

## Research on Intelligent Self-Studying Room Based on IPPG Technology

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**Keywords:** IPPG, Intelligence, Sharing economy, Self-studying room, Mental health

**Abstract:** In view of the problems such as the shortage of learning space, environmental interference, and high learning pressure that commonly exist in colleges and universities at present, this paper analyzes the current research situation of IPPG technology and the market prospect of paid self-studying room, discusses the feasibility of IPPG based paid smart self-study room. The conclusion drawn from the research on market demand and technical support is that the paid smart study room technology is feasible and has a good application prospect. In addition, this paper designs the overall structure of paid smart self-study room. It can provide reference for the construction of smart study room.

### 1. Introduction

Smart study room is the smart study room, also refers to the construction of the study room according to the smart standard. According to the national standard GB/T 36342 "Smart Campus General Framework", the wisdom of smart study room is reflected in the users can easily access resources and services at any time in the scope of the study room through smart devices. The smart study room envisioned in this paper collects physiological information based on IPPG (imaging photoplethysmography) technology, and then makes judgments through the PEM-D overall psychosomatic intelligent diagnosis and treatment system and puts forward targeted suggestions.

Physiological parameters such as heart rate, respiration rate and oxygen saturation have important reference significance in traditional medical scenarios, exercise efficacy, fatigue detection, psychological evaluation and other fields. At present, the observation in the field of education in school health, physiological parameter detection technology has been used in sentiment analysis, but most of the research is based on the traditional contact measurement methods, along with the application scenario increasingly rich, contact physical testing gradually exposed its limitations, and through video detection of physiological parameters by the user application in the field of education also is less, There are great prospects for development in the future. Therefore, this paper will analyze the feasibility of the application of imaging photoplethysmography technology in the construction of smart study room.

### 2. Principle of IPPG Technology

IPPG is a kind of non-contact physiological parameter detection technology, through the reflection of the imaging equipment acquisition detection, using the change of the reflected light data to calculate the blood volume change. The obtained information is further analyzed to obtain physiological parameters such as heart rate and respiration rate, which can effectively detect the physiological state of the detected person. Compared with PPG (photoplethysmography), it has the advantages of convenience, speed and non-contact, and has great advantages in remote detection and physiological status monitoring. Theoretically, any skin surface can generate light intensity changes due to blood volume changes, which can be used as a collection site for physiological signal parameters. However, due to the limited penetration of light through human tissues and the influence of light intensity, wavelength and other factors, it is difficult to collect the changes of

blood volume in the deep layer of human body. Therefore, IPPG technology is concentrated in the arm and face, which are rich in shallow capillaries<sup>[1]</sup>.

### **3. Research status of IPPG at home and abroad**

#### **3.1. Research status abroad**

Sun Yu et al.<sup>[2]</sup> proposed an artifact reduction method composed of plane motion compensation and blind source separation, which opened a new way for non-contact sensing of vital signs and remote physiological assessment, and has clear applications in triage and exercise training. Alexei Kamshilin et al.<sup>[3]</sup> developed new algorithms to accurately calculate cardiovascular parameters from video recordings of subjects' faces, and the technology also demonstrated the ability of the technology to visualize the trajectory of blood transmission through facial arteries. Daniel MacDuff et al.<sup>[4]</sup> conducted a comparative study of video compression algorithms to improve the measurement accuracy of blood volume pulse recovery from the human body using digital cameras. Keerthana Natarajan et al.<sup>[5]</sup> summarized the key experimental studies on this method so far, as well as the relevant contact sensor investigations and proposed suggestions for future research, and prospected the method.

#### **3.2. Domestic research status**

In recent years, with the improvement of artificial intelligence, computer engineering and other technologies, face detection and recognition technology has also achieved great development. Domestic scholars have also made rich achievements in the research of IPPG technology. Rong Meng et al.<sup>[6]</sup> introduced an algorithm as the core part of their IPPG system, and introduced the feasibility of the algorithm from the system principle, algorithm process, statistical analysis of results and other aspects. In the study of imaging photoplethysmography technology, Kong Lingqin<sup>[7]</sup> proposed a blood oxygen saturation measurement method based on double CCD against ambient light interference, realized the blood oxygen saturation measurement under ambient light, and proposed a blood oxygen saturation measurement method combining 520nm and 660nm wavelength. At present, the detection of human parameters based on IPPG technology is mainly limited by the performance of imaging equipment. The accuracy of heart rate algorithm is generally more than 90%, while the detection of respiratory rate is still only able to detect static respiratory rate (about 25 times /min or less). Therefore, the research on motion artifact elimination algorithm is more common<sup>[1]</sup>.

### **4. Educational applications of IPPG**

Since the COVID-19 pandemic began in 2020, online delivery has become an important method of teaching and learning, with Internet connections between teachers and students. But this method has revealed its drawbacks: teachers and students lack interaction and are unable to pay attention to students' concentration.

In traditional education, there is direct face-to-face contact between teachers and students in the classroom. Through vision and hearing, teachers can observe the real-time status feedback of students, and evaluate the real-time learning status of students according to the teaching experience, so as to further adjust their teaching content and teaching progress in time. However, this kind of real-time evaluation puts forward higher requirements for teachers. First, this evaluation method is based on an experience evaluation, teachers need to have rich teaching experience to make timely and accurate judgments. Second, in traditional education, due to the large teacher-student ratio gap, one teacher is responsible for dozens of students, so teachers can not observe every student.

The contactless heart rate detection method based on facial video has become one of the effective means to detect human heart rate and other physiological parameters, and in recent years has become a popular research topic for scholars at home and abroad. The IPPG technology has been applied in the medical field. It can assist doctors to judge the disease by detecting the physiological parameters such as heart rate. And it can also assist psychological diagnosis. In view

of the existing problems in the application field and method of imaging photoplethysmography technology, the academic community has conducted extensive research.

## **5. Feasibility analysis of paid smart study room**

### **5.1. Market demand analysis of paid study room**

Sharing economy can make full use of modern information science and technology to share idle resources efficiently through legitimate and reasonable methods, so as to realize the optimization of overall resource allocation. In 2019, after the rapid expansion of the sharing economy in the world, especially in China, through the active adjustment of the government, the growth rate of the sharing economy market size has shown a significant slowdown and tends to be rational. The emerging sharing economy platforms that have developed and begun to take shape have made new adjustments to their core values and strategic goals. Due to the sudden outbreak of COVID-19 in 2020, as well as the influence of various political and economic factors, the growth rate of the global sharing economy market tends to slow down. However, the overall development trend of the sharing economy is stable and positive.<sup>[8]</sup>

With the development of the sharing economy, paid study rooms have become a hot topic in major cities in China. 2019 is the first year of paid study halls in China. Due to the impact of the COVID-19 pandemic, the global economy is not performing well, and the overall downward pressure is greater, which is followed by large layoffs in depressed large and medium-sized enterprises and the sharp decline in the demand for new jobs. Specifically, in China, the number of fresh college graduates is still growing at a high level, presenting a more severe employment situation and employment pressure. In this way, more job seekers and professionals choose to take the postgraduate entrance examination, grade examination and certificate examination as a way to improve their competitiveness. By the end of 2021, there were 3,215 public libraries nationwide, according to data<sup>[9]</sup>. With an average of one library for every 439,300 people in China, public self-study spaces cannot meet social needs. Paid study rooms expand the shortage of public resources in study space and meet people's needs. Nowadays, many paid study rooms in China are mostly homogeneous, which only provide a learning environment for consumers, and do not pay much attention to a series of emotions and psychological states that may interfere with learning in the process of learning. Studying for a long time will cause learning burnout, resulting in low learning efficiency or the appearance of anti-learning emotions. Students negative emotion, psychological disease morbidity for years, especially the college students are under pressure to step into society, the proliferation of "emo" the mood, the incidence of mental illness rising year after year and we had to face their own physical and mental health, need scientific and effective method to help us better understand the emotions and somatization symptoms caused by it.

In 2019, there was a rapid development of paid-for study rooms, with nearly 1,000 new paid-for study rooms nationwide. According to statistics, there were more than 5,000 self-study rooms nationwide in 2019. After the pandemic, there was a blowout trend of study rooms, with more than 8,000 new ones in 2020. As of March 2021, there were about 16,000 study rooms nationwide<sup>[10]</sup>, most of the study rooms are located in office buildings near colleges and universities, or in commercial blocks where education and training institutions are concentrated.

The audiences of paying study rooms are mainly students or professionals. Therefore, there will be a cyclical characteristic, forming a significant low season. For the students in school, due to the closure of the school in winter and summer holidays or the lack of classroom resources, a large number of students need the continuous and stable resource support provided by the study rooms in the winter and summer holidays, especially during the final examination. In contrast, during the beginning of each semester, this demand is sharply reduced, which will lead to a significant decrease in the customer flow of paid study rooms. For professionals, the cyclical difference is mainly reflected in weekdays and rest days. In general, the passenger flow from working people decreased significantly on weekdays, but increased significantly on days off.

The study space for students mainly includes classrooms, study rooms and library on campus. All these areas have a common feature: non-exclusive and non-segmented. Strictly speaking, they are all public goods and therefore inevitably have unavoidable defects. Because they are non-exclusive, that is to say, they are freely available to college students, faculty, and even off-campus people, which leads to complex consumer groups, explicit or implicit interference with the environment, and further crowding out public resources that are not already rich. There are also natural drawbacks in public areas such as seat snatching, seat occupying, and items unable to be kept, while paid study rooms can provide an alternative supplement to the strained public resources.

For professionals, study Spaces are even scarcer, such as public libraries, local reading rooms and even coffee shops with milk tea. There is an urgent need for better study spaces to enhance their competitiveness and get promoted and paid more.

College students and professionals are faced with the pressure of study and employment, and their study time is long, and long time of study is easy to cause "learning burnout". A good learning space can effectively reduce the generation of learning burnout, so the requirement for learning space is higher and the demand is more. And whether students or white-collar workers, their minds are more open and receptive, therefore, they have a higher degree of acceptance of the study room with diverse functions and a better environment, which has a broad market prospect.

## **5.2. Technical feasibility analysis of paid smart study room**

In the field of education, the technology of physiological parameter detection has been successfully applied to the emotion analysis of students in the learning process. However, most of the current applications still use the traditional contact detection. The user must wear the corresponding hardware device, which limits the application scenario and scope. However, the application of contactless physiological parameter detection in the field of education is less, and it has great development potential<sup>[11]</sup>. With the development of big data and artificial intelligence, smart education has attracted more and more attention from the country. The IPPG technology is integrated into the smart study room. Emotion recognition is carried out by detecting the physiological parameters of the participants in the study room, and the psychological emotion of the users is monitored at any time, so that the users can know their learning status and adjust in time during the experience. Meanwhile, the mental health problems of the users can be timely intervened. It provides an efficient and scientific learning environment for the participants in the study room.

## **6. The overall structure of smart study room**

This paper combines imaging photoplethysmography technology with sharing economy, and establishes a smart study room based on imaging photoplethysmography technology in colleges and universities. In the study room, IPPG technology is used to detect the physiological parameters of students and the learning state inferred from the physiological parameters, and the whole PEM-D psychosomatic intelligent diagnosis and treatment system is used, which can effectively reduce the probability of students suffering from mental diseases, and effectively avoid the generation of learning burnout. Among them, the PEM-D overall psychosomatic intelligent diagnosis and treatment system can evaluate the psychosomatic state from multiple perspectives, and realize psychological self-assistance and counseling.

The overall architecture of smart study room is shown in Figure 1, including two subsystems: IPPG detection system and PEM-D overall psychosomatic intelligent diagnosis and treatment system.

The IPPG detection system includes two sub-functions: recording detection and local detection. When the bandwidth is sufficient and the user agrees, the recording detection function can be started. That is, the video collected in the study room is uploaded to the cloud platform for remote detection and the result is returned. When the bandwidth is insufficient or the network is unstable, the local detection function can be activated. That is, the videos collected in the study room are no longer pushed remotely, but directly detected locally.

The overall psychosomatic intelligent diagnosis and treatment system of PEM-D includes four sub-modules: psychosomatic assessment, early warning system, psychosomatic intervention promotion and effect evaluation. Among them, the data of the two submodules, psychosomatic assessment and effect evaluation, were mainly from the physiological parameters collected by the IPPG system. The warning system sub-module is mainly aimed at the state of excessive fatigue and excessive stress. The psychosomatic intervention promotion sub-module mainly adopts the way of music playing.

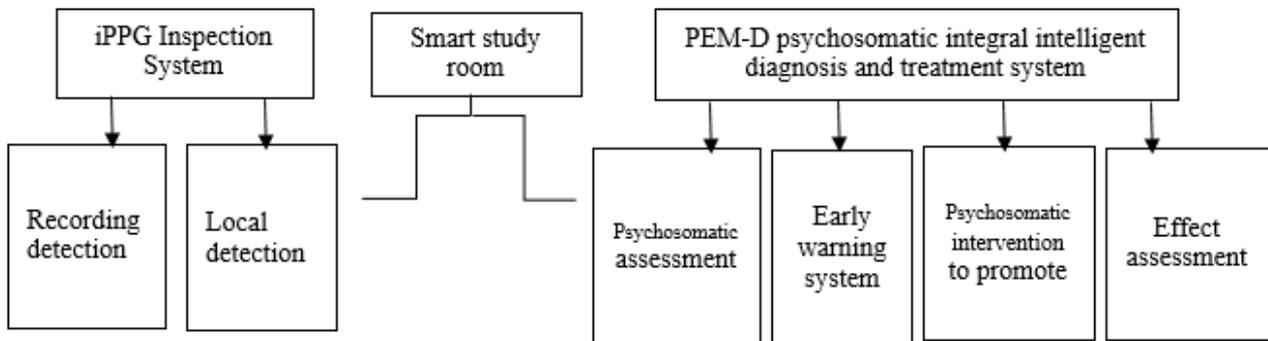


Figure 1 Overall architecture of Smart Study Room.

## 7. Conclusion

This paper analyzes and demonstrates the feasibility of the application of IPPG in the construction of smart study room, and designs the overall framework of smart study room. Both in terms of market demand and technical support, the intelligent study room designed in this paper has a good prospect. The next step is to build a smart study room system based on IPPG technology and supplemented with PEM-D overall psychosomatic intelligent diagnosis and treatment function, and carry out detailed design, implementation and verification.

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