introduction

3D visualization and holography

- the trigger of 3d tech

  'A picture speaks a thousand word'. As mirrored in the number of studies on visual perception, vision is our most important sensory modality. From the drawing sketch on paper to the digital photograph and electronic statistic diagram, people have long been seeking for effective way to display information and knowledge. The purpose of information visualization lies in facilitating user's understanding of object, which means people gaining knowledge from sense of sight, encoding and forming personal cognition, and obtaining memory or solution from the interactive analysis. During this process, the representation of the information directly affects users' understanding and reception of knowledge, and further affects their reaction and corresponding behavior. With the demand of intuitive and interactive method of visual representation, Stereoscopic 3D (S3D) technology grew up gradually and became an effective solution.

- peoples need of 3d representation, advantages

  Researchers did some work on exploring the advantages of 3D representation.
  泛论（更熟悉），研究表明有助于长期记忆，可以解决2D可视化的不足，一些独特的优势
  In general view, people are 3D creatures, living in a 3D world, being more familiar with 3D object, thus our preference of 3D content is natural. H. U. Amin et.al investigated the impacts of S3D technology on human behavior during learning and long-term memory, which showed that human processed the S3D contents with widespread cortical networks as compared to 2D contents. 3D technology also fills up the deficiency of traditional 2D visualization in industrial application. For instance, some multi-dimensional data is hard to be arranged in traditional tables and 2D diagrams, yet 3D information system can display data in various and hybrid forms, with high identification. It also allows users to view the whole structure as well as observing local details. As a disruptive innovation in simulating the physical world, 3D system allows highly realistic physical collision and interaction, which is closer to the real operating environment and easier for user to accept. Moreover, 3D representation also processes irreplaceable advantages in data storage, spatial structure display, innovative human-computer interaction and artistic expression.

- the history and development of 3D visualization

  The 3D visualization technology has been evolving over the years.

  Link1; link2; link3

- origin -perspective drawing

  The first break through in visualization can be trace back to Renaissance era which began in the 14th century. Filipo Brunelleschi, an Italian designer and architect painted the world first painting depicting the concept of linear perspective - by converging multiple parallel lines on a vanishing point in the horizon line to create a visual representation of how our eyes perceives reality [.img] His discovery pioneered the use of using perspective in analyzing and visualizing architectures and objects, allowing people's imagination and perception of stereoscopic space. Employing this technique, artists and architects can finally convey realistically, the difference in scale between subject matters.

- modern render software

  [With the introduction of computers, Computer Aided Design (CAD), the process of using computer systems to create, modify and analyses designs started to take shape too. Patrick J Hanratty is often credited as the Father of Computer Aided Design. During his tenure with General Electric, Patrick designed 'Program for Numerical Tooling Operations' (PRONTO) in 1957. This was the first example of a commercial Computer Numerical Control programming system. Five years later, Ivan Sutherland presented his famous thesis 'Sketchpad – a Man Machine Graphical Communication System' at the Massachusetts Institute of Technology. Its special attraction was the first graphical user interface where a light pen simulated objects on a Cathode Ray Tube.]

  [The appearance of the first 3D modeling and rendering software changed the game and gradually made the job of architects and designers easier. Besides, the advanced features of available 3D rendering programs affected almost all industries worldwide.]

  Since then, the giant wave of technology broadened the scope of Computer Aided Designs and subsequently interactive visualization became mighty powerful tool too. The computer-generated imageries slowly began to transform into something much bigger than mere designs or representatives.

- VR equipment as a tool for visualization

  The first appearance of VR equipment entirely changed our approach to 3D visualization. Although programs for visualization have been suitable for creating 3D animations for almost 40 years, the arrival of VR headsets added another dimension to 3D visualization.

  For example, the HTC VR headset is compatible with the latest version of Autodesk 3ds Max, which means that architects, 3D artists, and designers can feel the visualized space. Besides these industries, such equipment affected the industry of gaming and many more creative businesses.

  It's known that 3D visualization is related to creative fields and industries, but after VR equipment appeared, the use of this kind of visualization has spread over many other branches.

- Holographic imagery

  Science and technology keep stepping forward. Just when we thought that 3D visualization developed to its full potential, a company called Zebra Imaging Inc. proved us wrong. Something seen only in Sci-Fi movies has become our reality in 2017. Starting from the monochrome 2D drawing, simple 3D drawings using poor programs, in only 50 years, the dream of many children around the globe was realized overnight – the cutting-edge holographic imagery has finally arrived!

  The latest medium for displaying 3D visualizations using holographic imagery is helpful in various industries besides architecture, including military, retail, medicine, and other commercial efforts.

  VR equipment help architects attract investors and clients, since, with such a gadget, they can explore an imaginary space and influence the further development of an idea. Besides, the VR equipment facilitates long-distance cooperation and enables companies from developing countries to join leading global companies.

- what is holography

  - defination

    Simply put, holograms are three-dimensional images generated by interfering beams of light that reflect real, physical objects. Unlike conventional 3D projections, holograms can be seen with the naked eye.

    There are two ways to create holograms: via computer - with augmented reality glasses, and physical - for optical displays. Depending on which method is used, there are **two types of holograms - stereotypical and realistic**.

- THE PHYSICAL BASIS OF HOLOGRAPHY

  http://www.academy.rbru.ac.th/uploadfiles/books/123-2018-01-09-12-39-53.pdf

  In 1948, this technology was coined by Dr Dennis Gabor for which he received the Nobel Prize. The word hologram stands for 'complete message' which means the reconstruction of the image to convey complete message/information of the given part. Hologram refers to an image that is created when the light reflects upon meeting an object. Thus, it can be seen or obtained with the help of dense air like mist. A hologram is a permanent record of light, which is encapsulated in a three-dimensional object like glass or mirror. Hologram consist of two beams; a reference and an object beam which are diverted with the help of a half mirror and then the light converges forming a hologram using two full mirrors. This technique is used to perform imaging of multidimensional objects. Holography uses hardware, software and more exotic types of programming to create hologram image. This technology records light scattered from an object to present it in a 3D digital image. It allows light to shine through and the image is viewed from one side. The scattering of a laser beam produces multiple light waves that illuminate an object and create an image due to the principle of diffraction. It is recorded through a video camera in a 3D format. A hologram is a 3D photographic technique which projects image using 3D glasses.[1] Hologram diffracts light into an image and is easily projected for planning, teaching, learning and performing of complex surgeries.

  Computer-generated holograms: The mathematics of holography is now well understood. Essentially, there are three basic elements in holography: the light source, the hologram, and the image. If any two of the elements are predetermined, the third can be computed. For example, if we know that we have a parallel beam of light of certain wavelength and we have a "double-slit" system (a simple "hologram"), we can calculate the diffraction pattern. Also, knowing the diffraction pattern and the details of the double-slit system, we can calculate the wavelength of the light. Therefore, we can dream up any pattern we want to see. After we decide what wavelength we will use for observation, the hologram can be designed by a computer. This computer-generated holography (CGH) has become a sub-branch that is growing rapidly. For example, CGH is used to make holographic optical elements (HOE) for scanning, splitting, focusing, and, in general, controlling laser light in many optical devices such as a common CD player.

- hologram equipment and company

  The most common and recognizable example of a stereotypical hologram is Microsoft HoloLens. In 2015, Microsoft became the first company to introduce the HoloLens holographic glasses. The technology that the tech giant unveiled is widely used today to create **augmented reality**.

  To create holograms for HoloLens, content creators use HoloStudio software. Users can import models from other services or create 3D objects themselves with the help of the app. In short, you can use HoloLens to create complex virtual objects. In turn, these objects are superimposed on the imagery of the surrounding world through the use of virtual reality glasses.

  The result is an image that appears very similar to Pokemon Go. The only difference is that in HoloLens, rather than seeing fantastical dinosaurs, you are deploying a virtual workspace, an educational office, or a virtual conference with colleagues.

  HoloLens makes this possible by linking AR objects with traditional computer programs for work and entertainment.

- common industry use cases

  https://www.respeecher.com/blog/holograms-real-life-technology-works-industry-use-cases

  https://www.rfwireless-world.com/Terminology/What-is-3D-Hologram.html#:~:text=%E2%9E%A8It%20offers%20creation%20of,not%20require%20any%20projection%20screen.

  - spatial navigation
  - education
  - entertainment
  - marketing and selling
  - ...

holography application in medical field

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7694722/

http://www.ism.univmed.fr/mestre/CDRV-C/Documents/Sites_Enregistres/www.cybertherapy.info/pages/survey.htm#3

In the medical subject, knowledge and information have the general properties of abstraction and complexity. Physicians and patients suffer from the difficulties in communicating and understanding of medical expertise. Medical information visualization, as the response of this dilemma, has a long history of exploration and research. From Vesalius' anatomical drawing to the invention of X-ray and imaging-guided minimally invasive therapy, researchers aimed to use visual expression to enhance understanding of complicate and abstract medical concept, making use of various technology to show information clearly and vividly, thus help doctor to diagnose disease, make treatment plan, and communicate with patients.

Many medical systems generate complex data using advanced imaging technology, such as Magnetic Resonance Imaging (MRI) and ultrasound scans. Normally, that electronic information is used to display a flat image on a computer screen. But nowadays, with the disruptive innovation of holographic technology, these information can be used to produce full color, computer-generated 3D holographic images. Holography uses digital imaging inputs and provides an extensive visualization of the data for doctors, patients, surgeons and students. Compared with regular 2D images and diagrams display, holograms stores information about multiple images at different angles in the same graph, which means that the viewer can move around the display, allowing them to examine different body part or observe biological structures from different view. This extensive visualization are useful to assist successful treatment and surgery, and also the special interactive experiences can help medical students and patients gain better understanding and longer-term memory of medical knowledge.

- the importance and need

  Holography is an innovative imaging technology which creates detailed imaging that can be used for different applications. In medical imaging, there is a requirement of imaging of internal and external human body parts. There are digital imaging technologies which provide 2dimensional and even 3D images of body parts. Thus, we need to go a step further to see these images in motions, with different scales, with different colours and with languages. Its applications are increasing in image processing and precisely measuring human body parts.

  Literature gives us a good idea of the applications of holography used to measure the stress on surgical tools during surgery. It allows examining the different body parts like liver, brain, skeleton, heart, lungs, nerves, vascular system and muscles. It can digitally store patient data and provide a massive amount of detailed information. Thus, it is suitable for medical training, tumor localisation and remote therapy, visualisation and complex 3D structure measurement of the human body. In the medical field, holography is used to measure the natural cavity, organs and tissue of the human body in a non-destructive manner. This 3D visualising technology provides a unique experience to the doctor and offers empowerment to clinicians. It efficiently performs the studies of bones in a contactless manner.

  The report on Profiles in Innovation of VR and AR of Goldman Sachs (Goldman Sachs, (2016). *Virtual and Augmented Reality: The Next Big Computing Platform. Available at:* http://www.goldmansachs.com/our-thinking/pages/virtual-and- augmented-reality-report.html. (Accessed March 17th, 2018.) estimates a $5.1 billion revenue only for the healthcare industry and foresees 3.4 million people adopting this new technology by 2025. According to the report, the potential seen for this techs are as an aid for surgical procedures, treating phobias and enabling patients to access doctors with video-based visits, but we could argue there is more to that.

- current application (med industry and tech)
  - Augmented Reality Surgery - real time monitoring

- diagnosis and locating focus

  Enables to identify the abnormal growth of tissue, organs and even external body parts
  Researcher use holography to detect diseases and proper monitoring of health conditions like infections and hormone imbalance
  Helpful to researcher and doctors to eliminate the requirement of the physical testing procedure
  Useful technology for proper representation of the abnormal 3D structure and other unwanted growth/fats
  Used for the disease forecasting and identify advancement for the treatment procedure

  Used to detect a severe issue/abnormalities in tissues and organs in the human body
  The advancement of this technology is for various types of cells and Deoxyribonucleic Acid (DNA)
  Provide multidimensional information by performing simultaneous imaging about abnormalities
  Useful to carry out proper detection of disease, biomedical research & analysis and other related applications

- remote therapy

  For example, Proximie is a start-up that uses AR to enable surgeons to scrub virtually and in real time into any OR or clinical setting around the world. This collaborative visualisation tool permits to increase “access to high-quality surgical care to patients, improving their outcomes, reducing costs and delivering a highly engaging training experience to medical practitioners.” (Proximie, 2018. Proximie, the future of surgery via augmented reality technology. Available at: www.proximie.com (Accessed 30/3/2018).)

- Medical Education and training

  CAE Healthcare is expanding simulation-based training solutions to enhance medical education and improve patient safety using Mixed Reality with Microsoft’s Hololens. “Simulation has been proven to ensure better outcomes, more rapid product adoption and fewer patient complications.” (CAE Healthcare, 2018).

- Visualization and storage of Medical Databases

  In dentistry, useful to store the record of tooth prints and other dentistry models
  It checks the progress of the patient by storing all data digitally
  Provides nondestructive possibilities to see the gap and measurement of soft tissue with teeth
  Easily stored data of patient teeth digital and successfully carried out the study on these digital models in future
  Original tooth prints are easily stored which can be used to check the accuracy of treatment
  Ability to understand the complexity of treatment in the real world

  Holography is used to provide precise information as a real visual field
  Researchers used this technology to view detailed and realistic colour organs
  Reconstruct bright 3D image in natural colour which quickly provides solution of a given problem
  Used to make high resolution colourful digital medical model (recordkeeping)
  It is an important tool for human visual perception
  Researcher use this technology to produce digital 3D images of museum displays and advertisement and animation

- improve doctor-patient communication

  https://www.mdconnectinc.com/medical-marketing-insights/medical-marketing-insights/building-better-doctor-patient-relationships-with-virtual-reality

  https://uxdesign.cc/improving-doctor-patient-communication-with-ar-6d8d356beb67

  https://pubmed.ncbi.nlm.nih.gov/35725526/

focus on genetic conselling

- what is genetic, what kind of information do we want to learn

  https://education.23andme.com/virtual-reality-meet-genetics/
  While different types of cells all share the same DNA, they express (turn “on”) only a certain subset of the genes in your genome, and ignore the rest. Genes that are expressed can lead to the creation of proteins, such as hormones and enzymes. In each of these cells, your long, stranded DNA is compressed by tightly coiling around itself.

  In this form, different regions of the DNA can fold onto each other, causing interactions that can turn genes “on” or “off”. The genes that a particular type of cell expresses can have a big impact on its function.

- genomic visualizaiton

- traditional method
  https://onlinelibrary.wiley.com/doi/full/10.1111/cgf.13727
- 3d data
  https://febs.onlinelibrary.wiley.com/doi/10.1002/1873-3468.12778
- holographic solution
  - Delta.AR: An augmented reality-based visualization platform for 3D genome
    Delta.AR: An augmented reality-based ...
  - Designing a Mixed Reality System for Exploring Genetic Mutation Data of Cancer Patients
    Designing a Mixed Reality System for E...
  - (less related) Virtual Simulation for Entertainment using Genetic Information
    https://www.researchgate.net/profile/...
  - BioVR: a platform for virtual reality assisted biological data integration and visualization
    BioVR: a platform for virtual reality assi...
  - CRISPR-VR: Explore Sickle Cell and Genome Editing
    CRISPR-VR: Explore Sickle Cell and Ge...
  - Genius Genetics - TSP Virtual Reality VR Education Software
    Genius Genetics - TSP Virtual Reality V...
  - University of Oxford, MRC Weatherall Institute of Molecular Medicine (WIMM)
    https://education.23andme.com/virtual-reality-meet-genetics/

    https://adigaskell.org/2017/10/26/using-virtual-reality-to-understand-genetics/

    https://phys.org/news/2017-09-virtual-reality-tool-untangle-genes.html
- counselors feedback of VR/AR experience
  - Internet Versus Virtual Reality Settings for Genomics Information Provision
    Internet Versus Virtual Reality Settings ...