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A LITERARY REVIEWONCOMPUTATIONAL SYSTEMS, MODELING AND SIMULATION AND THEIR CONTRIBUTIONS TO MEDICINE

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Abstract

This paper aims to provide an overview and explanation regarding the impacts of developing technology within the medical sector. Throughout this report, concepts being implemented such as virtual simulation have been seen to aid medical specialists in achieving better outcomes, thus helping healthcare progress from uncertainty to precision.

Keywords: *Spatial visualization*, *Anatomical training*, *Computer aided designs*, *Radiation therapy*.

Introduction

Medicine involves a multitude of methods, some of which have undergone years of evolution and calibration, to prevent and treat illnesses. Computational Medicine helps to advance healthcare by developing computational models of disease, personalizing these models using data from patients, and applying these models to improve the diagnosis and treatment of disease. The reader possessing a basic understanding of operations carried out by 3Dsoftware would be ideal so as to have a comprehensive understanding of the content in the paper. Few contemporary modalities require acute precision in order to effectively treat patients, and have been capped so far by cost and limited availability of resources and training required to carry out procedures.

Theory

Biological systems and interactions can be simulated accurately using computer science, physics, and mathematics. A number of variables are programmed into a computational model to characterize the system being studied. By adjusting these variables in various combinations, the outcome can be observed, providing valuable data for researchers. Incorporating computational modelling to complement traditional in vitro and in vivo experiments is a paradigm enabling reliable methods of disease diagnosis, understanding biomolecular structures and biomaterials, innovative therapies, tissue engineering and regenerative medicine. The possibilities being limitless, computational modelling is transforming medicine.

For instance, we cannot touch a beating heart, but we can use modelling to infer important diagnostic and prognostic information. The increasing amount of available data from wearable sensors to digital medical images has also sped up the applications of modelling.

In recent times, event based surveillance models like GPHIN (The Global Public Health Intelligence Network)are being used to track infectious diseases, monitor them and identify interventions to reduce spread of the disease and predict future outcomes. These models and calculations were widely used during the COVID -19 pandemic, with scientists trying to predict how the SARS-CoV-2 virus would spread. GPHIN came into the spotlight during the SARS outbreak when, from November 2002 and February 2003, it issued the first alert of unusual respiratory illness in a province in China to WHO and GOARN members, setting off an international chain response [1].

The use of computational modeling and simulation in medical device development through virtual prototyping helps predict device performance and allows research and development earlier in the design process, though this requires high quality data and sufficient evidence is needed for clinical translation and formidable mathematical challenges involved.

Apart from surgical and design based aspects, medical simulation is utilized in training healthcare professionals through the use of advanced educational technology, which allows the acquisition of clinical skills through deliberate practice rather than an apprentice style of learning and is the future in an ever evolving healthcare. Anatomy is one of the core courses in medical education which traditionally uses wall charts, books, slides, anatomical specimens, and practical anatomy as teaching resources and methods. With the expansion of medical education and the reduction in human anatomical specimens, as well as the limitations of time and place for anatomical training, the quality of teaching has been severely affected. Anatomy is a discipline where spatial visualization is of importance. Students need to learn not just structures and functions but also spatial relationships to surrounding structures. Given the needs of anatomy teaching, the use of virtual reality (VR) technology to construct a virtual anatomy teaching system, could therefore provide real and reusable teaching resources for anatomy teaching In addition virtual anatomy teaching systems have the advantages of multi-level, multi-angle specimen observation and non-destructive virtual anatomy, among others. Simulation tools serve as an alternative to real patients, and a trainee can make mistakes and learn from them without compromising the safety of the patient.

Patient specific models and simulations can help predict clinical outcomes and keep the promise of a tailored treatment. Operating alongside 3D software, 3D printing allows support diagnosis, treatment and surgical planning. These creations provide clinicians with critical context and details regarding the patient's anatomy that routinely change clinical approaches and impact patient outcomes. Medical modeling through collaboration between various departments enables highly accurate segmentation and 3D printing can enable surgery that could not have been performed otherwise.

Vis a vis neurosurgery,3D Simulation starts with imaging,CT and MRI scanning sequences, alongside appropriate applications of more advanced imaging, which are used as input to all downstream simulation. The 3D structural models of the brain are formed from imaging data and interpreted.

During the generation of 3D data, structures in the head that are most important for the patient's pathology are identified within the radiological imaging and segmented from its surroundings. In particular, once a brain tumor is identified and modeled from the 2D imaging data set to produce a 3D model of the tumor, the brain's blood supply, or vascular network, and bony anatomy are modeled, in addition to more complex structures such as cranial nerves. The result is a set of models that accurately reflect the relationship between structures of the brain that are critical for the planning of the operation.

Once 3D data has been generated, it can be used in many ways. A typical pipeline will display the data pre-operatively to the patient, for improved understanding and confidence in the approach, and to the surgeon for procedural planning. These models are used to plan minimally invasive approaches to the skull base on the model itself, making it a trial run for the actual surgery.

3D Imaging and Simulation programs remain of huge assistance in areas of radiotherapy. The risk of missing the tumor is moderately high due to motion of organs or a setup variation may cause radiation to be slightly diverted to the patient's normal organs [2]. Systems like IGRT (Image Guided Radiotherapy) detect possible errors and makes room for corrections through data derived from pre radiotherapy imaging. The added accuracy can allow an escalation in radiation dose values [3]. In continuation and addition, SBRT (Stereotactic Body Radiation Therapy) is used to precisely deliver high dosages of radiation to eliminate small, defined oligometastatic tumors at any position in the body [4]. Though the high amount of radiation can damage immediately surrounding tissue, this tissue is tiny and usually non eloquent, thus clinically significant toxicity is less [5].

Result :

Computational simulations, modeling, virtual reality and a few other methods currently contribute towards healthcare and have established their position in the fundamentals of modern medicine.

Discussion :

The results indicate a growth in the simulation market, as well as a sizeable increase in the implementation of 3D modeling and virtual reality in healthcare due to their proven effectiveness.

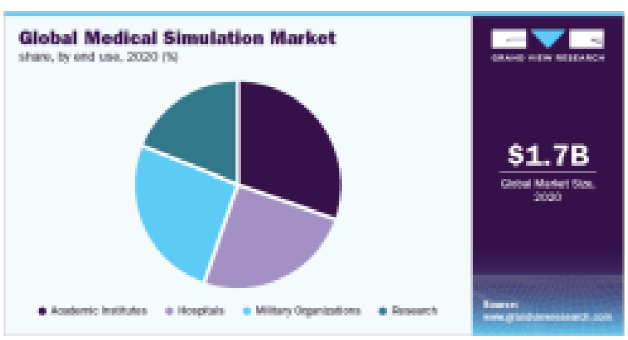

Fig 1. Global Medical Simulation Market distribution as of 2020. Hospitals and Academic Institutes shown in dark and light purple respectively

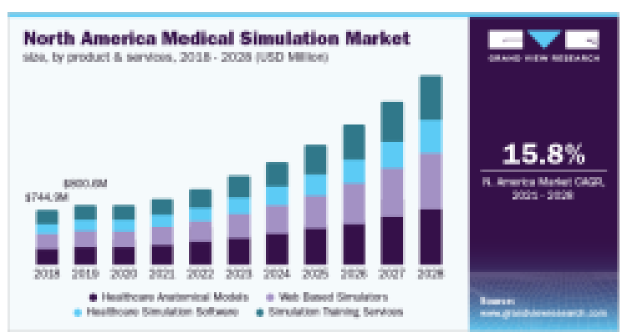

Fig 2. Estimated growth of the North American Medical Simulation Market until

Conclusion :

Through their widespread applications, computerized modeling and simulation in multiple aspects of the medical sector have turned into a powerful strategy to effectively prepare professionals to address the problems of the modern world.

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