MACHINE LEARNING AND IMMERSIVE TECHNOLOGIES FOR USER-CENTERED DIGITAL HEALTHCARE INNOVATION

1 Mounika Nalluri, 2 Chinna babu Mupparaju, 3 Dr. Rahul Pulimamidi, 4 Aruna Sri Rongali,
1 Senior Software Engineer, Information Technology(Masters in Computer Information Systems), Murray State University, USA, mounikanalluri89@gmail.com
2 Software Engineer, Information Technology(Masters in Computer Science), University of Central Missouri, USA, chinnababumupparaju@gmail.com
3 UI Architect/Software Developer, Laboratory Corporation of America Holdings, Durham, NC, dr.rahulpulimamidi@gmail.com
4 Senior Software engineer, Graduate Doctoral Information Technology/Graduate (Information Technology Emphasis/Information Technology, Ph.D.), University of the Cumberlands, St.Louis, MO, arongali34683@ucumberlands.edu

ABSTRACT
Virtual reality (VR), augmented reality (AR), and mixed reality (MR) are all examples of immersive technologies that improve data visualization and hence facilitate human connection. Stakeholders can be more effectively incorporated as essential members of the process with the aid of these technologies. Research on multidimensional genetic data processing for the development of better disease diagnostic and treatment procedures has begun to be influenced by immersive technologies. Some research aimed at addressing health and therapeutic requirements highlights the importance of immersive technologies, particularly for the creation of precision medicine. The research community has recently begun to pay attention to the possibility of employing immersive technology in the process of analyzing genetic data. Incorporating immersive technologies into the design of more realistic human-computer interactions that enable improved perception engagements is a primary focus of study in the field of genomic data analytics. Virtual reality and other forms of immersive technology have made it possible for people to believe that the digital world is just as real as the actual one. This leads to more accurate and error-free results from the learning process. However, there is a dearth of literature discussing the use of immersive technologies for healthcare and genomic data processing in specific digital health applications. This study contributes by giving a thorough analysis of the potential of immersive technologies in the field of digital health. Patient-centered apps, medical domain education, and data analysis (including genetic data visual analytics) are all examples of this type of software. As a case study for the gradual incorporation of immersive technologies into the field of genomic data analysis, we use the development of a visual analysis carried out with virtual reality (VR) as our focal point. Both the discussion and the conclusion provide a synopsis of the usability of the immersive technology applications that are already available, as well as their innovations and the future work that will be done in the field of healthcare and digital health data visual analytics.

1. INTRODUCTION

The outcomes of patient treatment continue to improve as a direct result of technological advancements in the healthcare industry, which also contribute to an improvement in the quality of care and a reduction in costs. Innovative technologies, such as immersive technologies, are used for augmented reality (AR) training, healthcare data use, patient-customer experience customization, big data analytics, and health result retrieval from data. [1] The users of immersive technologies are able to have the experience of feeling as though they are physically present in a nonphysical world through the utilization of a variety of inputs including pictures and sound. These technologies are getting easier to use, more affordable, and more widespread all at the same time. They have also been accepted and welcomed by a number of other businesses, one of which being the healthcare industry.[2] This is especially true in light of the sophisticated analytical tools and huge volumes of healthcare data that are currently being gathered from patients and the broader community. An strategy that is one size fits all will be abandoned in favor of one that takes into account the large amount of unmet information, makes a prognosis, and chooses a treatment plan depending on the genetic profile of the individual patient.[3] Artificial intelligence (AI), precision medicine, and immersive technology are some of the most promising innovations in the medical industry.[4] Users in the healthcare sector now have new possibilities thanks to the combination of advances in immersive technology and artificial intelligence. Many of the users' prior experiences will shift as a result of these possibilities. There is a growing demand for solutions that can facilitate the dynamic, flexible, and integrated display of diverse types of health data. To enhance traditional methods of data display, developers are working on immersive technologies that allow for more natural interactions between humans and machines, as well as the incorporation of additional perceptual factors, such as music. AI can make already groundbreaking data visualization technologies even more efficient at handling complex data.[6] Machine learning, a branch of AI [7], is one of the most cutting-edge technologies currently being used to improve the accuracy of clinical insights, the quality of decision-making, the efficiency with which procedures are ordered, interpreted, and recommended, and the likelihood of errors such as incorrect diagnosis and unnecessary procedures.[8]

For a number of years, "precision medicine" has been able to benefit from the application of machine learning. Precision medicine is "an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person," as defined by the United States National Library of Medicine [9]. Precision medicine is a more individualized approach to healthcare in which a patient's unique genetic makeup, geographic location, environmental influences, lifestyle choices, and behavioral patterns are all considered by the treating physician. As a result, doctors can tailor their patients' care to meet their specific needs. Machine learning allows for the discovery of richer and more useful insights, the improvement of searches for visualization dashboards, and the development of more accurate predictive models. Data visualizations may also be made more dynamic by including real-time analytics.[10]

1.1 The challenges of using machine learning in healthcare

Although there are numerous advantages to machine learning, there are also several problems that stand out as particularly difficult. [11]

1. Bias can happen

The healthcare system ought to be welcoming to all and representative of its patients. On the other hand, we are aware that this occurrence is not constant. It is possible that an application for machine learning that is unable to generalize its findings (that is, learn from fresh sets of data) is not the ideal choice for determining which treatment alternatives are optimal for each individual (taking into account factors such as gender, age, race, medical history, and so on). Therefore, it is of the utmost importance that we exercise caution in the way that we manage the data.[12]

2. The quality of data used

Machine learning algorithms require accurate data in order to produce accurate predictions. In addition, the act of cleansing and validating data is itself a process. Working with professional data scientists who are able to approach these difficulties in an appropriate manner is essential given that the healthcare industry typically deals with vast amounts of data that are both fragmented and unstructured.[13]

3. The skills shortage

The lack of skilled workers is not limited to just those working in the medical field. For healthcare facilities like hospitals and clinics to make efficient use of machine learning, they need to have specialized business intelligence skills as well as distinct jobs, such as data engineer, business analyst, and software architect.

2. LITERATURE REVIEW

The work of Huang et al. (2018) provides a comprehensive overview of the use of VR and AR in the field of dentistry. The investigation covered two different spheres: practical applications in education and practical applications in healthcare settings. They argued that the adoption of VR and AR in dentistry led to a shift away from the traditional training methods and procedures that had been used. Because of this shift, dentists are paying closer attention to the potential of virtual reality and augmented reality applications in their field. So, Huang et al. (2018) analyzed and compared the efficacy of numerous VR/AR educational applications (including PerioSim, CDS-100, DentSim, IDEA, and Moog Simodont Dental Trainer) by considering factors like ergonomic postures, instant feedback, exam simulation, direct transfer of data to convenor/tutor, teeth used, and right and left operation. On the other hand, they looked into several clinical navigation systems (such IGI and Iris-100) to see if and how they can be useful in contemporary surgery. They came to the conclusion that virtual reality and augmented reality, despite the fact that they were not widely employed in dentistry yet, had a substantial amount of potential to develop a secure learning and working environment.

Guedes et al. (2019) conducted a meta-analysis to compare the effectiveness of virtual reality (VR) simulators with conventional box-trainer instruction for the purpose of preparing surgeons for minimally invasive surgery. [14] The length of time necessary to finish minimally invasive surgery and the performance score were both considered as key performance indicators in their research. There were a total of 20 randomized clinical trials considered for inclusion in the qualitative analysis, but only 14 were included in the meta-analysis. The findings indicated that participants using virtual reality simulators had the potential to improve their performance scores during minimally invasive surgery. [15] On the other hand, there was not a discernible change discovered in the total amount of time required to finish the operation.

The purpose of the meta-analysis that Piromchai et al. (2015) carried out was to establish whether or not virtual reality (VR) simulation-based training might increase trainees' surgical abilities in comparison to traditional training techniques. Their area of use was fairly limited, which consisted of surgery on the ear, nose, or throat. They discovered nine studies with a total of 210 participants. Out of the nine total investigations, four were performed in actual operating rooms and the other five were conducted in simulated training environments. Virtual reality (VR) simulation-based training has been shown in studies conducted in real operating rooms to increase trainees' psychomotor scores and decrease the total time needed for procedures. On the other hand, just one of the experiments that were carried out in training environments that were carefully controlled indicated that virtual reality training is much more beneficial than traditional training when it came to the acquisition of anatomical knowledge. Various other investigations

have found no statistically significant difference. Virtual reality (VR) surgical simulation is used in several surgical training programs, however Piromchai et al. (2015) find only weak evidence on its favor. The inconsistency is to blame for this. They suggested more studies be conducted to determine if training in virtual reality (VR) actually improves patients' real-world outcomes and helps them learn non-technical skills.

Specifically focusing on AR system registration technology, Jiang et al. (2019) conducted a comprehensive investigation of AR applications in oral medicine. They classified registration methods as either static or real-time, depending on their intended clinical application. They further analyzed static registration by splitting it into rigid registration and nonrigid registration. Rigid registration is not hard to accomplish, and while doing so, the deformation relationship between models can be disregarded. The nonrigid registration process, on the other hand, is more difficult than the rigid registration process since it also needs to take into account the deformation.

Recently, Wu et al. (2020) carried out a meta-analysis on the efficacy of the learning performance of virtual reality (VR) utilizing head-mounted displays. They found 35 randomized controlled trials or quasi-experimental research. A meta-analysis was conducted to ascertain how much of a difference there actually is in the learning performance of VR HMDs. Immersive learning was found to be more useful than real-world activities for elementary school kids studying science.

3. IMMERSIVE TECHNOLOGIES FOR VISUAL ANALYTICS OF HEALTH DATA

3.1 VR Benefits Visual Data Analytics

Combining immersive technology, natural user interfaces, and visualization, which are all well-established methods, immersive analytics aims to produce a transparent cognitive experience and enable visual analytics in an immersive setting. [16] As a result, it offers innovative potential to improve digital data analysis. One such immersive technology is virtual reality (VR), which serves as a stage for collaborative, interactive visual exploration. VR is being applied as a form of big data visual analytics. Some of the advantages of using virtual reality (VR) for data visual analytics are a more organic approach, the ability to accommodate a large number of people, and the removal of distractions. Virtual reality (VR) technology can lead to a more intuitive understanding of the data and better recall of the recognized linkages within the data, all of which can be quantified. [17] Platforms for interactive 3D virtual reality can help eliminate distractions and provide more interactions, which helps users maintain their attention and keeps them focused on learning. With virtual reality (VR), users can interact with data in any direction: in front of them, behind them, above them, and to either side. Virtual reality (VR) makes it possible to express data qualities in a wide range of contexts by capitalizing on humans' innate abilities to think about and process data in many dimensions. [18] Virtual reality (VR) can make data analysis more fun since it enables users to "step into the data" and spares them the burden of laboriously looking over difficult data. It will then be possible for a higher number of humans to engage in the monitoring of machine learning models to assure that the decisions made by the computer continue to be ethical, fair, and rational.

When it comes to data analysis, some virtual reality systems for different disciplines merge all the latest technologies into a single system to produce superior results. For instance, the Oculus Rift VR goggles can be used with the virtual reality (VR) program iViz, which is a visual data analytics tool, to display vast amounts of data from digital sky surveys. [19] To determine the optimal mapping decision for a given scientific topic, iViz's user interface allows users to pick and choose which data parameters are mapped. Because of this versatility, visual data exploration and discovery may be made in a more powerful manner. Users can get a bird's eye view and work together in real time with a platform designed for immersive data analytics. Users can make adjustments to the data, evaluate the results, and collaborate on next moves. Virtualitics is an innovative virtual reality platform that uses AI to power its data visualization capabilities. This platform enables numerous users and can provide practitioners with insights that are more quickly actionable than those that can be obtained using traditional data analytics tools. In addition, this platform can help practitioners obtain such insights. Another virtual reality and three-dimensional (3D) platform created for use in enterprise information technology and cybersecurity operations is called 3Data. Users of this kind of virtual reality platform can have the deceptive feeling of being in the middle of complicated networks' command and control operations by "stepping into" those operations.

4. MACHINE LEARNING IN DIGITAL HEALTHCARE

The field of medicine has traditionally been in the vanguard of technological advancement due to the many advantages that rapidly adopting new technology provides to the care of patients and the development of novel treatments.

It should come as no surprise that machine learning, a subcategory of artificial intelligence, is gaining traction as a method of choice for health organizations as well as in the field of medical research. The application of machine learning in the medical field has several advantages because it may do administrative tasks, serve as a diagnostic helper, and help with research. It makes it possible to detect diseases at an earlier stage, to take preventative measures, and even to help patients adhere more closely to their treatment plans.

Continue reading to see what machine learning is actually capable of doing, as well as our case study of an app for health monitoring.[20]

4.1 What can machine learning actually do for healthcare?

Learning by machine is capable of handling a substantial amount of work, which boosts the productivity of personnel, helps patients, and contributes to medical research.[21]

Anomaly detection - locating situations in which actual results differ from those anticipated. For instance, abnormally high blood pressure and irregular heartbeats both qualify as deviations from the norm.

- **Classification** - putting diseases and symptoms into categories. It is of utmost significance for both medical diagnosis and scientific investigation.
- **Clustering** - the process of classifying and grouping together various medical occurrences. Accessing clusters in the data and locating significant patterns in the data are two of the most beneficial aspects of research.
- **Generalisation** - the capacity of the machine learning model to generate accurate forecasts in response to newly collected medical data
- **Automation** - automating important but time-consuming processes, such as monitoring medical records, is a step toward achieving this goal.
- **Prediction** - anticipating future health occurrences based on existing data, such as determining the likelihood of having a stroke based on factors such as age, blood pressure, family history, and so on.
- **Natural language understanding** - A significant amount of the data that is collected in the medical field is unstructured data, such as clinical notes. Natural language processing is able to assist in the extraction of vital information from this kind of data, information which, in the absence of this processing, would either be used insufficiently or not at all.

4.2 How is machine learning be applied to healthcare?

We predict that there will be a significant increase in the number of potential applications for machine learning in the medical field as AI continues to improve. The following items top the list and are most likely to become vital in the not too distant future:[22]

Automated health record handling

The organization of Electronic Health Records (EHR) can be done automatically, removing the need for a laborious and time-consuming process.

Machine learning has the potential to significantly enhance the management and analysis of electronic health records, which in turn will make it simpler for medical practitioners to access pertinent patient information and make decisions based on that information.[23]

Detecting and preventing diseases

Machine learning algorithms can analyse large sets of data - this takes into account sensor data from IoT-powered devices, medical records, radiographic images, etc. This saves a lot of time since it can be used to quickly detect patterns–and is more advanced than a traditional data system. This leads to early detection of all kinds of diseases, improving prognosis and treatment outcomes.

This is also true for predicting outbreaks and other events such as readmission patterns for individual patients making it easier to allocate the right resources and anticipate patient needs.

Improving treatment plans

Plans for therapy play a vital part in therapy and recovery. Machine learning systems may take factors such as genetics, clinical data, surroundings, medication, etc. and come up with an optimal and tailored plan. [24]

For example, some people may be high risk, but also allergic to particular types of treatment. Providers can utilize a solution to locate the best appropriate drug that will minimise the negative side effects, thereby boosting patient compliance with treatment.

Image analysis

The analysis of medical pictures, such as MRIs, CT scans, and other similar diagnostic tools, is likely one of the most significant applications of machine learning. A great degree of accuracy can be achieved by systems in both the detection of anomalies of any size and the identification of risk patterns. [25]

As a direct result of this, it contributes to the alleviation of the skills gap that exists in many regions that do not have enough radiologists. In addition to this, it assists providers in rapidly identifying any anomalies that they might have overlooked otherwise.

Discovering new drugs

The development of new medicines is essential, but the process is notoriously time-consuming and frequently involves a lot of trial and error. In order for researchers to uncover the most promising substances and combinations, they have to filter through a large number of datasets.

Exactly in situations like this does machine learning play a significant role. It is possible that years of study will be wasted before a medicine is finally abandoned due to the fact that it is ineffective against a particular condition. However, that identical combination may save lives in the treatment of a different condition, and an algorithm may make the process of matching them up more quickly.

Promoting treatment adherence
The degree to which a patient follows the prescribed treatment regimen is a significant indicator of whether or not the treatment will be effective. However, there is a limit to what doctors can do in terms of guiding and encouraging their patients. [26-30]

The development of apps that serve as health coaches, prompting patients to take their medication, advising them on how to improve their nutrition, and providing them with individualized health advice is one way that machine learning can contribute to the solution of this problem.

For instance, we developed a gamified platform that assists general practitioners in the process of setting up tasks (such as increasing the amount of sleep and water consumed), replete with levels and experience points. This turned out to be a significantly more effective method for engaging patients and ensuring that they adhered to their treatment regimens.

Medical research and development
Research in the medical field enhances not just the availability of new medications but also the overall quality of treatment provided to patients. The analysis of millions of research papers and the gleaned insights can be made easier with the use of machine learning.

This results in improvements in treatment programs as well as advancements in research because it identifies new areas of inquiry that should be investigated.

More accurate clinical trials
The conduct of meticulous clinical tests is an absolute requirement. Nevertheless, the process of discovering suitable people does not need to be as difficult as it has been in the past. The algorithms that make up machine learning are able to quickly scan vast volumes of data and rank candidates according to various health indicators. After that, they pick the most qualified candidates out of a pool of several hundred or perhaps several thousand persons.

At Qubiz, our team has been hard at work developing a solution that can process unstructured medical data, such as the plain language contained in hospital discharge notes. The information was then sent to the Electronic Data Capture systems (EDCs), which are utilized in clinical trials; this increased the likelihood of obtaining a result that is more reliable from the experiment.

Monitoring health
As was noted before, keeping track of the overall health of individual patients can be a difficult task; yet, doing so is of the utmost significance.

Real-time monitoring of patient outcomes is made easier with the assistance of machine learning. For instance, wearable devices can notify the provider directly whenever there is a sudden deterioration in a patient's health, which enables the physician to respond more quickly in the event of an emergency.

5. METHODOLOGY

5.1 Data preparation
Building precise medical imaging and technologies that function faultlessly for each and every patient throughout the world is the overarching goal of GE HealthCare's operations. Platforms and ecosystems are at the core of all that Karley and her team do in order to propel innovation in the healthcare industry.

Karley also predicts that a considerable amount of time is spent on data preparation, which refers to the process of transforming raw data into a format suitable for further investigation. This is extremely important since it will serve as the foundation for the AI and ML systems.

In point of fact, Karley and her colleagues have developed a tool that is housed within their Edison platform and can quickly and efficiently prepare healthcare data before passing it on to the data scientists. This frees up the time of data scientists so that they may concentrate on developing the most effective artificial intelligence systems possible for particular jobs, such as a faster MRI machine. It is also possible to use it to make the patient more comfortable while still obtaining precise diagnoses, which is necessary in order to establish which treatment options are the most effective. For instance, AI-based algorithms can evaluate the noise patterns produced by an MRI scanner in real time and generate counteractive sounds or change the pulse sequences in order to reduce the overall amount of noise. Patients will have a better, more pleasant, and less stressful experience overall as a result of this.

5.2 VR for Health Data Analytics
The amount of genomic data being processed by advanced computing systems continues to grow, along with its complexity. For instance, a single-cell data set generated by a total-seq platform may contain tens of thousands to millions of cells and hundreds to tens of thousands of characteristics. Using VR, one may successfully understand patterns in enormous data sets and influence one's subconscious mind. This is especially true for intricate medical information, such as DNA sequences. Data simulation, data visualization, and the fusion of data visualization with machine learning are just few of the many uses for immersive technology in the field of health data research. The bottom part of Table 2 shows some fascinating findings from the study of healthcare data.

The modeling of genetic data is a potential use for immersive technology. For instance, virtual reality can be used to combine data on the sequence of the genome with data on the interactions between genes, resulting in the creation of a three-dimensional model that

demonstrates the location of regulatory elements in relation to the genes that they govern. Additionally, it makes it simpler to comprehend the processes that are taking place inside of a living cell. This technology has allowed researchers to quickly aggregate their data, leading to a much more in-depth understanding of the effects of genome organization on gene expression, as well as the effects of mutations and variations on the relationships between genes. Immersive technology can also be used to reveal the molecular structure of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In order to better understand how viruses cause their effects, researchers can benefit from using immersive environments created by tools like Molecular Rift and VMD. It is vital to make advantage of virtual reality (VR) in order to convey such genetic data because the human brain is extraordinarily good at spotting patterns and people tend to think visually. Microscopy colocalization data can be better visualized and analyzed with the help of immersive technologies.

In these types of systems, a completely immersive manipulation of the microscope data and analysis tools is provided by making use of a hand gestures interface in conjunction with a standard controller as an alternative way of input. In an immersive environment, the user's perspective on data handling is expanded to its full extent.

iCAVE and other similar initiatives, such as Genome3DExplorer, make use of immersive technologies in order to visualize genomic data. Biologists are able to make better judgments based on the visualizations thanks to the immersive tools, which let them highlight some global topological aspects of the data. This allows the biologists to better understand the relationships between the variables. Some data visualization technologies, such as Deep Learning Development Environment in Virtual Reality, combine virtual reality (VR) and artificial intelligence (AI) as a more effective option for evaluating health data. Other data visualization technologies include augmented reality (AR) and mixed reality (MR). It is also utilized to describe the algorithms employed in deep learning. On the Oculus Rift virtual reality headset, this software operates independently as a stand-alone application. Another health data visualization tool, the Children Cancer Data Visualization tool, combines AI and VR in its work. This opens up the promising possibility of reporting results from AI-based pattern recognition on a VR display. After the data has been analyzed by AI algorithms, you can use this tool to display it as a 3D scatter plot for an entire group of patients. After that, you'll get access to each patient's records separately for inspection. In addition, it may present a comparative visualization between two patients of the user's choosing, as well as zoom in and out of the visualization plot, rotate it, compare the genes of many patients, interact with the user, and more. The software works with a number of VR systems, such as HoloLens and Oculus Rift. It offers a more immersive and innovative viewing experience for data than traditional displays and mobile devices. After that, the users will be able to see and interact with patient avatars as they move and are placed in a cohort, all in a fully immersive 3D environment.

6. DISCUSSION

There is a possibility that immersive technology will enhance people's perceptions. Humans are born into a multidimensional world, and it is to this reality that they are best fitted. Users of immersive virtual reality technology are able to experience things visually, aurally, olfactorily, and haptically in the same manner as they would in the actual world. Virtual reality makes it feasible to process sensory information in situations that are more similar to the real world. Because virtual reality provides a distraction-free and therapeutic care environment, as well as a pleasant and appealing atmosphere for patient interaction, more and more clinical applications are being developed for it.

Virtual reality and other forms of immersive technology may help teams from different locations work together more effectively. The vast majority of virtual reality experiences now only support a single user, however some can be modified to support multiple people. This allows programmers to design and distribute MR environments that can accommodate multiple users at once. On the technology side, this provides new opportunities. Because it facilitates collaborative work in three-dimensional settings and links data with natural human pattern recognition, virtual reality (VR) allows users to discover multidimensional relationships in data and extract actionable knowledge that would not be discoverable in any other way.

One of the key tenets of immersive technology, a promising field of research, is the combination of numerous types of data analysis, such as machine learning and data visual analytics. In the sphere of digital health, VR has the ability to bridge the knowledge gap between seasoned experts and newcomers. Virtual reality (VR) has the capability to improve perception and natural interaction, making it ideal for explaining complicated machine learning algorithms to clinical users and helping to build their trust. Researchers employ immersive technology to explain AI in the medical sector in a variety of ways, including simulation-based teaching in surgery and medicine and reinforcement learning as a tool to make people travel to a given area in Immersive VR. Research projects are becoming increasingly interested in combining XR methods with machine learning strategies with the goal of improving medicine or precision medication by analyzing digital data based on genetic information.

Care for the aged, remote general practitioner care, dementia care, child anxiety treatment, psychiatric care, distraction therapy, educational settings, and health data analytics are just some of the medical uses for

immersive technology. Patient outcomes, medical education, and the creation of more user-friendly data visualizations have all benefited from work currently in progress and recently finished. All of the initiatives are quite recent; the most of them were initiated in 2014, and the majority of them are still active. It will take some more time for virtual reality technology to reach its full potential when applied to the field of digital health. The practice of data visualization is beginning to expand into virtual reality (VR) environments because to VR's more interactive and naturalistic presentation of large amounts of genetic data.

Even while some study on immersive technology for genetic data visual analytics has already been done, the field is still in its infancy. Innovative immersive technology is needed to boost human involvement in the analysis of complicated genomic data and to uncover new patterns and insights. Another skill with room for improvement is knowing how to implement immersive technology in ways that benefit the people who actually use the domain. Understanding the "why" behind the "how" is essential for future research, and this can be accomplished by interviewing users before and after developing tools for visual analytics of genetic data in an immersive technological setting. This is crucial for the progress of the study. Users' genuine needs should be factored into the tool's design and development. Projects using immersive technology to visualize genetic data can build upon the results of previous studies, including those conducted using artificial intelligence, and incorporate new features to further improve the outcome for domain users. This feature enables the projects to leverage and incorporate the results of prior studies. An increased focus on ergonomic evaluation in usability studies with domain experts is necessary to advance data-driven and user-centered design with immersive technology.

CONCLUSION

The goal of this research was to compile a comprehensive overview of the current immersive and XR healthcare technology activities, including the use of XR in medical domain education, health data analysis, and visualizations of genomic data. To further illustrate how virtual reality (VR) interacts with other technologies such as AI and mobile devices to address clinical concerns, we present a research case study that represents the next generation of genetic data processing. The medical industry has just begun to explore the potential of immersive technology. There appears to be a dearth of literature on the topic of genetic data presentation in VR settings, and even fewer on the topic of integrating technologies like machine learning and game theory. Virtual reality's potential for usage in genetic data analysis is still completely untapped at this point. In order to do analyses and interactive visualizations of genetic data in an XR context, a novel framework may prove to be helpful. Resolution of real-world clinical cases should drive the development of a new framework that integrates domain experts' knowledge with technological advances like big data processing, machine learning models, visual design and interfaces, game optimization, and visual analytics. New usability studies should investigate the integration of all preceding technologies to ease the process of interpreting complex genetic data in a way that is accessible to people. Ergonomic evaluation in the VR setting is also necessary for a data-driven and user-centric design of the immersive area. Furthermore, the user interface for visualizing genetic data needs to be enhanced so that it may more naturally take advantage of the XR and 3D contexts. In conclusion, in order to give meaningful, trustworthy, and interpretable results to domain users, approaches for studying genomic data need to include many analytic procedures, such as machine learning, and contain adequate explanations. In the field of digital health, the novel technology known as immersive technology will be utilized more and more frequently to increase the precision and efficiency of the procedures that are now in use and to boost the capacities of people.

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