Advances in Social Science, Education and Humanities Research, volume 329

4th International Conference on Contemporary Education, Social Sciences and Humanities (ICCESSH 2019)

Application of Augmented Reality Technology for Anesthesiology Major*

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***Abstract*—Clinical teaching of anesthesiology occupies a very important position in the training of medical students, and it is of great significance for training high-quality anesthesiologists. The training of anesthesiologists requires a rich knowledge framework, a large number of case teachings, and many practices. And then, it can cultivate a qualified anesthesiologist. In this paper, taking augmented reality technology as a starting point, the use of the teaching method of multimedia technology combine the real medical scene with virtual assistant technology, which provides a perfect application system for medical students, hoping to train excellent anesthesiologists.**

Keywords—clinical anesthesia; teaching; augmented reality technology; facial recognition

I. INTRODUCTION

With the development of science and technology, as well as the improvement of computer computing performance, it can see that the teaching methods of many disciplines have changed from traditional teaching mode to new teaching mode combining with the new media. In recent years, 5G technology develops rapidly, and higher network transmission speed technology is born. On the morning of March 16, 2019, the first long-distance human surgery based on 5G, "brain pacemaker" implantation for Parkinson's disease, was successfully completed in Hainan Hospital, General Hospital of the Chinese People's Liberation Army. [6] From such a successful case of network telesurgery, it can see the rapid development of technology and the wide application of interdisciplinary technology. In this paper, the combination of real anesthesiology scene and augmented reality technology has been applied to many operation methods of clinical anesthesia operation, which can enable users to gain more learning experience and case handling experience in real scene compared with traditional teaching methods. It expects to build a virtual and augmented reality teaching platform for anesthesiology. As shown in the "Fig. 1" below, the virtual scene and three-dimensional real-time data will be interacted to form an experience that allows the operator to feel the actual operation of anesthesia. It will increase the interest of teaching and learning effectiveness.

*Fund: Youth Fund Project for Humanities and Social Science Research of the Ministry of Education in 2018 — Application of Virtual and Augmented Reality Technology in Anesthesiology Teaching (Project Approval No.: 18YJCZH084); The First Batch of Industry-university Collaborative Education Projects of the Ministry of Education in 2018 (Project No.: 201801079033); Liaoning Provincial Key Research and Development Guidance Program in 2018 — The Establishment and Application of the Virtual Simulation System of Emergency Equipment for Underwater Operations.

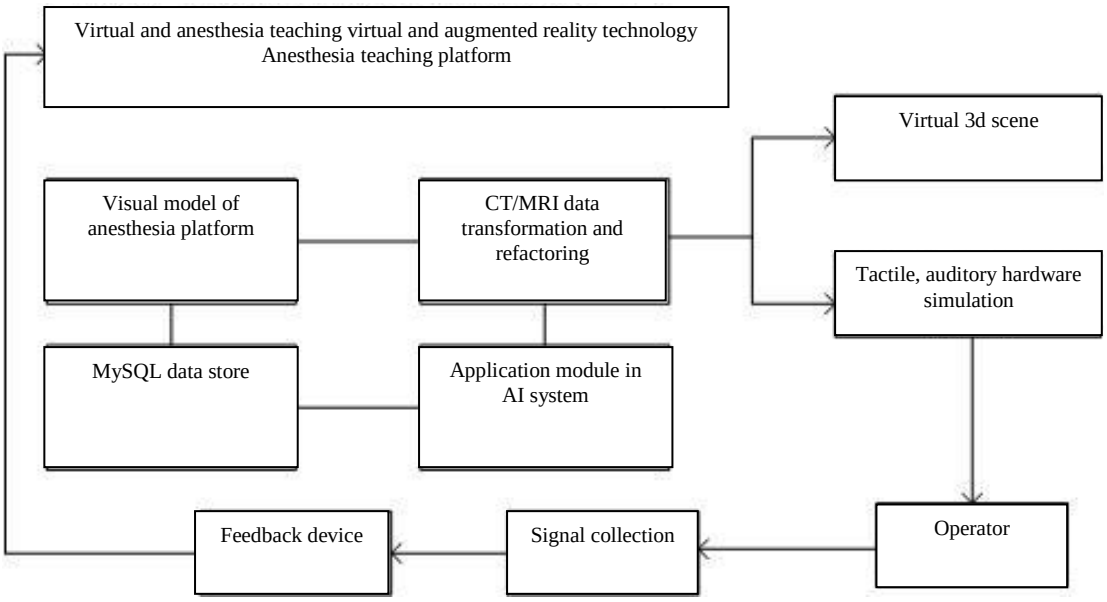

Fig. 1. The system structure of anesthesiology teaching through virtual and augmented reality.

II. CHARACTERISTICS OF CLINICAL ANESTHESIOLOGY TEACHING

At present, the mainstream method in medical colleges is that teachers will teach anesthesia knowledge according to the syllabus. Students' learning methods are mostly demonstrated by teachers, combined with video courses to practice in different operating rooms. By explaining the theoretical knowledge and analyzing the demonstration in the classroom, the students understand and grasp the essentials of anesthesiology, including internal jugular vein puncture, double-lumen bronchial teahouse, tracheal intubation, nerve block operation time and so on. The main teaching methods and characteristics of clinical anesthesiology are listed below.

A. Case-based Teaching

Case-based teaching originated from the situational case teaching course of Harvard University in the 1970s. It was first applied to medical and legal disciplines, and then to management and other disciplines. Anesthesiology is a subject that can't be mistaken. At the same time, according to different clinical cases, there will be many unexpected situations, so case teaching method is very popular in the early stage of teaching. As shown in "Fig. 2".

Teachers can set up specific teaching cases, and organize students to investigate, read, think, analyze and discuss cases. In this way, students' comprehensive ability can be cultivated. At the same time, the introduced cases can be arranged according to the syllabus. Also, it can adjust the case model timely according to the situation of the simulation site for students to discuss. Through group discussion and group debates, it can divergent students' thinking, and consolidate the students' logical integrity, comprehensive analysis and judgment ability.

Different classical cases of clinical anesthesiology can be thoroughly and meticulously analyzed to consolidate students' knowledge of anesthesiology. At the same time, it also poses a great challenge to students' practical ability. However, with the increase of the number of students, the teaching effect of the case will be affected by the number of students, which will reduce the teaching effect.

Fig. 2. Case-based teaching.

B. Teaching Method of Problem-based Learing

Problem-based learning (PBL) is a new teaching mode implemented by McMaster University in the 1960s. In problem-based teaching, a set of corresponding learning situations is designed. According to this way, problems suitable for students are set up to encourage students to think and solve problems based on the real world.

In the teaching of anesthesiology, students become the center. By setting up study groups and consulting materials together, the teaching process of anesthesiology is more detailed, and the students' ability to think about problems is increased.

However, there are also some shortcomings. When taking the students as the subjects, it is easy to lead to the weakening of the role of teachers. Anesthesiology is a subject with strong applicability and precise operation. In the overall learning process, it is more about the accumulation and application of knowledge and less about innovation. Moreover, the effect of PBL teaching method has a great demand on students' learning ability and team organizational ability. It is easy to see that each student has different levels of anesthesiology technology, which will not present the ideal teaching effect.

C. Multimedia Teaching Method

Multimedia teaching method has great attraction for contemporary college students. Anesthesiology involves many related medical disciplines, and leading students to the first step is a very rare process. When the setting of medical scenes is based on multimedia teaching methods, it can greatly mobilize the enthusiasm of students. Transforming the rigid documents in textbook teaching materials into multimedia forms, such as MG animation, real video explanations by famous teachers, etc., can help students understand anesthesiology knowledge system and operation methods in many ways. With the help of multimedia materials, students can complete their own study of basic anesthesiology knowledge after class in a comfortable and convenient environment such as the library.

The teaching characteristic of contemporary university is that a teacher leads hundreds of students. For many times, teachers distribute the contents of the course in advance, let students study after class, and consolidate the grasp of basic knowledge of clinical anesthesiology with different examination methods. After that, the teacher made the students combine theory with practice by explaining the mannequin and analyzing real cases.

III. CORE FEATURES OF AUGMENTED REALITY

The core feature of augmented reality technology is precise position tracking and real-time rendering based on real scene. Augmented Reality (AR) technology is a technology derived from the emergence of virtual reality technology. Driven by the Internet economy, it brings the practical application fields of artificial intelligence technology, such as machine learning, deep learning, etc., so as to make more people understand and realize the possibilities brought by such technology.

Augmented reality technology is the integration of virtual world and real world, and builds a bridge between virtual world and real world. Unlike virtual reality technology, which is based on user's omni-directional virtual world construction, augmented reality technology places virtual objects in real space by scanning and analyzing the existing target recognition objects, so that users can have new feelings. Compared with the high requirement of virtual reality technology for computer host performance, augmented reality technology can rely on portable devices to achieve the effect of integrating virtual scene and real world generated by device rendering.

Augmented Reality (AR) technology is based on real scenes, which has become the biggest difference between AR technology and virtual reality technology. It also makes a certain distinction between their application scenarios. James R. Vallino once proposed that augmented reality (AR) technology integrated synthetic sensory information into users' perception of the real world. [4] In 2017, Apple officially released AR Kit's AR development platform, which allows many developers to create augmented reality applications for iPhone and iPad platforms. Millions of users of Apple products can achieve practical augmented reality effects through simple system upgrades, such as measuring rulers. With the rapid development of cell phone chip technology, it can better match with the rapid development of computer vision, three-dimensional registration and tracking technology, computer graphics, and present the scene of combination of virtual and real for users. At the same time, through the flexible use of the existing technology, new interactive performance can be brought. With only one camera and software, virtual interactive simulation applications can be built in real scenes. With the help of image recognition technology, interactive effects of targets can be achieved through gesture recognition, facial expression recognition, image stripping and other technologies.

"Fig. 3" is Milgram's description of the relationship between Augmented Reality (AR) and Virtual Reality (VR) memory, illustrating the continuous change between them. [3]

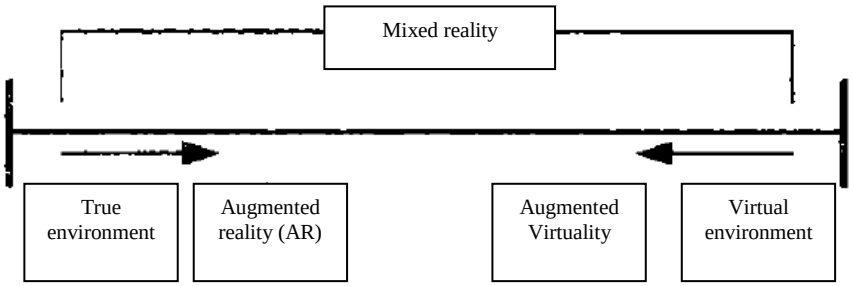

Fig. 3. The relationship between virtual reality and augmented reality.

IV. Development Status of Augmented Reality Technology and Application

A. Flow Theory

It is based on the study of flow theory of Csikszentmihalyi, that is, the emergence of immersion is related to the challenge difficulty of activities and the level of personal skills. The best immersion point is to challenge the balance between difficulty and individual skill level. The flow model is shown in "Fig. 4". [11]

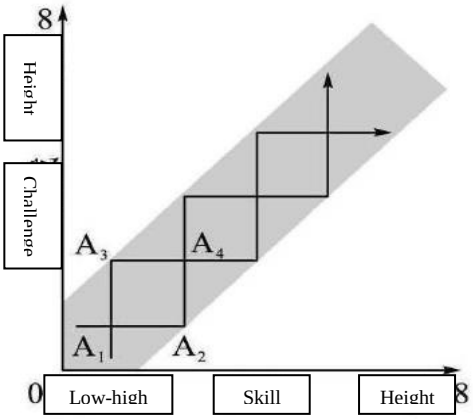

Fig. 4. Csikszentmihalyi's flow model.

At present, with the help of UNITY3D game engine, ARKit, and the interface provided by Apple, augmented reality (AR) can be easily realized. Or using Google's AR Core and Vuforia make augmented reality applications for Android devices.

They all have mature development mechanism at present. From a technical point of view, Apple's AR kit has excellent augmented reality performance. It includes a visual inertial ranging system based on 2D plane malicious function. It can track the user's spatial position in real time by software, and match the feature points in the real world with the pixels of camera sensor. [1]

It can track the user's posture. The mobile phone's internal frontal accelerometer and gyroscope can also track the user's posture. Through Kalman filter, combined with the output of the two systems, the real location of the user is calculated based on the ground condition. Therefore, the virtual object is rendered to the location feature points of the target.

In the process of building virtual objects, it needs to consider the effect of shadow rendering in real environment. It can draw shadow for them by UNITY3D, and simulate the projection situation. Through continuous testing and adjustment, it can make a complete application program.

B. Augmented Reality Technology Development

With the rapid development of computer technology in recent years, after the first year of virtual reality in 2016, augmented reality technology has developed rapidly. In recent years, many domestic and foreign Internet enterprises have invested a lot of money to develop this technology, hoping to develop the deeper value behind this technology.

At present, for augmented reality technology, more and more companies integrate this technology with machine learning technology. By recognizing, extracting and transferring the feature points of the photographed content to the corresponding models, they have produced vivid animation effect. Even with the help of this technology, they are different from the traditional single-frame matting method in the film and television industry, thus realizing the real-time transmission of facial expressions. At the same time, through the in-depth learning module of mobile phone, in the process of users' use, the accuracy of self-correcting recognition can be continuously improved, which reduces the traditional immobilized detection methods, and makes the use of this technology more effective.

The application fields of augmented reality and virtual reality are clearly divided. Virtual reality pays more attention to the simulation of virtual scene, which makes users feel immersed in it. Augmented reality is based on reality, but higher than reality, which creates a completely different style of environment. The application scenario of this technology is also more close to the real-time simulation based on the real scene, which is applied in medical, education and other industries.

V. Design and Implementation of Augmented Reality Visual Teaching Environment for Anesthesiology

A. Sequence Diagram

Based on UNITY3D engine, Vuforia augmented reality technology and 3D Max, Maya modeling technology, a complete teaching system of anesthesiology was established in the visual teaching environment of augmented reality for anesthesiology. Different from the traditional multimedia teaching method, students can learn and master how to give the correct clinical anesthesia plan according to different patient cases by means of augmented reality equipment. In the system, the biggest design point is intelligent event control. The controller integrates different case structures, individual patients, and generates random clinical emergencies according to template data. Users may face various emergencies in the process of using the controller, so as to exercise students' clinical experience to a great extent. As shown in "Fig. 5".

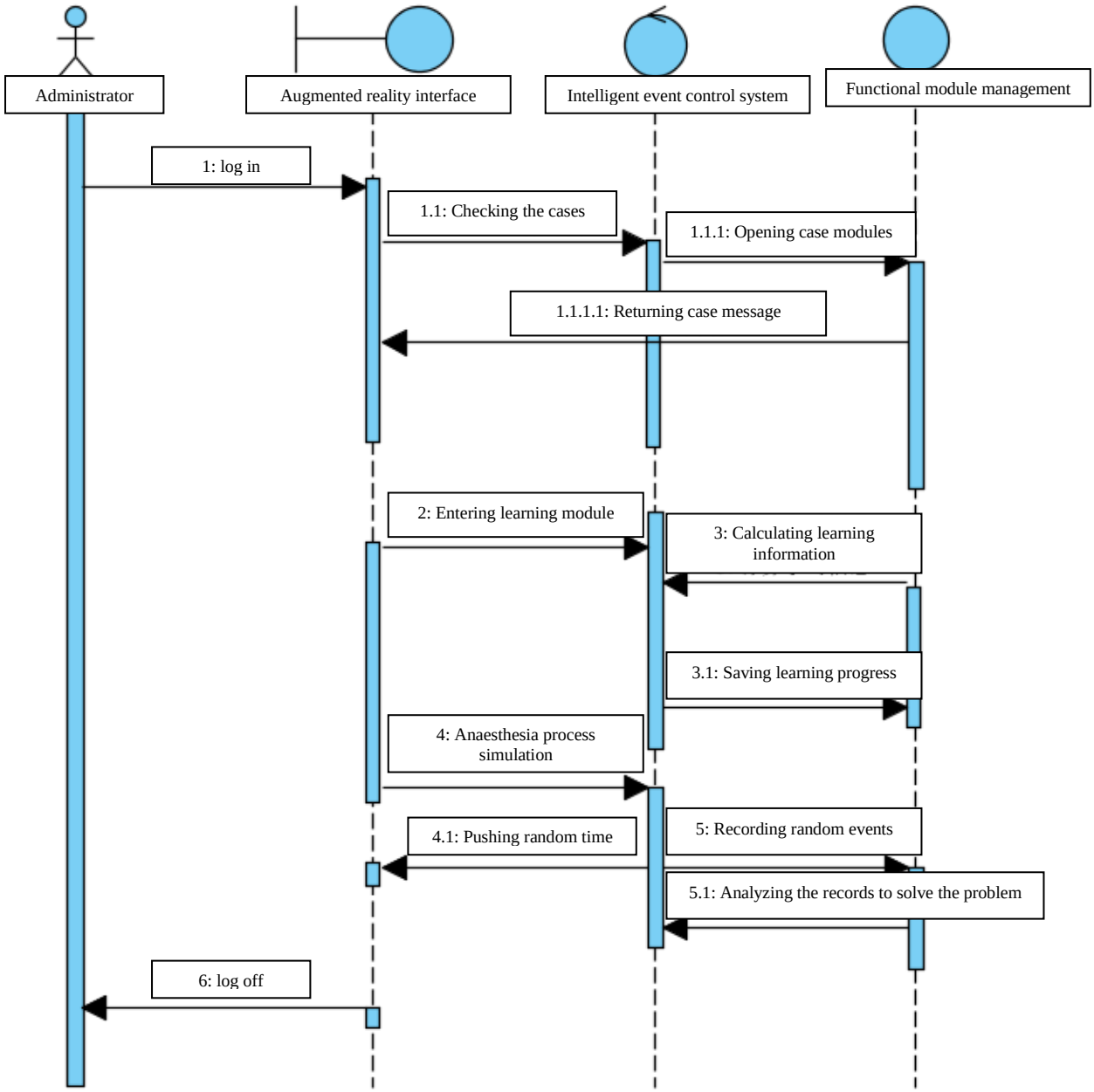

Fig. 5. Sequence Diagram.

B. Introduction of Module Function

Augmented reality visualization teaching environment system for anesthesiology consists of six modules, each of which is designed for clinical anesthesiology scenarios. [9] Through this system, the students can grasp the operation essentials of anesthesiology in an all-round way. As shown in "Fig. 6" below:

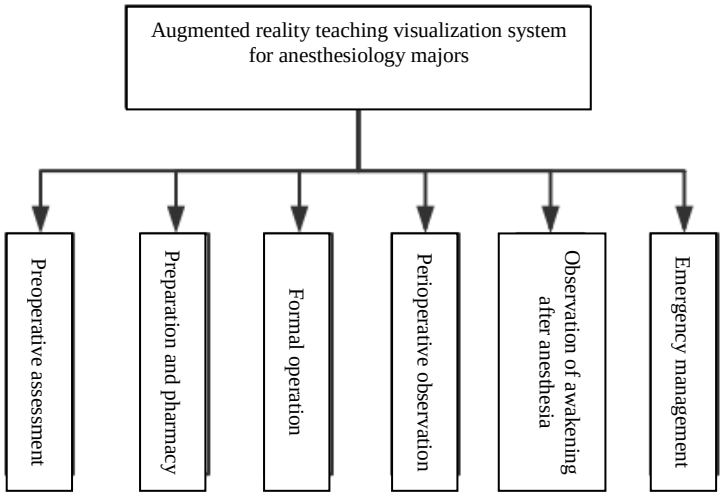

Fig. 6. Module framework.

1) Preoperative assessment module: Before operation, anesthesiologists make a preoperative visit after receiving surgical notification. In this module, combined with the database information of hospital patients, anesthesiologists can get cases in advance, understand enough medical history, and understand the diagnosis of surgical disease, the location of operation and the predicted bleeding degree. At the same time, anesthesiologists need to check the results of preoperative examinations and laboratory tests, and make risk judgments of anesthesia and surgery. The design of the module is presented as a case in the augmented reality device used.

2) Preparation and medication module: In this module, it is divided into two parts: preparation before anesthesia and medication before anesthesia.

In pre-anesthesia preparation stage, students need to use augmented reality equipment to observe the patient's general situation, and keep the function of each organ of the patient in a good state. At this stage, students need to have a comprehensive understanding of the preoperative evaluation of patients, and formulate appropriate respiratory system and cardiovascular system programs for patients, so as to avoid surgical accidents.

In the stage of pre-anesthesia medication, students need to use visual teaching system to understand the purpose of pre-anesthesia medication, the types of commonly used drugs, and their corresponding use methods and matters needing attention.

3) Formal operation

a) Judgment of anesthesia method: Anesthesia methods include local anesthesia, general anesthesia and intraspinal anesthesia. Students need to master different anesthesia methods, the mechanism of action of corresponding drugs, potential factors that may affect the pharmacological effects of anesthetics and toxic reactions of anesthetics. After familiarizing themselves with this basic knowledge, they can learn the key points of anesthesia operation by means of the corresponding character model and augmented reality equipment.

b) Respiratory monitoring: The structure of the airway is the first thing that every student knows. With the help of three-dimensional model and subdivision structure matched, students can learn the reasons that affect the patency of the anatomical airway. On this basis, students can grasp the method of maintaining airway patency. With the use of equipment mask, students learn to master organ intubation and organ incision. At this time, the visual teaching system will tell students the correct operation position by virtue of the positioning of image structure, and cooperate with the corresponding video to help them understand.

4) Perioperative observation: This module will simulate the whole operation process and give different scenarios randomly. It will help students to recognize the various situations that may occur during the clinical operation, such as controlled hypotension, temperature management, fluid balance management, blood protection and reasonable blood transfusion. In the operation process, students need to understand the corresponding physiological basis, indications, and contraindications, understand how to use medical equipment to timely observe the patient's physical condition.

5) Observation of awakening after anesthesia: After awakening up, the students should understand the routine work and the standard of leaving the room. And they should learn common PACU complications. The system will

simulate the complications in turn to help students understand the corresponding symptoms and learn how to deal with them.

6) Emergency management: This module belongs to the random module, produces the corresponding emergency warning according to the physiological settings of medicine in operation, trains students to deal with emergency measures, combines the real scenes with augmented reality simulations, so that students can feel the importance of efficient handling and calm thinking in emergency situations.

C. Technical Key Points Analysis

1) Augmented reality principle based on markers: In real anesthesia scenarios, patients usually wear surgical clothes with strong privacy. When using augmented reality equipment, they need a very accurate judgment ability to distinguish the occluder from the patient's limbs. Through three-dimensional registration based on natural features, it only needs to pay attention to the texture characteristics of the natural scene and manually add auxiliary feature point information in special cases, which can ensure the premise of the surgical scene to the greatest extent and realize the real-time tracking registration of the marker. [7]

Firstly, the basic feature points are obtained by scanning the markers. Through these feature points, it can be calculated and obtained in the computer. With the help of Harris's corner point matching and KLT feature point tracking algorithm, a good tracking effect can be achieved in a shorter computer computing path. However, such a technology has some drawbacks. It has higher requirements for the markers, and needs enough texture information of the scanned object to achieve a stable tracking effect. If the overlighting changes frequently, tracking failure will easily occur, which will cause a lot of trouble to users.

Therefore, when augmented reality technology is applied in medical field, AR Toolkit technology will be chosen more often. Such technology can be compared with template in database through template. Its advantage lies in more precise accuracy. Although there will be more computational requirements for computers, users can freely set the characteristics of templates and combinations, which can bring ideal results.

2) Face expression recognition based on computer vision: In the process of anesthesia, it is necessary to use the "Digital Assessment Scale of Pain Degree" to assess the degree of pain of patients. The pain is judged by the "Facial Expression Pain Assessment Scale". [2] Augmented reality equipment is needed to collect and process the patient's facial information to determine whether the degree of pain is consistent with that given by the students. The pain rating scale is shown in "Fig. 7":

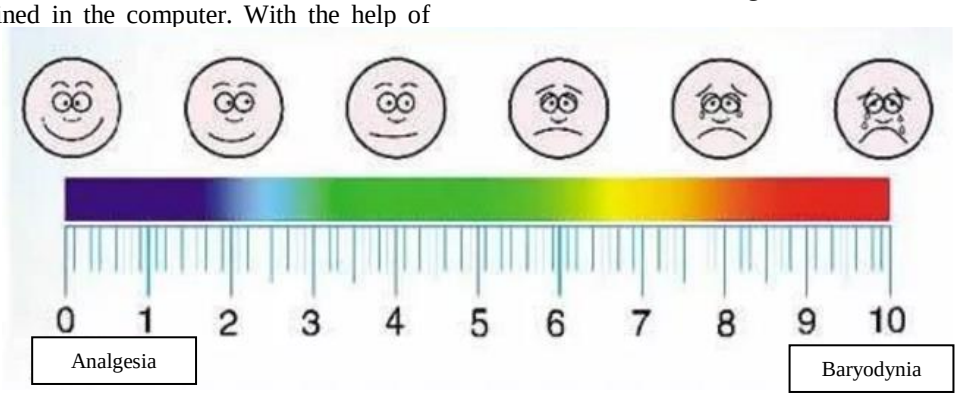

Fig. 7. Pain rating scale.

Augmented technology includes multimedia technology, computer vision, human-computer interaction and other features. In the whole operation process, first of all, it needs to recognize the face, classify the feature points of the face, use the face classification algorithms, such as the recognition algorithm based on the feature points of the face, the recognition algorithm based on the whole face, and so on. Through the basic face recognition algorithm, it can help the augmented reality equipment find and identify the target patients in the initial stage of use. [8]

After acquiring the facial data, it begins to extract feature points, and constantly trains the accuracy of recognition and the subtle changes of micro-expressions of the sample face training model with the help of machine learning technology. In the judgment of facial expression change, SVM algorithm is used to assist. The SVM algorithm uses the expression classification algorithm of support vector machine to ensure the performance in the case of fewer samples. At the same time, it can avoid the over-fitting problem of machine learning algorithm in traditional artificial intelligence, and can maximize the recognition speed and efficiency of facial expression change. [10]

In the augmented reality system for anesthesiology specialty, through face detection, image preprocessing, feature point extraction, matching and final result output and judgment, after the training of sample data model, students can be judged whether the judgment is correct or not according to the recording of sample training model in the system and the standard of prototype form.

VI. CONCLUSION

Anesthesiology is a very rigorous subject. In addition to grasping the basic techniques and methods of anesthesiology,

students need to test, regulate and control human functions, such as airway management, breathing, oxygen supply and demand balance, hemodynamics, body fluid balance and other characteristics. They need to learn about shock, ALI, ARDS, MODS and cardiopulmonary cerebral resuscitation and other knowledge of first aid, diagnosis and treatment of severe patients. Also, they need to learn to accurately judge the pain index of patients, the emergence of accidents during surgery, and the basic knowledge of late drug dependence and withdrawal. [9]

Augmented reality technology has a very wide range of application scenarios in all aspects of anesthesiology. In teaching, augmented reality display equipment can enable students to easily obtain the corresponding case data in the actual site, make different pre-judgments according to different cases, and operate in the real scene. When there is improper behavior in operation, the system can provide timely warning and hands-on teaching, which can avoid the situation that students of anesthesiology are at a loss to apply the theoretical knowledge and the content of the teaching video they usually read to the actual operation scene. Compared with virtual reality, augmented reality technology, which seamlessly integrates reality and virtual scene, can bring more professional immersion. The academic scene of anesthesiology not only relies on all virtual to give students the application of knowledge, after passing the test of virtual reality, it should be combined with augmented reality equipment, and give the accurate judgment of computer vision technology, assist students to have more accurate judgment of the current medical scene, so as to lay a solid foundation for the learning process and subsequent practice to become a professional anesthesiologist.

REFERENCES

[1] Anon. Apple is slightly better than Microsoft, why ARKit is the best choice for AR [Online], 2017. Available at: http://www.sohu.com/a/165426420_468731 [Visit date: 8]. (in Chinese)

[2] Anon. 2018. Pain Rating Scale [Online], Available at: http://www.360doc.com/content/18/0108/01/22020824_720083976.shtml (in Chinese)

[3] Milgram, P. a. F. K., 1994. A Taxonomy of Mixed Reality Visual Displays [J]. IEICE Transcantions on Information Systems.

[4] T, A. R. A survey of Augmented reality. Presence Teleperators &Vitual Environments, 1997, 6.

[5] Cai Su, Song Qian, Tang Yao. Framework and practice of augmented reality learning environment. China Educational Technology, 2011, 8. (in Chinese)

[6] State-owned Assets Supervision and Administration Commission of the State Council. Crossing nearly 3,000 kilometers, the first 5G remote human surgery in the country was successfully implemented, 2019 [Online]. Available at: http://www.sasac.gov.cn/n2588025/n2588124/c10743522/content.html (in Chinese)

[7] Han Xue. Research on medical augmented reality tracking registration method based on three-dimensional markers, 2017. (in Chinese)

[8] Tan Shuqiu. Research on feature point detection methods for facial dynamic augmented reality. University of Electronic Science and Technology of China, 2017, 9. (in Chinese)

[9] Yang Boxian, Li Wenzhi. Anesthesiology. People's Medical Publishing House Co, Ltd., 2016. (in Chinese)

[10] Yang Yang. Research on virtual environment interaction technology based on expression recognition. Chongqing University of Posts and Telecommunications, 2017. (in Chinese)

[11] Ye Hanyao. Analysis of the interactive influence factors of the game flow experience. Art Science and Technology, 2018, 12. (in Chinese)