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Perspective & Comments

Mixed reality assists the fight against COVID-19

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ABSTRACT

Coronavirus disease 2019 (COVID-19) made a huge effect globally. With the assistance of mixed reality (MR) technology, complicated clinical works became easier to carry out and the condition had been greatly improved with high-tech advantages such as improved convenience, better understanding and communication, higher security, and medical resource saving. This study aimed to introduce one kind of MR application in the fight against COVID-19 and anticipate more feasible smart health care applications to enhance our strength for the final victory.

1. Introduction

Coronavirus disease 2019 (COVID-19) is a severe acute highly infectious respiratory disease because of the causative agent, a kind of new coronavirus, and had spread rapidly in a short time. According to incomplete statistics, there were nearly 200 countries all over the world that had been affected with millions of mortality [1]. Until now, there has not been any available treatment for the contagion. Relatively speaking, chloroquine, respiratory therapy, and quarantine are the most effective methods to treat patients with COVID-19 in the present stage, which could comparatively reduce further deterioration [2]. There was a study comparing the contagion with severe acute respiratory syndrome (SARS) for a better understanding of COVID-19. It was found that COVID-19 is a disease characterized by pulmonary symptoms such as fever, cough, chest pain, and difficulty in breathing, with more rapid and larger spreading, cluster of infection, and higher mortality [3]. This severe disease had brought devastating blows globally and will continue to make a lasting impact on human life and health. Experts of related fields from all over the world had been seeking practical ways to have a better understanding and avail treatment for COVID-19. Therein, smart health care (the medical system upon high-tech productions to integrate the clinician, department of health care and other medical resources, energetically and intelligently meet the requirements of medical service) [4] which is represented by mixed reality (MR) technology had played an important role.

MR is a new digital technology of smart health care, which refers to a new kind of environmental visualization generated by a combination of the real world and the virtual digital world, in which physical entities and digital objects can coexist and interact in real-time. The new technology was proposed in recent years combining the advantages of virtual reality (VR) and augmented reality (AR) technology [5]. However, MR had also avoided the limitations of VR and AR such as the lack of realism, intricate navigational system, and heavy device with the assistance of “HoloLens”, a convenient high-tech head-mounted device that was invented by Microsoft to further effectively use the MR technology [6]. With MR technology upon HoloLens, things had changed a lot. A large amount of convenient MR-based applications appeared and made a profound influence on various industries including medicine, providing users a vivid pattern for their works with immersive experience between the virtual and real world. In the previous researches of our intelligent medicine group, we had confirmed the huge promotion from several kinds of smart health care in the medical field, such as MR technology, artificial intelligence, and wearable health devices [6–9], which brought new opportunities for the traditional model. In this article, we further introduced our recent study by applying MR technology to the fight against COVID-19; to help clinicians better understand the contagion and facilitate the efficiency and effectiveness of clinical works.

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Fig. 1. The application of MR in COVID-19. Clinicians are learning, discussing, and analyzing the patient's pulmonary lesions through HoloLens. Green means pathological lesion, whereas other colors mean different lobes. MR: mixed reality; COVID-19: coronavirus disease 2019.

2. The application

On the frontline of COVID-19 fighting in Wuhan Union Hospital, our intelligent medicine group had profoundly experienced the miserable situation, either the epidemic severity or medical supplies shortage, or the difficulty and inconvenience during the coronavirus disease diagnosis and treatment. Fortunately, benefited by the primary CT data of confirmed patients and numerous attempts, after preliminary works including data division and processing, suspicious spot recognition, and model reconstruction, our group successfully took the advantages of MR technology to deal with COVID-19 using the HoloLens device. The detailed operation processes were as follows: CT DICOM data of patients were imported into a "3D slicer module" of medical image workstation (Visual3D, Beijing, China) to segment, reconstruct, and obtain STL data of the lung. Then the STL data were imported into "Scene editor module" for colorization and transparentizing. After that, the final data was exported to the system of HoloLens for hologram visualization.

As demonstrated in [Figure 1](#), with the assistance of MR technology, the CT-reestablishment lung could be presented in a more vivid three-dimensional way by labeling with different colors and further rendered by HoloLens for clinicians. The normal and diseased tissues were divided, and during the presentation, medical workers could magnify, shrink, and rotate the model and also make perspective through figure gestures in the air. The observation, measurement, and illness level evaluation could also be realized in a contactless way to avoid the possibility of transmission from contact and to cut off the transmission route, which could be significant for works in the hospital during the COVID-19 period.

3. The superiority

3.1. More convenience

Using the MR technology and rendering pattern of HoloLens, the reestablished lung from CT data could be directly and vividly presented in front of the clinician's eyes. Clinicians can freely adjust the size and orientation of the model as required through figure gestures in the air, which is realized by the picture archiving and communication systems (PACS) on a computer, reducing the complicated processes of detection for each CT layer. Besides, clinical workers could also hide the surface pulmonary tissue and make a perspective for deep lesions by the HoloLens operation system, which could be crucial to observe and detect the hidden tissue. Therefore, the application of MR in COVID-19 can bring convenience for clinicians to get the visual information of pa-

tients and make further analysis. Relatively, a more convenient work style improves work efficiency and reduces clinical workload.

3.2. Better understanding and communication

As a new disease had never appeared before, the imaging performance of COVID-19 is also quite difficult to distinguish. The three-dimensional MR pattern makes things better by helping junior clinicians to learn the classical characteristics of COVID-19, who might feel difficult to straightly read the results of two-dimensional X-ray or CT layer on-screen as professional pulmonary experts. From the vivid presentation pattern, clinicians can also get a more macroscopical conception of how coronavirus affects and distributes in patient's lung and also grow the vision of an overall situation about pulmonary infection and understand the disease better. With a vivid MR model, clinicians can communicate with each other and exchange views besides making private label conveniently; any model transformation for better observation and learning will be available through the HoloLens system. Thus, the efficiency and effectiveness of medical consultation and making treatment plans were promoted.

The communication between doctors and patients also became easier with the assistance of MR technology. Commonly, owing to the gap of complicated anatomy, basic skill of CT reading, and professional term, it might be hard for a clinician to clearly explain the disease situation and relative medical complications for patients without medical knowledge. Patient's confusion and worry always impede the establishment of a doctor-patient relationship. Through the vivid MR model, things can be quite easy for clinicians by strengthening the impact of communication. Clinicians with the HoloLens device can stay at a safe zone outside the isolation ward to explain the illness condition. The scene and visualized model can be shot by the "Camera System" (Visual3D, Beijing, China) and transferred into the isolation ward in real-time and presented on the screen of electronic devices such as a tablet computer. During the communication between doctors and patients, with the three-dimensional model as a reference, patients can better understand what had happened to their body at an anatomical level. The illness condition will also be presented clearly and vividly, which suits the nonmedical person to form a visualized impression and to eliminate the fear of the unknown, contributing to build a good doctor-patient relationship.

3.3. Higher security

COVID-19 has a highly infectious characteristic that can spread from person to person and even from a contacted object, which is a surface

transmission pattern [10]. Besides, there are no available treatments at the present stage for the global pandemic; valid quarantine is the most effective method to retard the spreading of COVID-19, which also conform to the conception of blocking transmission routes, one of the three key points to control infectious diseases (other two ones are controlling infection source and protecting vulnerable groups). Moreover, the process of disinfection for the medical environment and facility is important for nosocomial transmission prevention. With the application of MR technology, the process of CT reading and analyzing could be realized without a computer and photographic film, which as a public office equipment, might be a route of COVID-19 transmission. All of the operations could be finished through an observer's easy finger gesture, which means a contactless way without the possibility of surface transmission pattern, and hence, the health and security of clinicians have been effectively guaranteed by avoiding contact with public medical objects. With the portable HoloLens device, a clinician can acquire a patient's CT data anytime and anywhere, eliminating imaging department visits and the use of heavy imaging equipment at a fixed location. The nosocomial people turnover rate and aggregation can be reduced for safety reasons. Finally, to better confirm the security, to prevent cross-infection, and to maintain sanitation, each of the clinicians was provided with one HoloLens device, which was disinfected with alcohol after use.

3.4. Medical resource saving

Except security guarantee, the contactless way of MR technology could also reduce the unnecessary wasting of medical resources. For example, a printout of the traditional photographic film is not required for clinician referring anymore, owing to the available and effective MR observation pattern. The print costing can be saved, which is beneficial to relieve patient's financial burden and economize medical resources. Besides, the free pattern also cuts down the trips in contaminated areas, the consumption of protective clothing, and other preventive products, which are already in short supply. The intuitive and understandable pattern helps junior clinicians to assist with clinical works. This could also free the medical experts, who might contribute largely with more energy and time in the frontline of COVID-19.

4. Conclusions

In general, MR, the smart healthcare technology provides effective help to assist the fight against COVID-19. In this study, which is our attempt to apply the useful technology in fighting COVID-19, the main performance is as follows: (1) improved convenience; (2) better understanding and communication; (3) higher security; and (4) medical resource saving. With the assistance of MR technology, medical workers can obtain a more clearer comprehension of the unknown coronavirus at the scientific and credible level. The difficulty in fighting the epidemic had been alleviated to some extent, the morale of clinician and patients were also enhanced with more confidence to confront COVID-19. Our study reminds of a feasible method in face of the epidemic dilemma, and the MR can be a timely method to help clinical workers with better epidemic prevention and further public health management. However, during the application of MR technology, the clarity and completeness of CT DICOM data, the reconstruction level, and the operational ability of computer hardware might have some limitations, which bring an

adverse effect for the application. However, with the development of science and technology, these limitations will be resolved soon. In addition, the MR technology could also be applied with artificial intelligence and 5G communication technology for intelligently recognizing and presenting the lesions and remote consultation along with other scenarios. Hence, we appeal more useful applications of smart healthcare to assist us through the hard times and achieve the final triumph.

Author contributions

Pengran Liu, Lin Lu, and Songxiang Liu completed the research and wrote the article; Mao Xie, Jiayao Zhang, Tongtong Huo, Yi Xie, Honglin Wang, and Yuyu Duan made the previous investigation and survey, and also revised the article; Yu Hu and Zhewei Ye designed and guided the research.

Editor notes

Given his role as editorial board members, Zhewei Ye and Yu Hu had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to Jing Sun and Zhuqingqing Cui.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest.

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