one end of the continuum, and virtual environments, at the opposite extremum. *(Milgram. P, & Kishino. F, 1994)*



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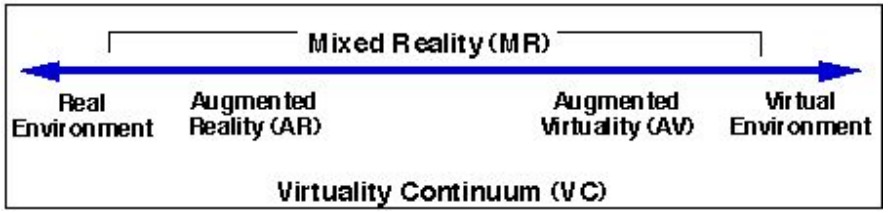
[4] *Image Source:* https://www.digi-capital.com/news/2017/11/1-billion-ar-vr-investment-in-q4-2-5-billion-this-year-so-far/#.Wz7RH9gzYWo



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This is where the virtual environment gradually merges into the real environment and vice versa. The virtuality continuum therefore provides a spectrum of various degrees of interaction between the two worlds. Within this continuum we have the virtual reality, augmented reality and mixed reality technologies.

Virtual Reality

Virtual reality provides a complete immersive experience of a virtual world where the participant-observer is able to interact with the virtual elements with a sense of control. The view to the real world is completely occluded. The properties of this synthetic world can be anything as real as our real physical environment or fictional, sometimes even exceeding the bounds of physical reality.

Augmented Reality

This augments the display of the real world by means of virtual objects and computer graphics. The participant-observer sees over-layed graphics on video streams of the physical world.

Mixed Reality

Mixed reality is the blending of the real and the virtual worlds in a manner that virtual elements also interact according to the physical reality and physics of our real environment.

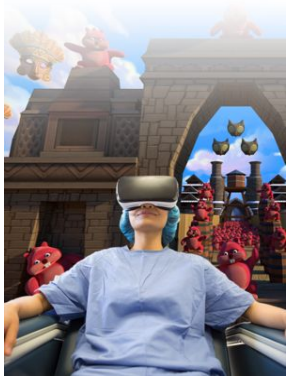
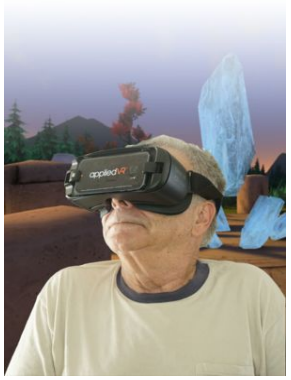
[5] *Image Source: http://etclab.mie.utoronto.ca/people/paul_dir/IEICE94/ieice.html, (Milgram. P, & Kishino. F, 1994)*

AR/VR in medical Field

In order to understand how AR/VR is being used currently in the healthcare industry, some examples mentioned next were studied.

1. Applied VR

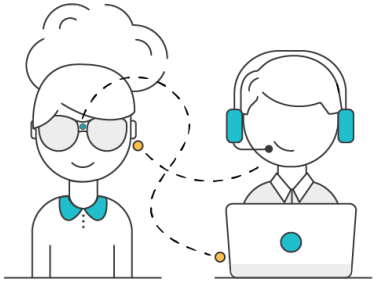
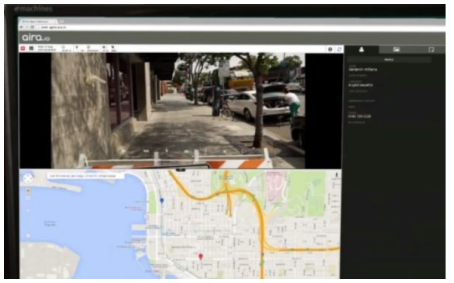
   Applied VR uses virtual reality as a means to transform behaviour through amazing VR experiences amongst patients. They design these experiences with a deep understanding of needs and motivations of the patients especially when they must face scary and painful experiences in healthcare. (Link)

appliedVR™			 [6]

2. Aira

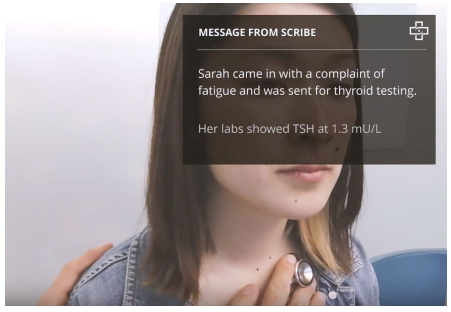
   Aira uses a video-equipped smart glass along with a smartphone app to allow its visually impaired users to navigate. It connects them to a trained professional agent who is dedicated to enhancing their everyday experience. The agents are provided with a mission control dashboard that has the real time view of the users smart glass and the GPS location along with other details.

[6] *Weblink: https://appliedvr.io/*

aira			 [7]

3. AugMedix

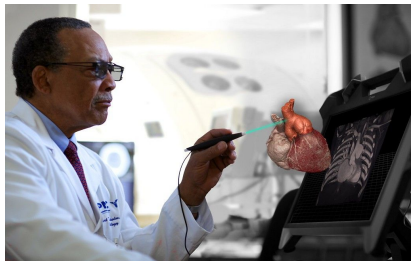
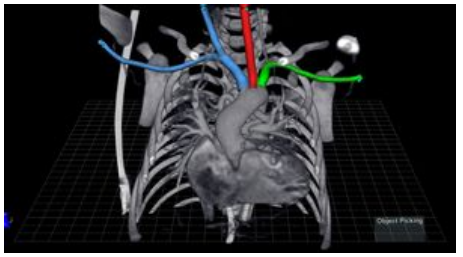
Augmedix enables doctors to give their patients the attention required during patient visits by doing away with use of computers and using smart-glass instead. The doctors are provided real-time assistance by a second-person - the scribe, for handling and accessing medical data.

AUGMEDIX Rehumanizing Healthcare			Scribes are part of the clinician's care team. They in constant contact with the clinician and can see and hear everything the clinician sees and hears. Scribes the clinician's own software to create a narrative of a patient visit.[8]

[7] *Weblink: https://aira.io/*
[8] *Weblink: https://www.augmedix.in/*

4. EchoPixel

Echopixel specializes in 3D medical imaging and aims to take it forward with virtual reality. They create 3D CT-scans as well as advanced medical visualisation software solutions that allow interactions with patient tissues and organs in 3D form. This also allows the physicians to intuitively grasp, dissect and size key clinical features out of the 3D models thus opening up possibilities for more efficient surgical planning.

echopixel			Quickly identify the anatomy of interest and determine its location in relation to surrounding anatomy. True 3D allows this.[9]

AR/VR is generally immersiveness, for instruction based applications, study of anything using 3D model that can be manipulated and for tele-communication abilities.

Hololens in Medical Field

Microsoft hololens is a holographic device that has a see through-display which allows the user to the physical environment even while wearing the headset. The virtual objects, called holograms are projected onto a translucent screen into our line of sight without completely blocking our view of the real physical world. Hololens technology then allows users to place these holograms anywhere in real world, lock it in physical space or allow it to tag-along by its capabilities of spatial mapping and sensors. Image processing allows gesture recognition for enabling interaction with the holograms. The device is in its development stage but has been released for developers and tech enthusiast to explore and experience its capabilities.

[9] *Weblink: http://www.echopixeltech.com/*

Most of the Hololens projects done in the medical field are all exploratory in nature. They have been used mainly as educational tools for simulations and learning various procedures with 3D holograms that can be manipulated. Concepts of mixed reality for surgical planning and remotely-assisted surgery have been brought up too.

AR/VR projects done in Philips[10]

1. Ultrasound Ergonomics
2. Customer Service Training
3. Site Planning with VR
4. HoloLens + Lumify
5. VitalSky AR and VR
6. Fiber Optic Real-Shape FORS + Hololens
7. VR for Behavior Change
8. Visualizing Healthcare scenarios
9. Mime: a mixed reality system helping patients to test their blood at home

[10] *Weblink: https://intranet.philips.com/Pages/Center-of-Expertise-for-Augmented-and-Virtual-Reality.aspx*

3. B.

Frame

Radiology

Radiology is a field in medical sciences that makes use of imaging to diagnose and sometimes even treat diseases within the body. It has two broad areas namely diagnostic radiology and interventional radiology.
Diagnostic radiology uses X-rays and other imaging techniques to diagnose a disease or an injury of the patient. Interventional radiology also uses imaging techniques like x-rays, Computed Tomography (CT), MRI and ultrasound for direction during a minimally invasive procedure that is carried out as part of a treatment or diagnosis.

Radiologist

They are doctors who specialise in the field of medical imaging. They are trained to diagnose and treat patients by executing and interpreting medical images. These include X-rays, (CT), Magnetic Resonance Imaging (MRI), Nuclear Medicine, fusion imaging, Positron Emission Tomography (PET) and ultrasound. As a radiologist, adequate training and understanding of radiation safety and protection is important because some of these imaging techniques involve use of radiation.

A radiologist does most of the readings and interpretations in dicom workstations in the Reading room. The important features of this room include good ergonomics with right amount of ambient light for optimal visibility and comfort during long reading hours. The room should allow a radiologist to work interactively and also improve their interpretation techniques. The furniture system must be ergonomically designed to reduce fatigue and stress related factors in the work environment.

Opportunity

MR can be used to create a more natural interaction with the 3D dicom images of the patient. The radiologist can be given options to look/walk around and through an organ or body part apart from just sitting in front of the 6-8 monitor setup for reading and interpreting the visual data.

Interventional Radiology uses medical devices like the C-arm to visualize real-time inside an operating room. They can used to visualize kidney drainage, cardiac surgery, vascular surgery, neurology procedures etc. Usually when doctors use such devices, they are provided with an adjacent screen which shows the real-time visual data obtained from the machine. Looking away from the patient to read the image is not the most natural interaction with the real-time data.

Opportunity

With the capabilities of Hololens, real-time visual data can be projected onto the transparent glasses and the physician can be enabled to see both the target and the output data together without having to look away from the target.

ICCC - Tele-ICU program

Intellispace Consultative Critical Care is a tele-ICU solution by Philips healthcare that connects hospitals to expert intensivists for consultations and enables remote-monitoring by experts. India currently is facing two major healthcare challenges - a lack of qualified Critical care experts (aka Intensivists) and access to quality critical care for people in smaller towns and villages. ICCC provides to the growing shortage of qualified physicians and nurses and aims at improving the quality of critical care delivery in remotely located hospitals. With this solution, an intensivist at the central command centre is able to monitor patients in distant multiple ICUs almost in real time. The onsite clinical staff is also empowered and provided best specialised advice while working collaboratively with all the other specialists.

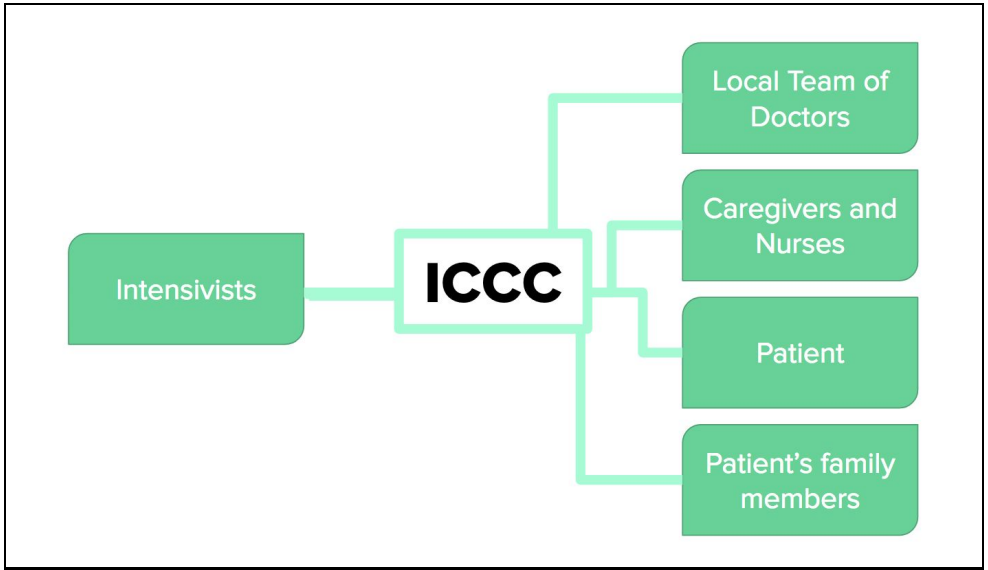


Image 1: ICCC stakeholders

ICCC setup

(Images from UNICORN lab - PIC Bangalore)

Image 2: Intensivist workstation

Image 3: ICU setup at a remote hospital

At the command centre (Image2), the intensivist is provided with a 6 monitor setup along with devices to support audio-video communication. The ICCC solution provides softwares and online portals that bring all the patient data from the connected beds straight to the workstation of the intensivist. The intensivist is able to view different ICUs and the beds that are connected to them. They are constantly provided real-time data of patient's vitals, acuity, ventilator information and various dicom images from the PACS server.

The ICU at the remote hospital (Image 3) is supported by special equipments and devices that enables real-time two-way audio-video communication with the intensivists at the command-centre and the local bedside staff. Each bed also has a bedside Emergency alarm that can be pressed for establishing immediate communication with the remote intensivist in case of an emergency. The ICU is provided with a portable cart that has a display monitor and a PTZ (Pan-tilt-zoom) Camera attached to it.

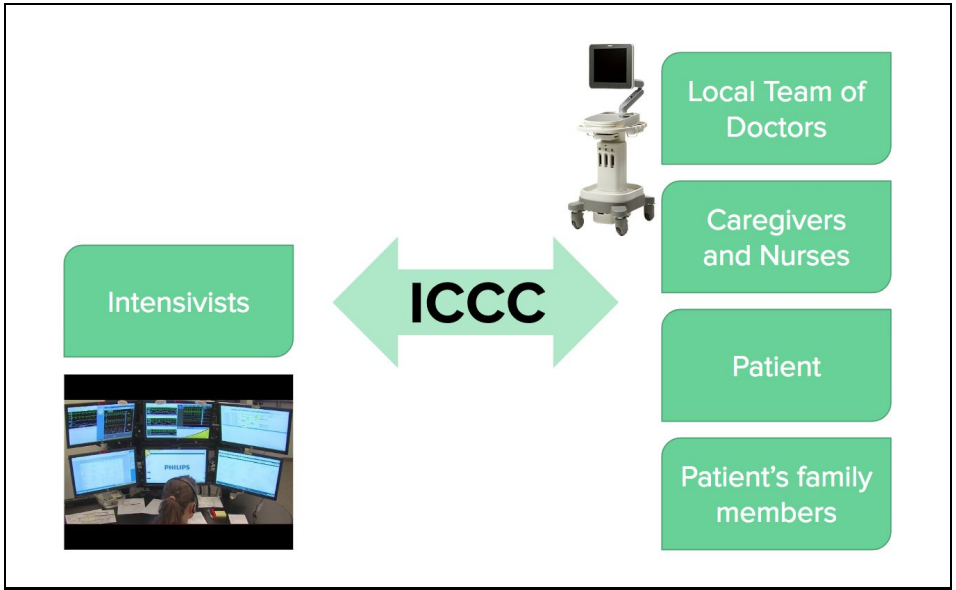


Image 4: Two way communication between the intensivist at the command centre and the local bedside staff

Opportunity

The two-way AV communication is supported with just a stationary PTZ camera and a display on the cart. There could be several critical occasions when the local bedside staff may need more than just verbal instructions to carry out a procedure on the patient or with the complex equipments that support the patient. Hololens can be used to provide the intensivist with the POV of the bedside nurse for better view. Also, the intensitist can provide live annotations and markings to the nurse's POV while the verbal instructions are received from the hololens speakers. The nurse wearing the hololens would be able to view this annotations and markings as holograms from his/her POV.

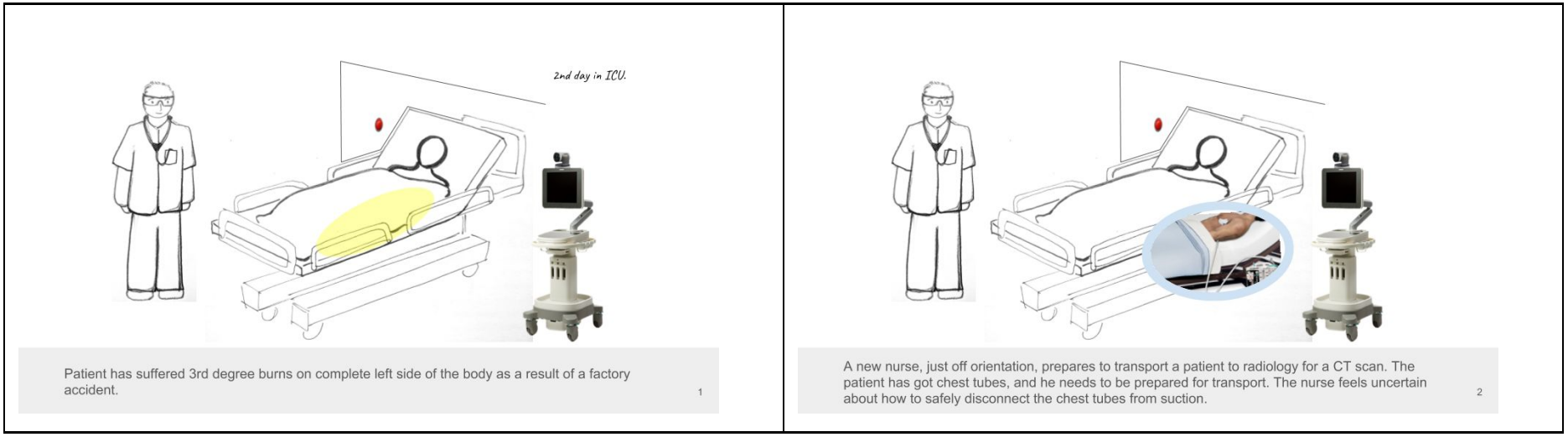
Area of Interest

Of the above three opportunities spotted, I decided to work on hololens applications for tele-ICU.

3. C.

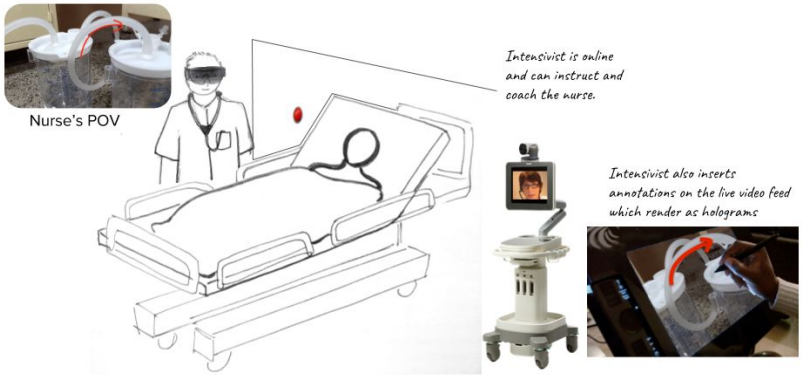
Ideate

Storyboard 1 : Critical Care Delivery at ICU with Hololens



The nurse presses the bedside alarm for requesting help and is immediately connected to the concerned intensivist.

3



The bedside nurse is relieved and feels confident and supported in caring safely for his patient.

4

On a regular routine checkup, the nurse interacts with the patient and this time the intensivist is online.

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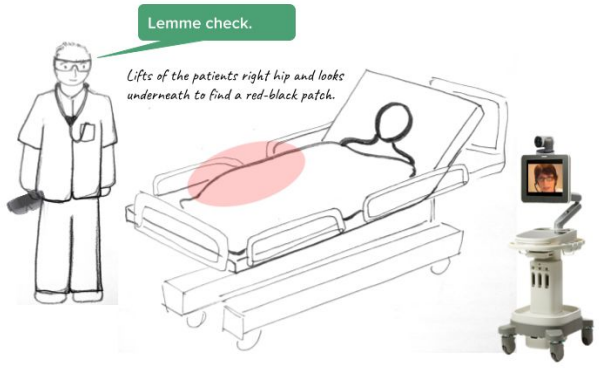

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After noticing the pressure sore below the right hip, the nurse wears the hololens and examines the wound. He also uses voice commands to enter the observations to the e-records of the patient which can also be seen by the intensivist.

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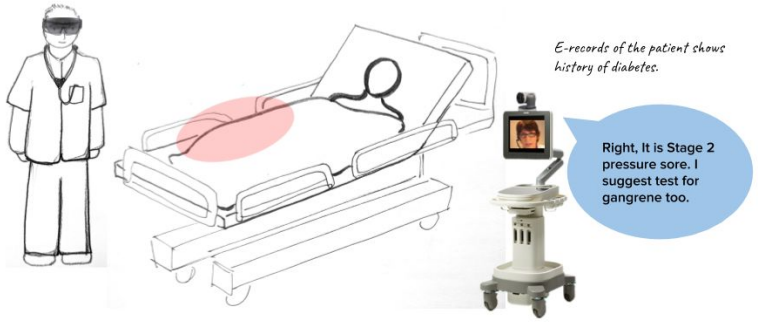


The nurse immediately carries out the dressing while the intensivists notices another valuable information on the patient history and request a test for gangrene.

9

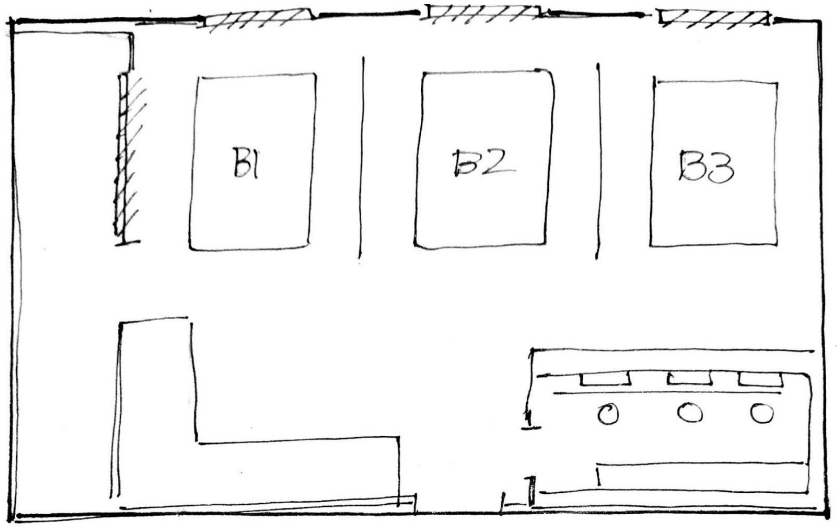
Following the lab tests, the wound is given further treatments to curb the gangrene and the care plan is revised for the patient immediately.

10

Storyboard 2 : Patient monitoring with Hololens

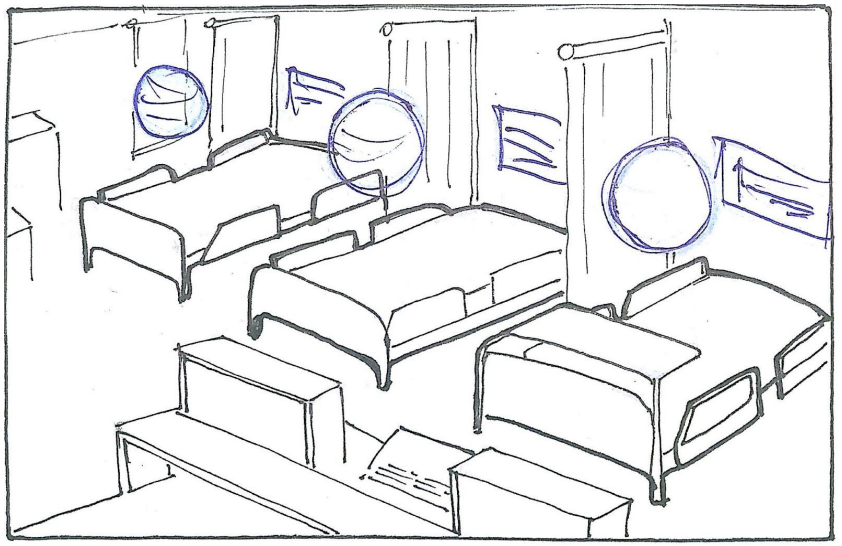
Recovery period for a patient in a hospital and especially in an ICU is about being surrounded by multiple equipments and displays. All the information on the bedside patient monitors is for the knowledge of the medical staff and not the patient. Depending on their condition they may even have several tubes and wires attached to them. Apart from this, the constant sounds of the ventilator and different alarms from the medical devices can leave behind haunting memories from the stay period at the ICU. Patients sometimes even fear sleeping thinking they might never wake up again.

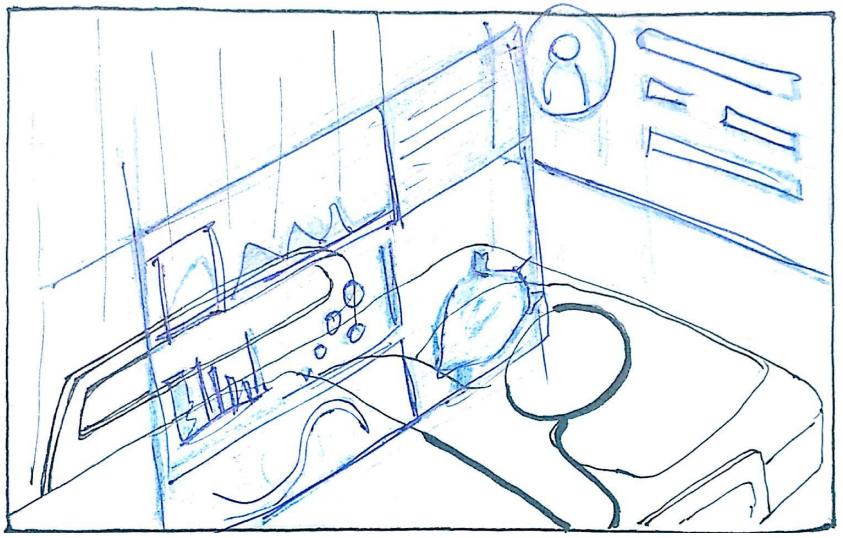
The question asked here was, what if ICU environment could be made more homely and comfortable by replacing bulky devices with smart embedded sensors that send information to a central hub in the patient monitoring room. What if bulky display monitors could be replaced with holographic screens which can be viewed by the physicians and bedside staff with hololens when required at the bedside?

An ICU plan with 3 beds and a patient monitoring hub at bottom right. All the real time data from the individual beds go to the monitoring workstation where the bedside nurses keep watch in shifts.	

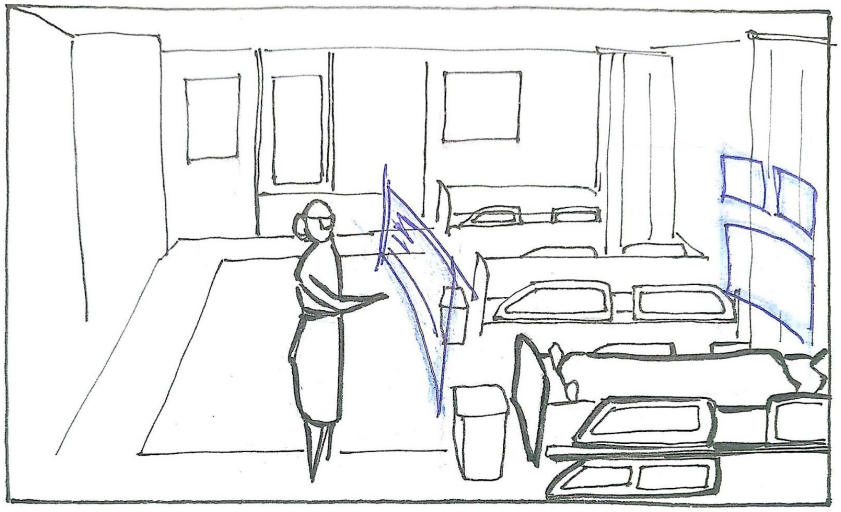
Should there be a need to view the a patient detail by the bedside, holographic information can be placed on the beds. The holograms are locked in place after the identification of a unique marker for each patient and their bed no.

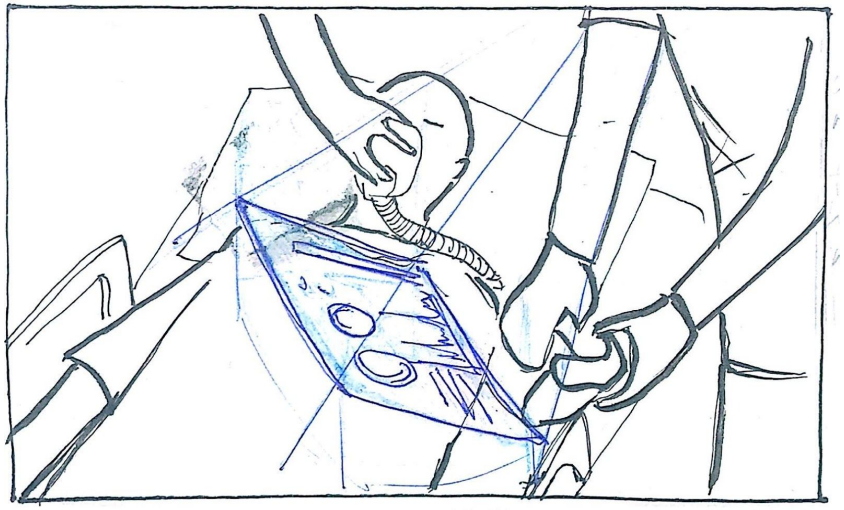
Further interactions with the hologram can be made to reveal further necessary details which could be for example a timeline of patient's medical history along with 3D dicom attachments.

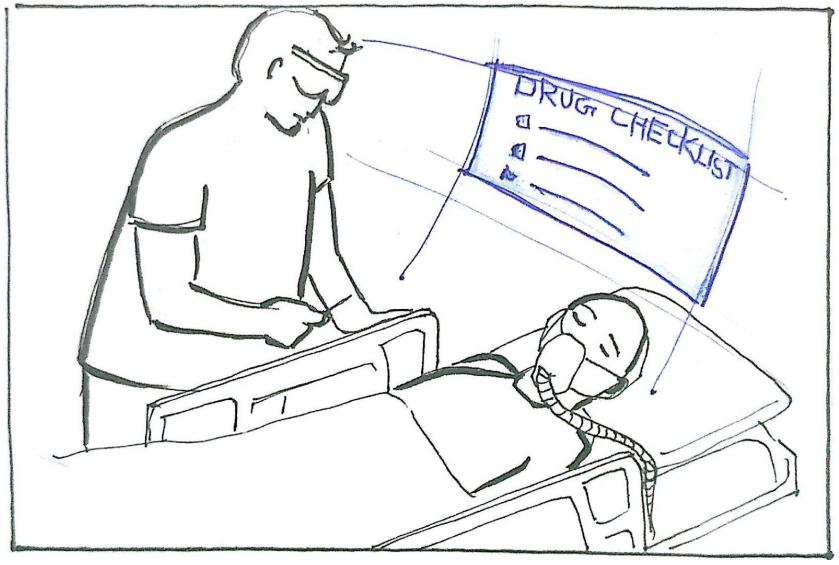




Certain applications can be made for the bedside staff to aid in their daily routine of caring for the patient. These could be in the form of tag-along holograms.

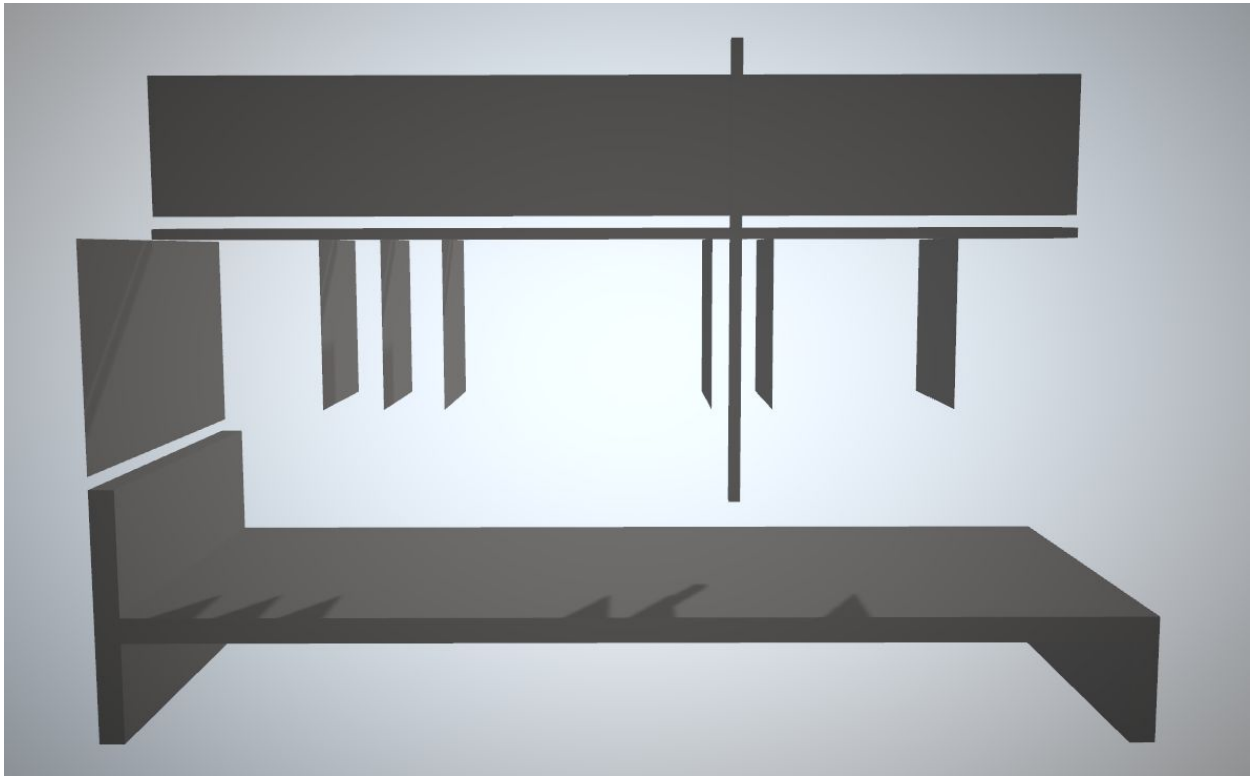




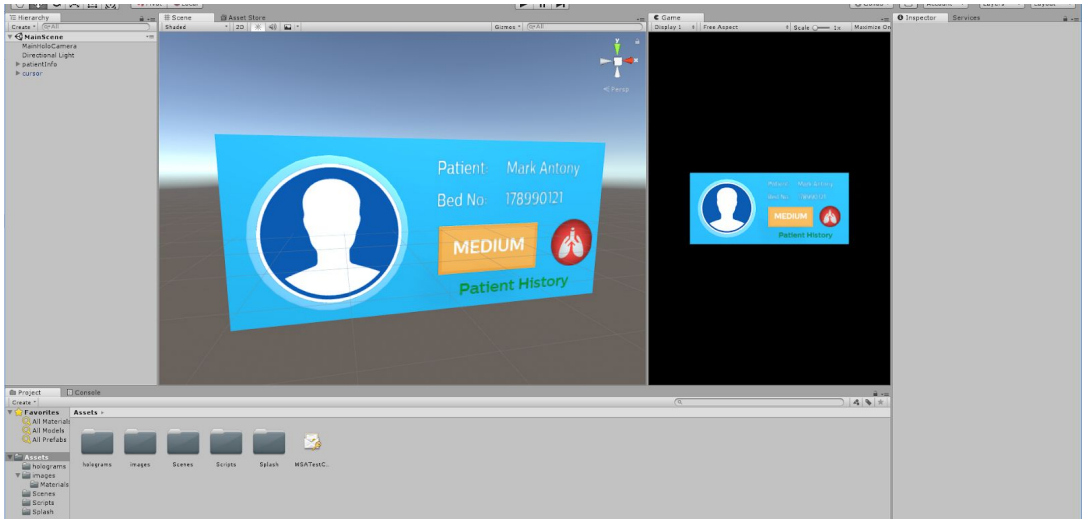


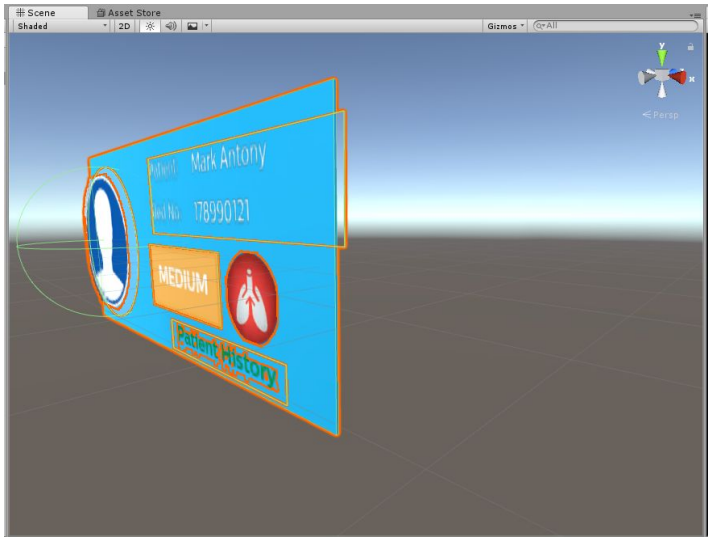
3.D.

Build

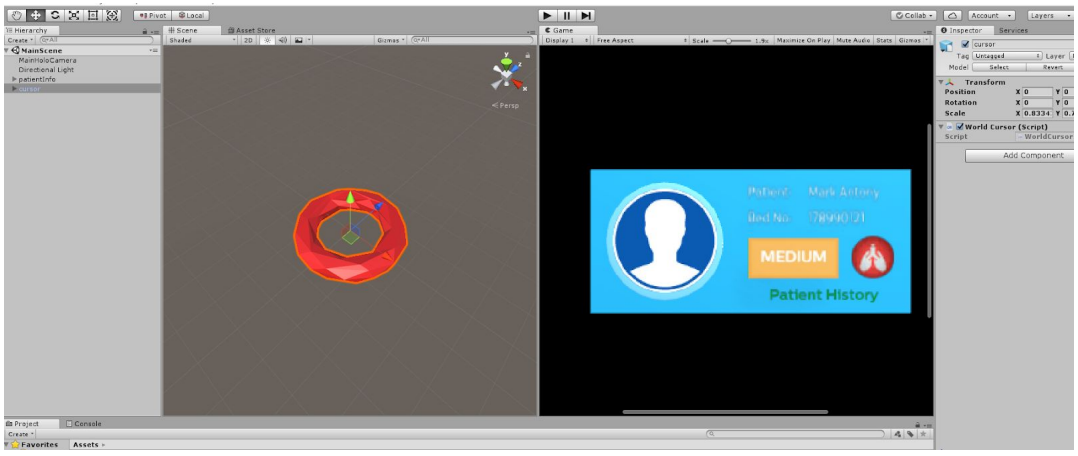


3D concept Model for positioning the holograms over the patient bed.

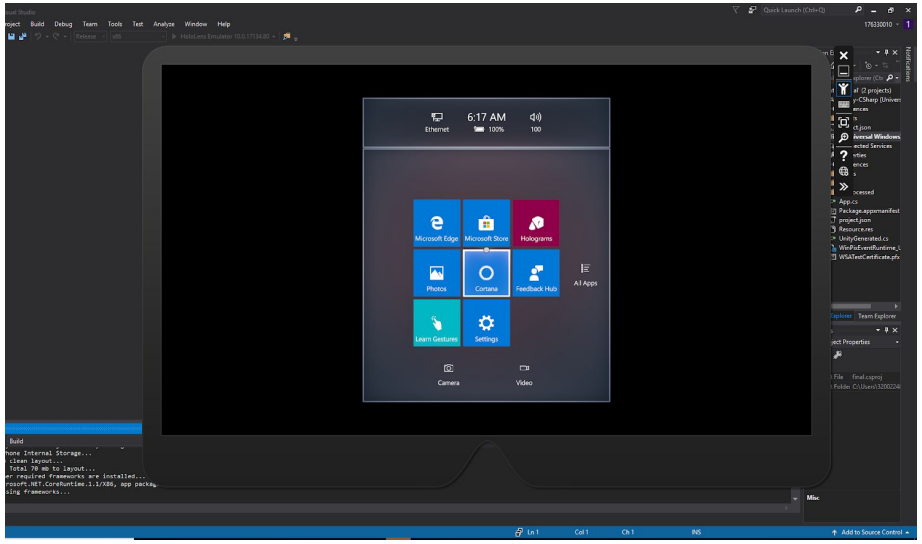
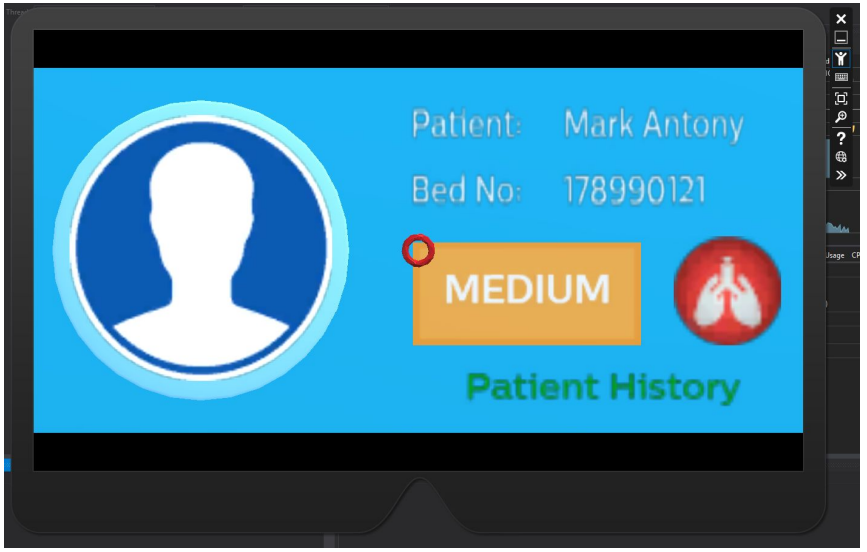


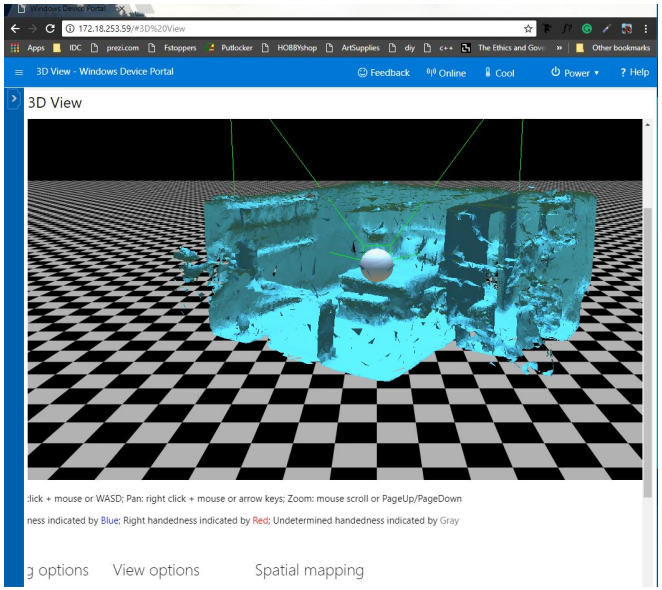
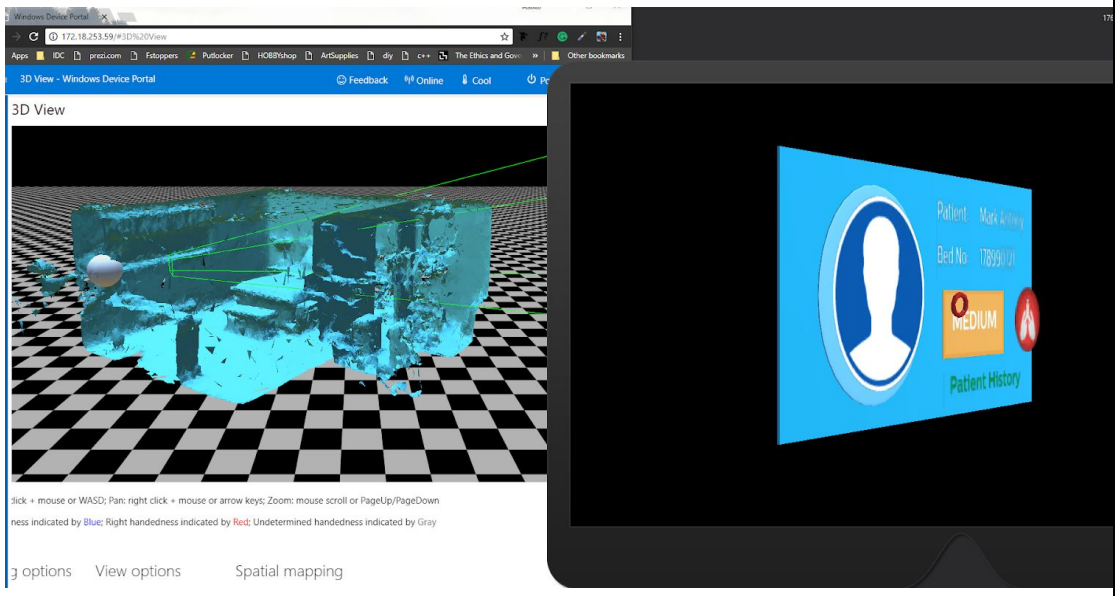


Basic Patient Info hologram modeled in Unity



3D world cursor for a gaze pointer

	
Hololens Virtual Emulator startup screen	Basic Patient Info hologram in the Emulator

	
Default Virtual Room as seen in World View	The blue mesh is the spatial map of the Default Virtual Room.

4

Overall Learnings and reflections

Dangers of Mismanaged expectations

Microsoft Hololens is a device that is still in its development stage. Most of the work done in Mixed reality so far have been concepts for future application of the device.

Device limitations like the tiny field of view will still require the user to look around for their holograms in surrounding space.

Holograms are elements of the virtual world and physical interactions with holograms is not the same as interactions with tangible elements of the physical world. Further study still needs to be done on best ways to replicate interactions like for example a button press.

Constant interaction with Holograms still causes arm fatigue after some time. This effect is also known as the Gorilla arm effect. Interactions on a vertical plane is not the most comfortable option for a prolonged use and in that case even placing a 3D vertical plane for a holographic UI must be given a second thought. To add to this on a real critical scenario, it would lead to much frustration for physicians and doctors to still use their hands for interacting with the holograms. Learning the gestures and performing them with accuracy in a critical situation will be a challenge.

When it comes to what can be shown as holograms, simple 3D models and virtual objects are the safest. Showing text content with complex data visualisation is possible but at the cost of fidelity. Moreover, only making a data 3D doesn't always have to enhance the users ability for its interpretation.

Finally, I must confess working with Hololens has been so far the most exciting project I have been on. The learning curve was indeed steep and challenging but it feels great to have started soon. A lot is being explored and studied in the area of Mixed reality and there's much to learn and unlearn.

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