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VIRTUAL REALITY IN HEALTHCARE

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Investment Banking | Healthcare Finance | Consulting

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INTRO:

The book inspired 2018 movie *Ready Player One* explores the futuristic world where VR drives life. Is the healthcare industry, both the patients and providers, ready to accept VR & AR in a variety of their daily activities? We explore the history, current, and potentials applications in this paper. Are you ready, Patient One?

During the 80's & 90's videogames began to play a major part of life, including education. This is an industry that has grown from nothing in 1972 to an estimated $100bn global market in 2016, and has no intention of slowing. As technology continues to advance at an increasing rate in both its hardware and software capabilities, our application of it evolves. It appears that the latest videogame craze of Virtual Reality ("VR") – which spans across all videogame platforms from phones to PC's—has much further implications than entertaining teenagers. Evolving somewhat in tandem and distinctively different, Augmented Reality ("AR") is an interactive mixing of digital images into the real world environment. Its seems as each day passes new viable and innovative applications are being put into use, from healthcare to social media, VR & AR is taking the world by storm.

But several questions remain: When will it be viable? What are the real applications? What are the implications for healthcare?

HISTORY:

Before discussing the current state and potential future of VR and AR within healthcare, it is important to understand the lineage of virtual reality, from the concept to modern fruition. According to Merriam-Webster's dictionary:

> virtual reality
> *noun*
>
> :an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment; also
>
> : the technology used to create or access a virtual reality

> augmented reality
> *noun*
>
> : an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera); also : the technology used to create augmented reality

Although the first digital computer was invented in 1938, the history of virtual reality goes back further than one might think. Some have made the argument that the concept of VR can be traced back to a 19th century French play which questioned the difference between an illusion and reality; which is arguably a bit of a stretch. But the fact remains that the people have at least dreamt about a device capable of producing a virtual reality, much the same way people dreamt of flying without knowledge of being able to do so. While an entire paper could be written on the history, below we highlight some of the devices and technological advances we consider the most important.

TIMELINE:

Some argue the stage for VR began earlier, but we believe that it began with the commercialization of simulations in the late 1920's; from there, there were many stepping stones to modern virtual reality:

1929 – Link Trainer or Blue box:

Edwin Albert Link forever changed military training with his invention of a flight simulator, powered by nothing more than pumps, valves and bellows. This invention which started to take flight in the 1930s became standard equipment for the US military and was used to train over an estimated 500,000 pilots during WWII.

1961 & 1962– Heilig's patent for a HMD & the Sensorama:

Modern VR started to first take shape with Morton Heilig's 1961 patent for the first ever head-mounted stereophonic television display. A year later Heilig introduced his invention of the "Sensorama", a mechanical device which immersed the user into a film of a motorcycle ride through Brooklyn, including vibrations, sound, wind and smells. While never commercialized these prototype represented the goal of fully immersing the user into a different reality, and led to a pleather of other analogous inventions

1966– Ivan Sutherland's HMD – "The Ultimate Display"

Sutherland's invention of "The Sword of Damocles" is credited as being the first modern VR headset. His invention was a bulky computer based system that used two mounted CRTs, half-silvered mirrors among other things and was able to project a monoscopic wireframe image such that it looked like a cube floating in mid-air. – *source: MIT.edu*

1972– The Magnavox Odyssey

September 1972 the first commercialized video game console was released, laying the foundation for VR to be created.

1977– Apple II – Age of Personal Computers (PC)

While the personal computer had been around for a number of years it wasn't easily accessible to the general public or really practical until the Apple II.

1984– Virtual Programming Languages ("VPL") Research

Headed by Jaron Lanier and Jean-Jacques Grimaud and funded by NASA and Thomson-CSF; VPL research is responsible for developing a number of ground breaking devices including: the Data Glove, the EyePhone and the Data Suit. Additionally it was Lanier who actually coined the term "virtual reality."

1991– Sega VR Proto-type

Sega's VR looked very much like modern equipment, featuring a LCD screen in the HMD and headphones, stereo headphones and inertial sensors. Due to complications (mostly motion sickness and "severe headaches") Sega VR was never released despite 4 games having been developed. Sega ended up utilizing a lesser form of VR for select arcade games.

1992– Virtual Fixtures

While the term "augmented reality" was coined in 1990, it was Louis Rosenberg who is credited with inventing the first AR system, which he called Virtual Fixtures. Rosenberg developed this technology at the Air Force's Armstrong Laboratory.

1995– Nintendo Virtual Boy

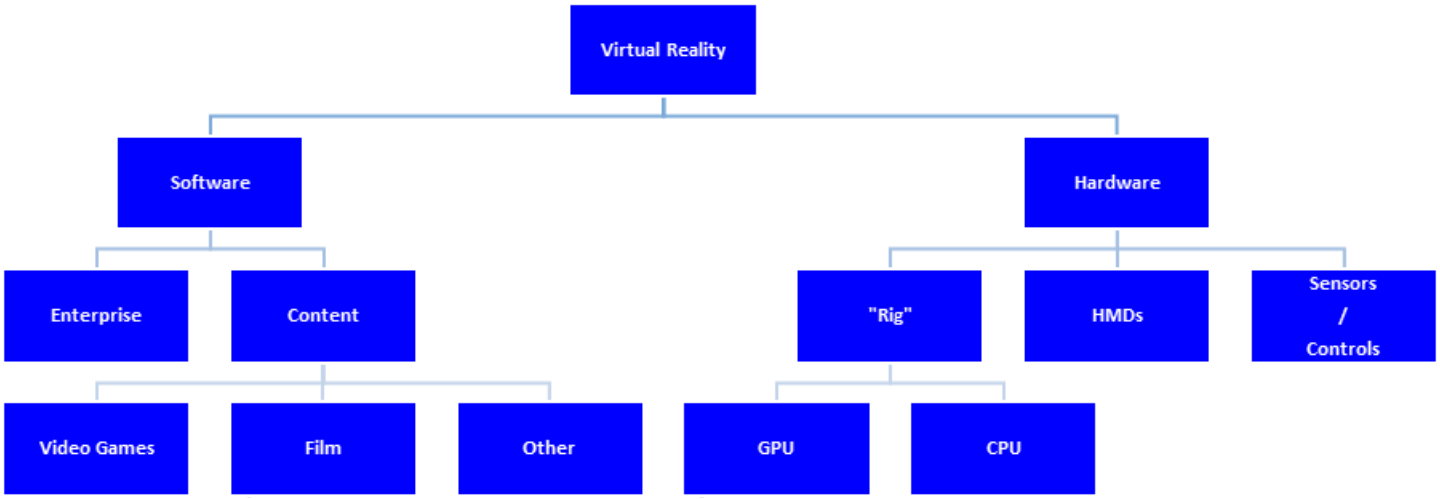
Despite Nintendo's Virtual Boy being a commercial failure, for a number of reasons including price, and graphics (with a side of motion sickness), it created an important landmark as the first VR console.

2010–Oculus Rift – VR Headset Company

Founder of Oculus VR Palmer Luckey first designed the Oculus Rift in 2010 and further expanded the technological capabilities and commercialization of VR. Oculus VR was acquired by Facebook in 2014 for $2bn.

WHAT GOES INTO VR?

It is important to understand the different aspects that make up the modern Virtual reality set ups to understand its current applications, limitations and ultimate acceptance. Broadly speaking, it consists of two main categories: Software and Hardware, and from there is broken down.



Software:

- Enterprise
  - The enterprise software represents the backbone of this immersive technology, and is responsible for the features and expansion of applications across different industries.
- Content
  - Film
    - Some films are now being designed specifically from the VR perspective
- Video Games
  - Currently representing the largest portion of the market and certainly the growth driver for the industry as it still seeks to develop widespread acceptance.
- Other
  - Other applications of these devices are being developed outside film and video games within the healthcare sector including: training surgical students, aiding infusion patients, and aiding therapies to name a few.

Hardware

- The "Rig"
  - The Rig is slang for the actual device that allows the other VR components to do their magic. The "Rig" can consist of a video games console, PCs or even a smart phone.
- GPU or Graphics card
  - Graphic Processing Unit (or graphics card) represented a rapidly growing industry during 2017 and 2018 as crypto currencies took the headlines. However these chips are what allow for virtual realities to take shape.
- CPU or Processor
  - Central Processing Units read and carry out the programs instructions that allow the computer to function
- HMD's
  - The Head Mounted Displays is the display device that the user wears
- Sensors & Controls
  - The sensors are placed around the users designated area to sense the user's movement, the controls are the components that the user holds to interact with the virtual world.

DEVICES:

Although there are simpler set ups available that can consist of as little as a disposable cardboard viewer and a smart phone, we examine the more advanced options as costs continue to decline, allowing them to become more accessible. Several manufactures have entered the market (which will be discussed later). but Oculus's products were used for our example.

VR Headsets or HMD is the backbone of the VR and AR's immersive experience. This is largely due to the implementation of a high resolution 3D screen, a wide Field of View ("FOV") usually 110 degrees, a higher refresh rate (normally at least 90Hz), and 3D stereophonic headphones.

All of these elements are imperative to the user's immersive experience as well as the functionality. Resolution normally sits at 1080 x 800 per lens, totaling a collect resolution of 2160x1200. High refresh rates are required because screens with a refresh rate of 60Hz or frames per second ("FPS") causes the screen to loose sync with the video feed, and cause what is known as "screen tearing", which can cause motion sickness.

The FOV is also important to the user so that he may forget he is wearing a HMD. The average human eye has a binocular FOV of roughly 120, while most HMDs are capable of 110 degrees. Lastly higher end HMDs are equipped with 3D stereophonic headphones.

Headset: Oculus Rift

AR Headsets although similar to the untrained eye, are actually quite different. Augmented reality isn't about immersing the individual into another reality, rather "enhancing" the current one. The Microsoft HoloLens is the real contender out right now, but is noticeably young in its development with a very limited field of view is roughly 30 degrees compared to VR at 110 degrees

Headset: Microsoft HoloLens

Controllers are used to interact with the virtual or augmented reality and vary from manufacturer to manufacturer in terms of their cost, functionality and features.

The controllers shown to the right is an example of a fully interactive device equipped with both buttons and sensors capable of tracking of tracking the users physically movements, including lateral, vertical as well as rotational motion. Alternatively more basic controls can also be used.

Controller: Oculus Touch

Sensors are a newer commercialized element to VR, with HTC rolling out the sensor based tracking system in 2016. Sensors are used in conjunction with the headsets and controllers to track the user's movements within a defined space. However, these sensors are not required to use all the functionality of VR.

Sensor: Oculus Sensor

MARKET SETTING:

While Oculus VR, who was acquired by Facebook for $2B in 2014, held majority market share, Oculus VR is no longer the only player. A number of large tech giants have entered the VR and AR markets on either the hardware or software side or both, and they seem to entering the market at an accelerating rate. As technology and investment in VR / AR continues to grow, it becomes more accessible. International Data Corp. (IDC) estimates that total spending on AR and VR grew from $9.1B in 2017 to $160 billion in 2021, representing a CAGR of 113.2%.

Selected Major Players – VR / AR

Oculus VR (Facebook)
VR HMD - Oculus Development Kit 1 – March 2013
Price: $300

Google
AR HMD - Google Glass – Jan 2015
Price: $1,500

Samsung
Phone VR HMD - September 2015
Price: $99.99

Microsoft
AR HMD - Hololens Development Edition – March 2016
Price: $3,000

HTC & Valve Corporation
VR HMD – HTC Vive – April 2016
Price: $800

Sony
PlayStation VR - October 2016
Price: $400

Lenovo
Microsoft VR HMD - "Mirage Solo" - January 2017
Price: $400

Acer
Microsoft VR HMD - December 2017
Price: $300

Asus
Microsoft VR HMD – February 2018
Price: $429

CAPITALIZATION:

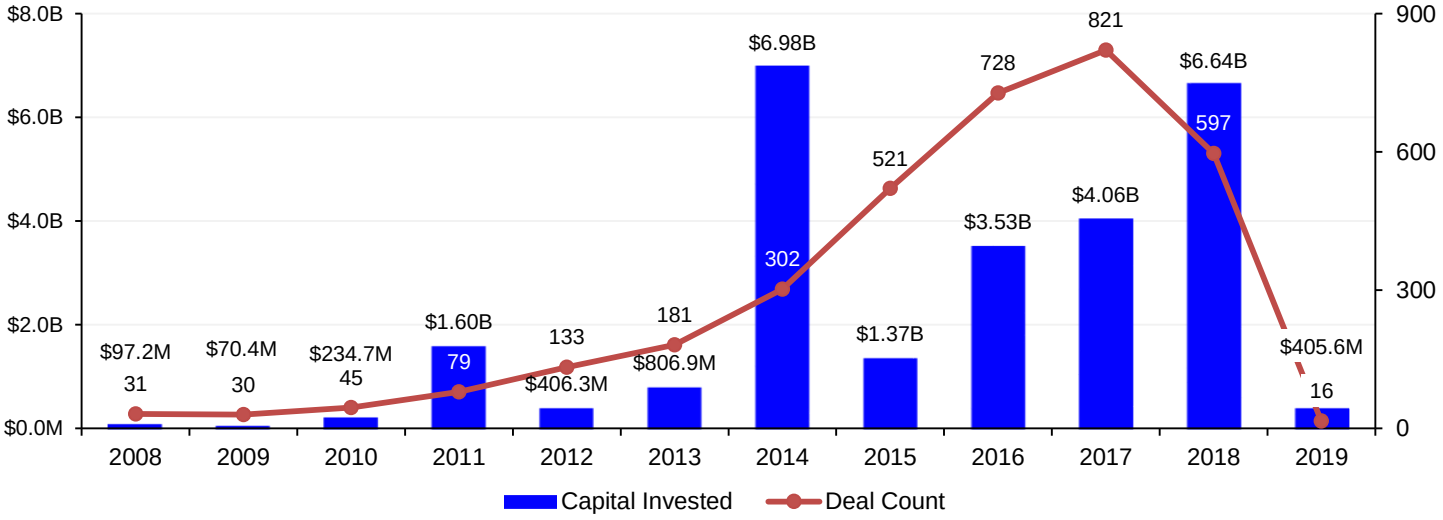
As with most technologies there are many heavily backed, innovative startups looking to change the world. Shown to the right is a list of 12 most capitalized VR or AR focused startup companies.

Transactions sizes are increasing in the AR & VR space across the globe and through a variety of methods, including IPO's and M&A activity.

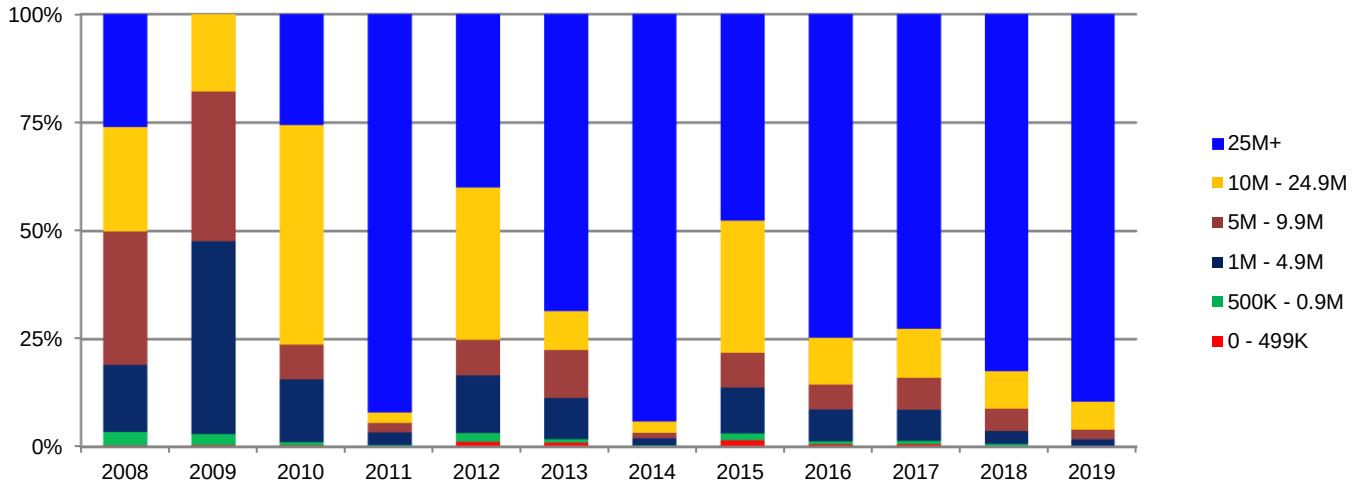
Total transaction activity in 2018 saw a 64% increase YoY with a strong start within the first month of 2019. Additionally the average VC deal size continues to push high with a 64% jump in average deal size between 2018 and 2017.

#	Company Name	Product	HQ Location	Deal Date	Deal Size (millions $)	Deal Type
1	Oculus VR	Developer of the first widely popular moderan VR Device	Menlo Park, CA	21-Jul-2014	3,000	Merger/Acquisition
2	Epic Games	Large video game company investing in AR & VR technology	Cary, NC	26-Oct-2018	1,250	Later Stage VC
3	Magic Leap	Developer of a AR software and headset	Plantation, FL	07-Mar-2018	963	Later Stage VC
4	Polariant	Developer of a light sensing module used in VR technology	Seoul, South Korea	18-Jan-2017	600	Grant
5	Crytek	Video game company investing in VR focused games	Frankfurt, Germany	27-Dec-2016	500	Grant
6	MindMaze	Developer of a VR, AR software used to build novel interfaces for neurorehabilitation	Lausanne, Switzerland	17-Feb-2016	100	Corporate
7	Aira	Developer of a wearable assistive product designed to help visually impaired people	La Jolla, CA	27-Dec-2018	17	Early Stage VC
8	Vicarious Surgical	VR / AR robot assisted surgical platform	Charlestown, MA	01-Jan-2019	10	Early Stage VC
9	Surgical Theater	VR visualization platform for patients and surgical prep	Cleveland, OH	19-Oct-2015	9	Early Stage VC
10	Karuna	VR based pain and physical therapy clinic	San Francisco, CA	30-Jan-2019	3	Angel

AR & VR Capital Invested



AR & VR - VC Investments by Deal Size



Source: Pitchbook Data, Inc.

SELECT HEALTHCARE VR/AR TRANSACTIONS:

#	Deal Date	Company Name	Deal Size (millions $)	HQ Location	Deal Type	Description
1	04-Sep-2018	MVI Health	20.0	Alameda, CA	Secondary Transaction -	Developer of a digital health platform designed to explore healthcare applications of virtual reality technology. The company's digital health platform combines a unique immersive computing platform with an innovative approach to develop and commercialize medical products and bring the tremendous potential of immersive, full-presence virtual reality to help improve lives through better healthcare.
2	12-May-2012	Archermind Technology (Nanjing) (SHE: 300598)	17.4	Nanjing, China	Corporate	ArcherMind Technology Nanjing Co Ltd is a China based company engaged in offering software research, development, and consulting service in the fields of mobile devices and internet software. It provides solutions in the fields of Intelligent terminals, Smart automotive, Internet of Things (IoT) and Mobile internet. In Intelligent terminals, the company provides solutions for smartphone, tablet and virtual reality. Smart automotive comprise solutions such as digital cluster, automotive infotainment, intelligent cloud mirror, and smart cockpit. IoT solutions offers solutions for healthcare, home, kitchen and bath, whereas Mobile internet involves finance solutions. The company has business presence in around the world.
3	18-Jan-2018	SyncThink	7.4	Palo Alto, CA	Later Stage VC	Developer of eye-tracking metrics and devices designed to give medical professionals objective metrics for visual attention. The company's eye-tracking metrics and devices are fully-integrated, head-mounted eye-tracking device for rapid and reliable assessment of attention focus and it uses virtual reality to assess abnormal eye movement, enabling doctors to monitor and optimize brain health of patients.
4	06-Jul-2018	AdviNow Medical	6.0	Scottsdale, AZ	Seed Round	Developer of a SaaS platform designed to manage the clinical experience of patients as well as automate clinical operations for primary and urgent care facilities. The company's platform utilizes artificial intelligence and augmented reality for patient triage without the presence of medical staff and intuitively instructs the patient using AR to self-perform vital measurements following standard of care medical protocols. This creates a more comprehensive data set for the AI to accurately diagnose the patient illness. This allows for the elimination of patient wait time, reduction of provider documentation time, and improvement in outcomes with a dramatic reduction in clinic operating costs as well as health system care management cost.
5	22-Jun-2015	Help Lightning	5.3	Birmingham, AL	Early Stage VC	Developer of virtual interactive presence technology designed to establish customer relationships by changing the speed, quality and responsiveness of the service organization. The company's virtual interactive presence technology offers a patented mobile application technology that digitally merges two real-time views, blending local and remote collaborative video streams to give or receive interactive help anywhere, enabling technical, healthcare, manufacturing and service experts to show a resolution, not just describe it, even thousands of miles away, enabling users to improve their communication capabilities.
6	14-Sep-2018	Limbix Health	5.0	Palo Alto, CA	Early Stage VC	Provider of a virtual reality and digital therapeutic tool intended to help mental health professionals get more effective care. The company's tool uses virtual reality to administer VR exposure therapy, assign CBT assessments or exercises and track patient progress, enabling patients to overcome anxiety, phobia and obsessive-compulsive disorder easily.
7	24-Oct-2017	DVR	4.5	Moscow, Russia	Early Stage VC	Developer of a software designed to create virtual reality and augmented reality technology for business and entertainment. The company's software development services are customized as per business and entertainment needs and users can play games virtual reality mode with their smartphone and mobile VR helmet. It also helps to complete business tasks of various levels and designation for industry, healthcare, education, culture for implementing advertisement, PR and marketing projects that lead to customer's brand awareness and increasing brand loyalty.
8	25-Jan-2019	ELoupes	4.2	Seattle, WA	Seed Round	Operator of a platform intended to offer visualization technologies. The company's platform offers virtual and augmented reality, enabling medicinal businesses to avail improved and enhanced healthcare technology systems.
9	20-Sep-2018	Oxford VR	4.1	Oxford, United Kingdom	Early Stage VC	Developer of cognitive treatments for clinical conditions with significant impact on patients, the health system and wider economy. The company's treatments take a cognitive therapy approach, basing therapeutic techniques on a tested theoretical model of each problem. Its treatments are automated, with the therapy delivered by a virtual coach which helps to increase dramatically access to the best therapies.
10	13-Jun-2016	Reacts	4.0	Montreal, Canada	Later Stage VC	Developer of an interactive audio-video platform designed to suit the multiple collaborative needs of healthcare professionals and patients. The company's platform offers features like secure instant messaging and file transfer, teleconsultants, remote education and supervision tools and group licensing and administrative dashboard amongst others, enabling users to create a rich, virtual presence experience.

HEALTHCARE APPLICATION - TRAINING:

Healthcare is fraught with difficulties on all fronts. Whether it is effectively and safely training med students or, delivering cost effective treatment, patient engagement or patient morale, virtual reality and augmented reality are working to improve old methods.

Medical schools, in increasing numbers, are implementing VR into their programs and in a big way. The University of Nebraska Medical Center invested $118.9mm into a VR and AR center in 2017 which will be used to train medical professionals. This is likely in part to the fact that multiple studies suggesting that utilizing VR in the classroom can increase memory retention.

Specific training applications for this technology include:

1.) **Surgical**

a. **VR - Observing** is an important part of learning as a medical student, particularly with surgery. Rather than having the students observe a live surgery, possibly struggling to get a proper view, students are now given the ability to watch a complex surgery anytime. Surgeons are now being equipped with a small camera, recording a first person view of the entire surgery, allowing for med students to experience the surgery first hand.

b. **VR - Simulations** allow students (or patients) to "tour" the human body to gain a better understanding of human anatomy (or a scheduled procedure). Additionally VR can be used to create surgical simulations, allowing the med students to practice techniques without the risk of operating a patient. Shown to the right is an example of a knee surgery simulation. This technology is taking a foot hold with the Ohio University has beginning to replace cadavers for VR simulations, as they are a safer more cost effective tool.

Source: newscientist.com

2.) **Dentistry**

a. **VR - Simulations** for dentists are designed to create an immersive experience, and are able to practice many procedures such as drilling. The drilling simulator requires the student to use the correct technique appropriate amount of force as well as providing feedback on how to improve.

3.) **Paramedic**

a. **VR - Simulations** allow paramedic students to practice lifesaving procedures in an immersive, high stress environment; without a patient's life at stake. The researchers at the Australian university, Edith Cowan University have been working with the VR production company Virtual Guest to create a fully immersive 360 virtual reality environment which simulates a mass casualty event.

4.) **Hospice Nurses**

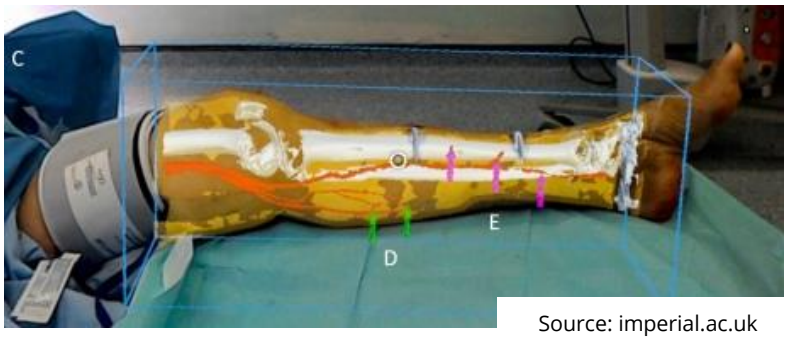
a. **VR - Simulations** are now being explored for hospice nurses to help the nurses have a more sincere understand of the patients experiences, hopefully leading to better care.

HEALTHCARE APPLICATION - CLINICAL:

While the classroom setting involved mostly VR, hospitals across the country are testing and rolling out both VR and AR for a clinical setting. However augmented reality largely remains in its infancy, as such many of its applications listed below are in a research capacity.

1.) **Surgical**

a. **AR – Location of organs and major blood vessels** is of crucial importance to a surgeon. Augmented reality will allow to surgeons to identify where specific organs are without making an incision. The Imperial College of London is testing out the Microsoft HoloLens and how it can be used to help surgeons find blood vessels directly.



Source: imperial.ac.uk

b. **AR – Vitals** are of vital importance for any surgeon. Augmented reality now allows for a surgeon to easily monitor things such as an echocardiogram, just above the field of view as the surgery itself.

c. **VR – Surgical Robotic Arms** over the past several years has gained a lot of popularity, boasting a faster and more precise surgical option when compared to traditional surgery. These robots are now starting to be used in combination with VR headsets

2.) **Paramedic**

a. **AR – telehealth** is one of the proposed uses for the Microsoft HoloLens, and is probably one of the more innovative uses of AR in healthcare. However, as for now, this technology is still in its infancy.

3.) **Patient Care / Engagement**

a. **VR – Rehabilitation** has gained significant traction in terms of market interest and success. Large hospital systems, such as Nationwide Children's Hospital, have also teamed up with game developers such as Multivarious to create custom applications. Specifically, Multivarious created an application that measures upper body movements and improvements after therapy. Additionally, Mindmaze, who successfully raised $100mm in February 2016 from Hinduja Group, had developed a therapy for stroke or traumatic brain injury.

b. **VR - Chronic Patient Care** is one of the largest applications of VR in healthcare we have seen. There are numerous startups and hospital systems who are developing software to relax chronic patients. Nationwide Children's Hospital has developed a pediatric patient engagement videogame called Voxel Bay.

These are just a few examples of some of the applications hitting the market. However, as the technology continues to develop, we will see more direction and more applications of it.

SELECT HEALTHCARE COMPANIES

VR & AR companies are finally pushing past the stages of a pipe dream, with real applications, and real investment specifically within the healthcare space. A select few of the healthcare focused companies are discussed below:

Virtual Reality: Patient Engagement / Surgical Planning / Education

SURGICAL THEATER

https://www.surgicaltheater.net/
Privately Held (backing)
Founded: 2010
HQ: Cleveland, OH

Surgical Theater, a venture capital backed startup out of Cleveland is the developer of a VR platform designed to offer an immersive environment for patients and physicians alike. The company's solutions include a surgical planning tool for physicians, a patient engagement element that walks the patient through a procedure and an education element for med-students, walking students through various cases. The company currently sees its product mostly used in an education setting and in the patient engagement setting; less so in the surgical planning.

Source: surgicaltheater.net

The company raised $9 million of Series A venture funding from lead investor HTC on October 19, 2015. Great Lakes Innovation and Development Enterprise, Shanghai Creation Investment Management and other undisclosed investors also participated in this round.

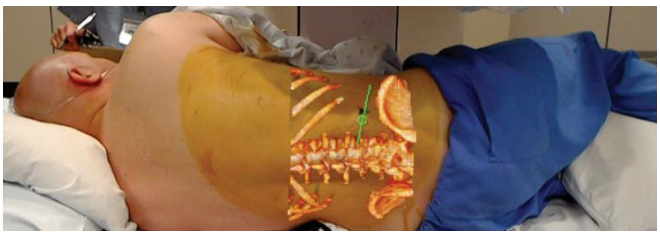
Augmented Reality: Surgical Planning

NOVARAD®

https://www.novarad.net/
Privately Held (no backing)
Founded: 1990
HQ: American Fork, UT

In October the Utah based company Novarad, made history with its product OpenSight as being the first AR medical solution for the HoloLens to receive FDA 510(k) clearance for pre-operative surgical planning. The technology which is distinctively different from VR solutions is capable of uniting preoperative imaging and AR to projecting 2D, 3D and 4D imagines onto a patient's body in real time.

This technology is capable of handling a multiple users at once in either a clinical or training application. However the company sees the value proposition the new found speed and accuracy surgical planning offered with OpenSight.



Source: novarad.net

Virtual Reality: Patient Engagement

LittleSeed
Clincally driven. Evidence-based fun.

http://littleseed.io/
Founded: NA
HQ: NA

Nationwide's Children's hospital has developed a patient engagement tool for children who are undergoing treatment which is often reoccurring, painful and difficult for the child to endure through its project LittleSeed.

LittleSeed has developed the VR patient engagement game, Voxel Bay, which is a cost effective VR video game that works to captivate and distract children as they go through procedures, often painful such as infusion therapy.

Source: littleseed.io/

Virtual Reality: Education

BIOFLIGHTVR

https://bioflightvr.com/
Privately held (Incubator backed)
Founded: 2015
HQ: Los Angeles, CA

BioflightVR is a developer of an immersive platform designed to cater to hospitals, universities, and medical device companies. Although many companies in the VR space are creating educational platforms for doctors and medical students to learn, this company has a unique offering for medical device companies.

Suppose a company has a new medical device offering. However, teaching physicians how to use the device might be a little more complicated than anticipated. BioflightVR is working with medical device companies to create an educational component to them. Therefore, physicians will only need the proper equipment to learn how to properly use the new medical device, or apply a new surgical implant.

Source: Oculus

The company's value proposition comes from a 2018 case study, which suggests that employee training time was cut by 40% with the use of VR. Additionally, they mention that the live training can be very costly, and a virtual reality training session allows whomever is being trained to conduct the training session at any time, at their own pace.

BioflightVR boasts a variety of big-named partners, including Nvidia, Oculus, HTC Vive, Duke University, and a couple hospital systems in Los Angeles and Akron, Ohio.

Virtual Reality: Mental Health Therapy

MAESTRO GAMES, SPC

https://www.maestrogames.com/
Privately Held (no backing)
Founded: 2016
HQ: Los Angeles, CA

Maestro Games, SPC is a mission driven social purpose corporation based in Los Angeles who is developing a digital health targeting the mental health epidemic, focusing on those who suffer from PTSD, Moral injury, depression, anxiety, addiction and stress.

Maestro's platform works to gamify the proven effectiveness of music, with the captivating power of positive imagery on the virtual reality platform; creating a fully immersive experience, called "The Last Maestro" ™. The Company is currently partnered with Oakland Symphony Orchestra and is finalizing its partnership with a large technology company.

Concurrently, they aim to disrupt expensive and inefficient employee wellness programs. When the workplace is the fifth leading cause of death in the US (and global statistics are equally alarming) innovative and effective solutions are urgently needed.

Source: maestrogames.com/

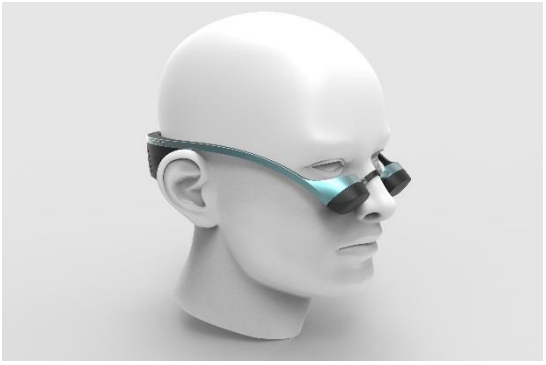
Virtual Reality: Physician-focus Headset

Amalgamated Vision

http:// amalgamatedvision.com
Privately Held (no backing)
Founded: 2010
HQ: N/A

Amalgamated Vision is the developer of a patented optical engine and binocular eyewear HMD, capable of VR, AR and MR configuration. Their product is capable of displaying images, video and text to the user without obstructing the user's field of view.

The device is designed to display "routine DICOM data generated by CTs, MRIs and other widely-used radiographic modalities, using readily available software algorithms." Capable of being operated by a tablet, phone or other device, Amalgamated Vision's HMD offers a unique way for a physician to interact with a patient without blocking the normal field of view.



Source: amalgamatedvision.com

CONCLUSION

The VR & AR industry saw a tremendous spike in interest and investment in 2014, what many people believe to be a momentary peak, recalling the initial VR craze in the early 90s that never took off. This time things may be different for a multitude of reasons:

1. Accessibility: When VR was first entering the markets in the 90s it was exciting but it didn't' quite make sense. At almost the cost of the N64 a more powerful fully functional system, Nintendo's Virtual Boy cost $179.99 and its technology was inadequate at best. Worst of all, it still caused motion sickness, with some speculating it caused lazy eye conditions in children. The dramatic improvement and cost of technology has made VR incredibly accessible (also known as Moore's law), needing nothing more than a smart phone and a cardboard headset. However with AR being a much newer technology it remains incredibly expensive, with Microsoft's HoloLens last quoted at $5000 for the prototype.

2. Hardware and Software Developments: Over the past two years, let alone the past 20 we have seen an astonishing leap in graphical capabilities on both the hardware and software side, primarily noticed within the gaming community. Although seemingly irrelevant to healthcare, we must understand in order for the VR & AR applications to be successful, they must be immersive (a lack of motion sickness or "severe headaches" would be a nice start), and convincing in terms of video and audio stimulation.

Source: pcgamesn.com

Source: techspot.com

Currently the most popular application of VR within healthcare broadly speaking is patient engagement and training; we believe this application will continue to receive investment and acceptance as an effective, low cost option.

While both the cost and technology have come lightyears over the past 10 years (mind you the comparison above is already out of date), the technology is likely too early for widespread / meaningful acceptance within the physician community. Aging physicians who didn't grow up or train with these devices will likely be resistant to use its application outside of patient engagement. Additionally, the matter of who is baring the cost of these devices is still on the hospitals, although multiple groups are working to get CPT codes put in place. And as for now, the hospitals who advertise this technology for surgical application are likely using it as a marketing tool. However as more med-students are learning or incorporating VR / AR, it could be a reality for physicians to apply VR or AR into everyday practice.

Founded in 2003, Lawrence, Evans & Co LLC is a boutique healthcare financial advisory and investment banking firm comprised of senior level professionals who provide lead advisory services to private companies, lenders, and other parties-in-interest that are executing financial and strategic transactions. The firm provides a wide array of services such as finance and capital raising, mergers and acquisitions, management consultancy services, turnaround management and restructuring, and real estate finance and development. The firm caters to the healthcare providers and service companies (senior housing, hospital, physician services (dental, derm, opth, PT) behavioral health, RCM, HCIT, Population Health, etc.), transportation and logistics, and select niche manufacturing sectors. Transactions typically up to $250 million revenues or $15 million EBITDA.

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