Spatial Computing Within the Medical Field

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IT104-002

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20 September 2023

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Introduction

Technological progress holds a substantial amount of weight over the trajectory of human life. The reach and influence of these advancements are beyond extensive and have been fundamental to creating the world as it is today. Nearly all sectors of society are directly impacted by technology. Spatial computing, for example, has already made strides within numerous fields such as the entertainment and automotive industries. It is the next step in the development of digital interfaces and will likely lead to unparalleled progress within various fields of expertise including the medical field. Thus, the purpose of this research paper is to evaluate the impact of spatial computing within healthcare and its overall effectiveness as a tool.

Background

The purpose of this spatial computing is to allow virtual objects to be incorporated into one's environment with respect to surroundings. In the automotive industry, this technology may come in the form of advanced GPS systems or autonomous vehicle systems. In the realm of entertainment, spatial computing may present itself in the form of virtual reality. Virtual reality itself can be utilized for a multitude of purposes, however, and is by no means limited to the entertainment industry alone. In the field of health, spatial computing is represented in various forms of extended reality. Extended reality, or XT, encompasses the entirety of virtual reality, augmented reality, and mixed reality (Taghian et al., 2023). It should be noted that there are differences between these forms of reality. VR utilizes optical systems and monitors to effectively capture the user within an entirely virtual world. Augmented reality, or AR, on the other hand, is an interactive system with an environment that uses optical systems to generate information corresponding to the user's surroundings. Mixed reality, otherwise known as MR, is a mixture of the two AR and VR systems (Vardhan, 2023). These spatial computing systems,

when applied correctly, allow one to gather a better understanding of their environment and provide the user with an alternative perspective. In relation to healthcare, XR allows users to improve overall performance when encountering a situation that would normally have severe physical risks whether in procedures or in training. This immersive medicine has great implications for surgical operations, medical training, and even rehabilitation. In India alone, the AR market is expected to expand at a rate of 38.29% by 2027 (Vardhan, 2023). Spatial technology, unfortunately, does not come without challenges or limitations.

Current Use

Spatial computing is already playing a role within healthcare and is currently being applied to various procedures and diagnostic tools. It has become abundantly clear that XR has the capacity to act as a tool in both the treatment or diagnosis of a patient regardless of whether the treatment in question targets physiological or physical forms. For instance, AR has been used to assist with a number of different surgical procedures as it allows information to be readily accessible in a holographic manner. In neurosurgery, according to Taghian et al., XR has proven to be “beneficial in pre-operative planning as well as multimodal neuronavigation” (2023). Remarkably, AR can be used to identify key elements of the body such as blood vessels and nerves, further reducing potential risk in surgery as the user is more accurately able to determine proper placements (Brockmeyer et al., 2023). It is worth noting that surgical developments, in correspondence to the implementation of XT, have been primarily in spinal and orthopedic surgery. AR assists in processes such as spinal surgery, pedicle screw placements, bone biopsies, osteotomy planning, and even targeted cervical foraminotomy.

AR Surgical Navigation, otherwise known as ARSN, has been recorded to have an average of nearly 85% in terms of precision in comparison to 64% shown in free-hand

positioning (Taghian et al., 2023). In an evaluation of AR's accuracy, 20 operations were performed in which an orthopedic spine surgeon used an ARSN device to insert 253 pedicle screws without the use of fluoroscopy. The study found that ARSN without fluoroscopy was significantly better for thoracic pedicle screw placement as no screws were wrongfully placed and the total accuracy was 94.1% (Taghian et al., 2023). Furthermore, A France-based medical company, Pixee Medical, has made critical progress in conducting the first FDA-approved knee surgery guided by AR (Vardhan, 2023). Such a surgery marks a significant milestone in regards to the role of spatial computing within healthcare. Additionally, both VR and AR are being used in exposure therapy procedures in order to treat disorders such as anxiety, OCD, depression, phobias, addiction, psychosis, and even post-traumatic stress complications. These technologies are better known as VRET and ARET (Vardhan, 2023).). AR and VR are also finding uses within medical training and education allowing individuals to learn with greater efficiency and ease. The AR in Surgery and Education program (ARiSE), for example, uses holograms in order to increase interactivity within the learning individuals. The software utilizes voice commands in conjunction with UI buttons and has numerous applications within health based education (Taghian et al., 2023).

While all of these practices continue to revolutionize the medical field, limitations persist that unfortunately hinder the efficiency of spatial computing on a more extensive scale. Extended use of XT, for instance, may result in headaches, discomfort, and even vertigo. Thus, while the patient is being cared for with greater accuracy, the medical professionals themselves may be at a disadvantage. There are also challenges with the physical spatial environments themselves as users will have a wide range of environments that differ in terms of purpose and dimension. These differences in designing virtual experiences are rather challenging as the experience must

adapt to each user's physical surroundings (Keshavarzi, 2022). Finally, it should be taken into account that "surgery professionals value tactile touch, but current VR systems cannot accurately imitate it" according to Taghian et al. (2023). Such sentiments only prove spatial technology has a long way to go, however, the future remains promising.

Future Use

It is undeniable that spatial computing within the medical field has great prospects and will most likely vastly improve in terms of effectiveness. New applications of XT are being devised in order to improve other procedures outside of spinal surgery and rehabilitation. Spatial computing is often used as a means of therapeutic treatment within the medical field, however, numerous methods of implementing it on a higher level of complexity are currently being researched. It is hoped that such spatial technologies will one day aid in the treatment of cancer more directly. Current Medical Augmented Reality Systems, or MARS, are simply the foundations of the future of medical treatment. Eventually, these spatial systems will be even better equipped to handle difficult healthcare environments. Research is going into figuring out how these spatial systems can be more adaptive and context-aware going forward (Navab et al., 2023). XR will continue to advance within surgical processes and assist with treatments and mapping on a greater scale. Though, it should be noted that in order for this to occur the imposed security and legality issues of such a technology need to be sorted and properly dealt with.

Security and Legal Concerns

Spatial computing, in order to operate effectively, requires a substantial amount of data and information regarding the user's state. When considered in a medical context, the need for such data only increases as patients must be properly cared for. The collection of this data, and

the method in which it is to be handled, raises concerns regarding privacy. In order to keep one's personal information safe, it is imperative that the challenges within spatial computing are addressed. Thus, data must be adequately encrypted, authentic content generation should be ensured, and the potential for social engineering should be mitigated (Vardhan, 2023). If proper security is to be ignored within the implementation of spatial computing, then the safety of individuals is put at risk. Severe harm could arise as a result of the failure to provide an adequate level of security. If information was to be misused or misplaced, there would be grave consequences on both personal and societal levels. It should be taken into account that personal data in this context would no longer simply include basic credentials. Personal data would be far more than credit card numbers, purchase histories, or social media presence. Instead, personal data would include specific feelings, judgments, behaviors, and even physical appearance (Morvan et al., 2020). XR will undoubtedly attract individuals who look to gain off vulnerabilities. Morvan et al. state that "the more we rely on XR technologies to perform critical day-to-day tasks, the more vulnerable we become to malicious actors" (2020). Meaning, if spatial computing is to live up to its expectations for the future, then privacy and data must be a priority. Otherwise, the systems would violate standards and confidential information would be at risk thus creating a situation in which disadvantages outweigh the potential advantages of spatial computing.

Ethical and Social Concerns

Unfortunately, there are several ethical concerns that arise when taking spatial computing into consideration. While high-performance mobile computing is becoming more and more readily available and VR systems have become more cost-effective, spatial computing systems are still restricted in terms of availability. Furthermore, additional costs must be accounted for in

terms of other hardware and software requirements. One might even require special accessories or high-resolution displays (Vardhan, 2023). Not everyone has the means to buy such items or take part in such activities. The following is true, especially in underdeveloped areas of the world. Additionally, social isolation is another issue that may arise and is closely related to the concerns of effects seen in digital learning (Taghian et al., 2023). Though, in the professional medical field social isolation is not likely a big concern as spatial technologies will be used only when necessary. If unsupervised, however, a patient who is using XR for recovery may be susceptible to this issue as they may not be held to the same workplace standard and are using spatial technology for treatment rather than operations. Overdependence on these technologies could be significantly harmful to one's mental state and well-being. Extended exposure to virtual environments may be harmful in the way that it misconstrues an individual's perspective drastically. While quite useful in handling everyday tasks, even outside of the medical field, virtual worlds often omit small details such as flaws a natural environment would have. This may result in conditions such as depersonalization or derealization disorder as well as dissociative identity disorder (Morvan et al., 2020).

Conclusion

The potential of spatial computing is vast and promising. As stated prior, it has been established and implemented in numerous fields and industries. Spatial computing can accommodate complex and intricate tasks, as well as mundane day-to-day tasks. For example, VR and AR provide efficiency in handling email, creating schedules, and sharing videos as well as other content from the internet. These features can be helpful in managing oneself, however, in the context of the medical field, these features are simply not up to standard. When considering MAR, or medical augmented reality, it should be noted that spatial computing needs

to be held to much higher expectations. The same is held true for all versions of spatial computing within healthcare. In fact, many of the features listed above may need to be blocked for patient safety and to fulfill certain professional standards (Navab et al., 2023). Ultimately, potential lives are put at stake when bringing spatial computing into the medical field, which suggests that if spatial computing is to persist then adversities must be addressed promptly and effectively. Only then will spatial technology achieve its maximum potential.

References

Brockmeyer, P., Wiechens, B., & Schliephake, H. (2023). The Role of Augmented Reality in the Advancement of Minimally Invasive Surgery Procedures: A Scoping Review. Bioengineering, 10(4), 501. Retrieved October 13, 2023 from https://doi.org/10.3390/bioengineering1004050

The journal looks into the current uses of spatial technology and how they are likely to impact the future. It is very likely that this technology will find its way into everyday life. The uses of which would prove to be very efficient within education and health alike. Thus, the effectiveness of XR is questioned within medical training, rehabilitation, and MIS, or minimally invasive surgical procedures. Specific surgeries aided with spatial technology are compared. The results of these surgeries provide insight into the future of the technology.

Keshavarzi, M. (2022). Contextual Spatial Computing: A Generative Approach (Order No. 29212384). Available from ProQuest Dissertations & Theses Global. (2737937180). Retrieved October 13, 2023 from http://mutex.gmu.edu/login?url=https://www.proquest.com/dissertations-theses/contextual-spatial-computing-generative-approach/docview/2737937180/se-2

The article covers the foundations of spatial computing and how it relates to virtual reality, augmented reality, and mixed reality. The applications of such are explored and the potential impacts or implications of such are brought into question. Limitations are outlined such as the overlay of information from a 2D environment to that of a 3D environment. Spatial limits are detailed, and their corresponding consequences are solved. A framework is provided in order to combat these limitations for future reference.

Morvan, L., Hintermann, F., & Ovanessoff, A. (2020). Preparing for the Risky World of Extended Reality. MIT Sloan Management Review, 61(2), 1-4. Retrieved October 20, 2023 from http://mutex.gmu.edu/login?url=https://www.proquest.com/scholarly-journals/preparing-risky-world-extended-reality/docview/2335157806/se-2

The consequences of the implementation of virtual reality within healthcare are listed and acknowledged within this scholarly journal. The journal charts different issues that range from barriers to conditions. Limitations are gathered as well as the factors that influence such observations. The negative effects of ignoring such limitations are also delved into. Extended reality could prove significant if secured properly and doing so indirectly affects its application in the medical field.

Navab, N., Martin-Gomez, A., Seibold, M., Sommersperger, M., Song, T., Winkler, A., Yu, K., & Eck, U. (2023). Medical Augmented Reality: Definition, Principle Components, Domain Modeling, and Design-Development-Validation Process. Journal of Imaging, 9(1), 4. Retrieved October 13, 2023 from https://doi.org/10.3390/jimaging9010004

Spatial technology is explored in relation to augmented reality and MAR (Medical Augmented Reality). The frameworks are explained as information goes through both the physical and digital worlds. Multiple components are considered, such as sensors, perception, display, and user interaction. The future of MAR is considered and the requirements for this to be a possibility are explored. Possible challenges within the advancement of MAR are listed.

Taghian, A., Abo-Zahhad, M., Sayed, M. S., & Abd El-Malek, A.,H. (2023). Virtual and augmented reality in biomedical engineering. Biomedical Engineering Online, 22, 1-25. Retrieved October 13, 2023 from https://doi.org/10.1186/s12938-023-01138-3

The expansion of extended reality technology is explained as well as its advancements within multiple fields. Medical uses are examined such as picture-guided surgery and other clinical applications. Augmented reality in surgery is noted and its influence over medical education is detailed. The current uses of spatial computing within the medical field are described in detail. The outcomes of these procedures are directly compared to constants that prove the effectiveness of this technology.

Vardhan, H. (2023, Jan 26). Reshaping the future of healthcare with AR, VR, and MR. Financial Express Retrieved October 13, 2023 from http://mutex.gmu.edu/login?url=https://www.proquest.com/newspapers/reshaping-future-healthcare-with-ar-vr-mr/docview/2769852653/se-2

The roles of augmented reality, virtual reality, and mixed reality as a whole are taken into account when considering the medical field. XR, or extended reality, has already proved substantial within healthcare and opens up many windows of opportunity. Specific applications are listed and briefly explained such as that of VRET and ARET. Therapeutic solutions are considered, and their effectiveness is outlined. Further applications are considered with more complexity besides rehabilitation.