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Holography applications for orthopaedics

Dear Editor,

The holographic technique is an emerging tool for medical and its associated applications. This technique provides imaging of bone, tissue, ophthalmology, otology, dentistry, urology and pathology. A hologram provides a non-contact three dimensional (3D) image that can be seen with the naked eye.These 3D images provide details of the human anatomy and activity of an internal organ of the body in high resolution. The capabilities of holography are used for measuring purpose. This image processing tool hasan extensive application in various medical fields like orthopaedics. Mostly, X-ray holography is used for an aqueous solution. In orthopaedics, it is an excellent tool for contactless study, which is used to measure the external fixture of the fractured bone. Doctors can see the patient in holography image without the physical presence of the patient.[1]

Dennis Gabor coined holography in 1948 and was honoured with Nobel Prize for this work. In 1962, the development of the recorded 3D object had been done, which allows displaying the required static object. Holography involves providing the whole picture in a 3D form, which allows a person to look around and behind its subject. Currently, this technology is being improved further, and humans can see a 3D object without any requirement of 3D glasses. Holography is a two-step process. In the first step, it records a hologram in which a radiographic image is converted into a photographic record. The second step is to convert hologram into a virtual image. Holographic technology provides real-world applications. It subsequently projects light to create a faithful 3D representation of the human body. In medical imaging, this technology creates dramatic improvement. It improves computer tomography (CT), magnetic resonance imaging (MRI) and two dimensional (2D) scan. This technology provides an intriguing novelty in medical diagnosis, image resolution, treatment, information sharing and planning. An orthopaedic surgeon can use this technology for accomplishing complex surgery. It is also applicable for the planning of cardiac and liver surgery.[2] Holography is also used in Industrial fourth revolution which is commonly known as Industry 4.0.

Holography is linked to imaginary as it provides a virtual environment. By using this technology, a radiologist becomes more informative and easily addresses the complex issue of image storage. This technology rapidly increases electronic storage, and a vast amount of information can now be stored in the hospital. It can easily display body structure 3D, having superior visual capabilities. In radiology, holography is used for the better treatment of disease, diagnosis and injury. It is helpful for training, protection and safety rather than the CT and MRI image. Using this technology, one can understand the vascular anatomy, cranial nerves, renal, skull base and pelvic anatomy. It is the best technique to visualise intricate details of the anatomical structure.[3] Figure 1 shows the process as used in capturing holography.

This technology can create endless applications, such as planning, education, safety, security and research.[4] Other holography applications are gaming, movie, better communication, advertising and training. Holography is also available for non-destructive testing in laboratories. Its applications are applied in automobile, aircraft, telecommunications, television computing and scanning of different assemblies. In industrial applications, it is used in quality control and fracture testing in production.

Holography is an excellent tool to study an orthopaedic structure and measure strains on fixations of pins and rods. It is a contactless tool offering an excellent study on an external fixture being used in a bone fracture and determine the piezoelectric coefficient of human bone.[5] This technology may revolutionise healthcare for accurate human skeletons, organs, muscle, veinsand vessels. A doctor/surgeon can plan operations and discuss the operating procedures as shown in Figure 2.

From Figure 2, doctors/surgeon can see the images of hard tissue of the human body by using holography beam of the patient. There are lucrative growth opportunities by holographic technology, such as live imaging, disease informationand visibility of live organ in an effective manner. This technology completely displays 3D homographic orthopaedics data. From an original object, it provides the original shape and size object with a multiangular view.[6] It successfully shows patient-specific orthopaedics data, and we observe that it is helpful for spine surgery, trauma, prosthetic, joint replacement and reconstruction of complex maxillofacial and calvarial defects. This technology provides better information about bone, tissue, osteochondral and chondral defects, planning of surgery, cost-effectiveness for orthopaedics, surgical training and improves patient care.

Holography helps the surgeon by the low cost of planning and improves patient outcome. In medical, a hologram is used to test breath, blood, saliva and urine. It is applicable to test glucose, hormones, bacteria, drugsand alcohol. Thus, to

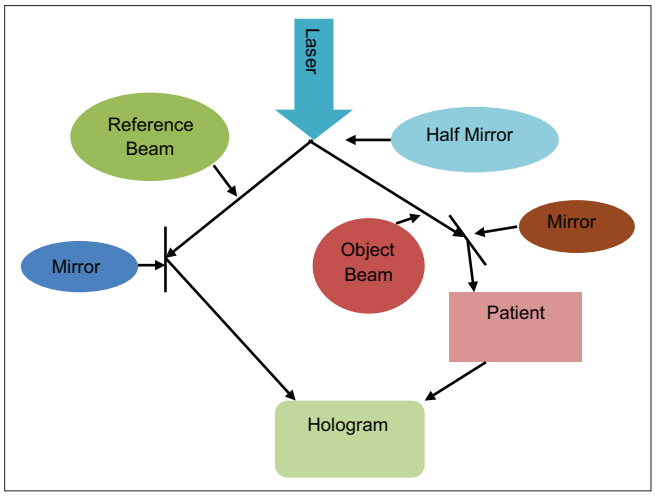

Figure 1: Process used in holography

create a 'holographic image', an image is captured, and then it is processed to make a 'stereogram'. A hologram image is recorded through a reference beam and projected beam in space. Holography is a recording of a light image formed by lens without any aid of special glasses or other optics. It uses laser light to complete hologram from the actual object and record complex data with the original reference beam.[1]

This technology is applicable in teaching and learning, as it provides efficient performance as compared to traditional book images. By using this technology, the teacher can clearly show body metabolisms. It has superior visual capabilities and provides 3D imaging of many anatomical structures that are difficult to conceptualise. This technology has a superior capability to store patient data digitally in a 3D format, which can further be analysed. It can record thickness rather than the just surface.[7] In the upcoming years, it will become commercially viable to perform treatment of complex cases in orthopaedics.

Holography has great potential to transform radiology into virtual reality (VR). It addresses the challenge of storing the complex issue of 3D image storing of the patient. In hospitals, patient diseases/bone fracture/other information can be stored digitally. It is used for external recording using an external reference beam to reconstruct an image.[8] This technology is also used for industrial testing.

The main limitation of this technology is the requirement of a complicated method to record holographic images and the requirement of higher skill sets. Holography does not produce images of complex movement. Many people are unfamiliar with this technology and the adoption of holographic storage.

In future, holography seems a useful technology to design artificial bone, limbs and joints. It is useful in areas such as industry, commerce and scientific research. Doctors can use

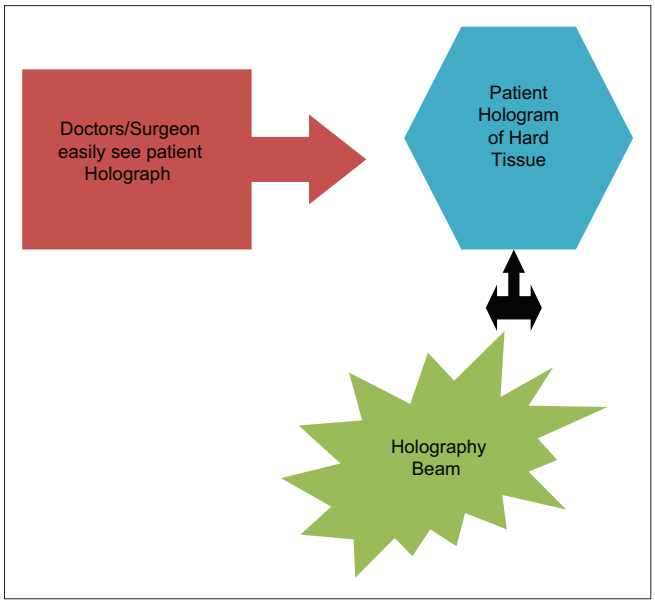

Figure 2: Working of holography in orthopaedics

3D holography to undertake measurement without invasive surgery.[9] Medical professionals can cut virtual tissue and organs in various angles to create unlimited cross-sections. In upcoming years, it the best approach to identify the growth of abnormal tissue. Holography may emerge as disruptive 3D imaging to impact a different aspect of life and can be a game-changer in medical industries.[10]

In the future, holography will help doctors for analysis of patient orthopaedics conditions, their causesand prediction. The patient-specific surgical procedure will be performed easily using examined data along with better user information. In upcoming years, it will become efficient technology for decision-making, solving a complicated problem and creating innovation in orthopaedics.

Holography is a useful technology to store the data of a patient, which is quite helpful in training and research. This innovative technology designs an image in a 3D format. It is clinically reliable by which new and old record is used to watch the progress of the patient. It allows the surgeon to plan the procedure of complicated surgery, such as the spine. A hologram can be used as a powerful microscope to observe individual cells of patients. In orthopaedics, holography produces 3D images of bones with sizeable focal depth and will create unlimited benefits in the future. No doubt, it can be used with artificial intelligence (AI) for solving patients' problems.

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Conflicts of interest
There are no conflicts of interest.

Abid Haleem, Mohd. Javaid, Raju Vaishya[1]

Department of Mechanical Engineering, Jamia Millia Islamia,
[1]Department of Orthopaedics, Indraprastha Apollo Hospital,
Sarita Vihar, Mathura Road,
New Delhi, India.
E-mail: mohdjavaid0786@gmail.com

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