

Digital Virtual Simulation Experiment Design of Consumer Behavior in Smart Classroom Scenario

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Abstract—This work provides a specific experimental teaching paradigm for the establishment and application of the social context aware system under the smart classroom. The paper studies the physical context aware system based on the smart classroom, and generates the original big data by constructing the Consumer Behavior Cyber-physical system. And then, the dimensionality reduction of the data is processed to form a reliable data source for deep learning, and the TRIZ theory method is used to develop the virtual simulation experiment design of the specific consumption scene. The research has a positive exploration of the virtual simulation experiment of economic and management behaviors, and also verifies the practical application value of virtual simulation frontier technology in experimental teaching.

Keywords—smart classroom; Cyber-physical system; consumer behavior; deep learning

I. INTRODUCTION

The construction and teaching practice of smart classrooms is in the ascendant in China. It provides an advanced implementation platform for teaching content management, classroom data processing, classroom situational design and data-driven scientific management of teaching. At present, the design and implementation of the smart classrooms with Sichuan University, Huazhong Normal University, Xi'an Jiaotong University and other institutions as pioneers has achieved considerable results in the fields of resource platform construction, physical space design, and information interaction means realization and general data collection. These results provide strong support for the deep virtualization design of experimental teaching based on smart classrooms. Therefore, the laboratory construction and teaching design based on VR and AR technology will become the focus and experimental field of the smart classroom concept in the reform of the virtual simulation experiment.

II. THE PRESENTATION OF CYBER-PHYSICAL SYSTEM

A. The education applications of Cyber-physical system

The CPS (Cyber-physical system) is a simulation system in which the physical environment is fully digitized into a virtual reality environment^[1]. Virtual simulation of complex systems has been attempted at engineering design, architectural design

and medical teaching practice in China^[2]. This field is different from traditional mathematical modeling. Instead, product digitalization method is adopted to realize the transformation from physical environment of digital twin CPS (Cyber-physical system) to virtual environment^[3].

Practitioners in the field of engineering teaching and practice took the lead in proposing the construction of digital twin production system CPPS (Cyber-physical production system) using real-time data acquisition and processing technology. Beijing University of Aeronautics and Astronautics (Tao Fei, Liu Weiran, 2018) put forward the idea of Cyber-physical workshop, and applied the idea of information physics integration fusion to the digital operation design of production site^[4].

Since then, Donghua University has applied the Cyber-physical experiment of aerospace structural component modeling^[5] to realize the digital interactive integration of physical space and information space in production site (Guo Dongsheng, Bao Jinsong, 2018). Beijing Institute of Technology has realized the Cyber-physical design of complex environment for spacecraft assembly on orbit (Zhang Yuliang, Zhang Jiapeng).

In addition, in the field of Humanities and Social Sciences, Cyber-physical applications have been adopted in the construction of material cultural heritage^[6], reflecting the shift of VR virtual reality applications in social sciences from front-end sensory simulation to back-end application data simulation (Qin Xiaozhu, Zhang Xingwang, 2018).

B. The situation of smart classroom construction

The construction of smart classroom forms the context-awareness system in the physical world, while the teaching activities in smart classroom are social situations characterized by social intercourse. In social situations, the social activities in the human real world can be mapped to virtual social networks through electronic social relationships, thus forming a Cyber-physical world convergence.

In the Cyber-physical world convergence, social scenarios in real social networks and virtual social networks can be perceived as social scenarios; in real social networks, social scenarios are acquired through physical sensors; in virtual social networks, social scenarios are acquired through various

social application software interface APIs. Therefore, according to data sources, social scene acquisition platform can be divided into physical platform, virtual platform and hybrid platform.

The core mission of this research is to integrate CPS from design idea and implementation scheme into the experimental teaching of economics and management department, and to establish the Cyber-physical consumer behavior system (herein after referred to as CPCBS). Previous research results of this study have successfully constructed a VR experimental design of consumption accompanying environment, which has been applied in the exploration of experimental teaching of economics and management. This research is to follow up the design effect of VR visual exhibition experiment in the early stage, relying on the construction of smart classroom, using digital twin technology to realize the digital conversion of consumer behavior characteristics and the interactive integration of virtual and real information, thereby applying CPS system to the experimental teaching practice of economics and management.

III. DESIGN OF CYBER-PHYSICAL CONSUMER BEHAVIOR SYSTEM

A. The design concept

The study uses the theory of social context-awareness to guide the establishment of cyber-physical system under consumption scenarios. Social context-awareness computing is a computational model, which is the product of the integration of social context-awareness and social computing. Social situation belongs to one kind of scenario, which mainly refers to the aggregation of users' social relations and social activities. Its focus shifts from the user's physical environment (location, time, temperature, etc.) to the user's social environment (social relations, social roles, interactive events, etc.). Social context-awareness computing has three meanings: identifying social scenarios, perceiving social scenarios and computing social scenarios^[7]. In this computing model, the system can discover and utilize social scenario information, analyze and process the social attributes of user scenarios, and provide users with the required services the five social contexts include: people, social event, object, at time, at place.

Social context-awareness computing based on consumption scenarios can play an incredible role in the real world. Previous studies have explored how to identify individuals' influences based on community scenarios and optimize advertising strategies. In terms of customized movie information retrieval and recommendation, H.P. Xuan's research achieves intelligent distribution based on real space-time scene (Where? When? With who?) and virtual scene (My Movie History of Facebook account) that information realizes intelligent distribution.

The design and deployment of the existing smart classroom has completed the work of physical context-awareness computing. Now the engineering digital twin technology is also the engineering scenario application of physical context-awareness computing. At present, the establishment and application of social context-awareness system has not been

applied in the experimental teaching of economics and management.

B. Design objectives

The system is intended to address three real-world application issues:

- The application content of experimental teaching is not deep enough in the existing construction scheme of smart classroom, and the users' big data of smart classroom platform is still lack of application setup.
- The existing VR virtual simulation laboratory construction and research focus on the realization of sensory simulation implementation, and lack of progress in the simulation of data background.
- The teaching application of the existing Cyber-physical system is limited to the field of engineering manufacturing simulation, and has not been applied in the simulation teaching experiment of economic and management system.

C. Implementation Methods

In the design of CBCPS, the key of this research is to realize effective information conversion from physical layer -- signal layer--digital layer, and digitalize the real consumption environment. In addition, embodying the frontier results of fog computing and edge computing in computationally supported virtual consumer behavior decision-making has become a technical issue to be further explored.

- Using TRIZ analogy method of engineering, 39 inventive principles and 40 corresponding contradictory methods to solve practical innovation problems are transformed by analogy of contradictory matrix in the design of CPCBS. The analysis results the main contradictory and conflict relationship, and then the overall solution design is realized by collecting the core data and modeling the system.
- Deploy full digital acquisition environment. The physical context-awareness system of smart classroom should be built and deployed in physical layer, device layer and network layer. CPCBS should enhance the perceived devices density and acquisition frequency of consumer behavior and status. In addition, in order to meet the needs of cognitive multi-modality learning, eye tracker, and brain biometric scanner should be deployed to collect and digitalize non-contact consumer bio-signals. The acquisition and digital conversion of consumer physical space signals are realized by using the entity green curtain in VR environment, limb movement locator and trajectory location in Internet of Things environment. The above data constitute a large data base RAW for consumer behavioral experiments.
- Store the above data in the cloud, and form a large data base through structured data processing, and construct a system model of consumer behavior characteristics under the condition of cardinal utility theory and

ordinal utility theory. Then invoke deep learning model to realize the design of simulation experiment.

- In the VR and AR environment, the system experiment of consumer behavior virtualization is carried out by changing the external impact such as the consumption environment, and the experimental design of teaching and research purposes is gradually realized.
- To debug and optimize the system arithmetic logic, we use the double-blind test method of real consumer information interaction in physical world and information interaction in CPCBS system to solve the specific marketing problems of new product development, consumer characteristics portrait, market segmentation and so on.

After completing the research and design of the project, relevant research concepts can be introduced into the experimental design of consumer behavior, and the digital modeling of consumer evaluation system can be carried out to realize the dynamic simulation of demand side. In addition, a digital simulation system for consumer decision-making with edge computing features can be realized, which can provide a testable digital feedback simulation environment for enterprise business activities such as R&D, market segmentation, new product promotion, and simulate the real market feedback effect. The scope of project revenue covers the related experiments of marketing behavior in management and economics, which can effectively improve the effectiveness of existing VR experiments.

IV. DEEP LEARNING AND VIRTUAL SIMULATION EXPERIMENT DESIGN BASED ON CBCPS

The main idea of virtual simulation experiment design based on CBCPS is to mine the big data of Cyber-physical system through deep learning technology, and form the virtual simulation of consumer behavior data.

The CBCPS acquires information through the physical layer of smart classroom and carries out digital regulation through digital-to-analog conversion. This multi-dimensional and multi-modal primitive digital information exists in a rough and non-structured way. Many problems in the complexity and diversity of consumer behavior data affect the quality of big data itself and the feasibility of in-depth learning. Therefore, more consideration should be given to missing values, redundancy and sparsity of data. The massive real-time data collected by CBCPS cannot be directly mined by the deep learning model, thus reduced-dimensional vectorization method is needed to process the original information data into linear machine-readable data. This type of data text can be recognized and calculated by the deep learning model and used in decision-making of artificial intelligence system.

Data mining based on deep learning technology mainly includes the input of large data of consumption context-awareness, large data processing based on deep learning model and the output of large data mining results. Among them, CPS achieves the input of large data, and the purpose of large data mining determines the output of large data mining results in relevant consumption scenarios. Therefore, deep learning

model will choose the direction of input and output according to the scope of application of different models. Deep Belief Networks (DBN), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Long Short Term Memory Networks (LSTM), and Recursive Neural Network (RNN), etc. is a typical and widely used deep learning model.

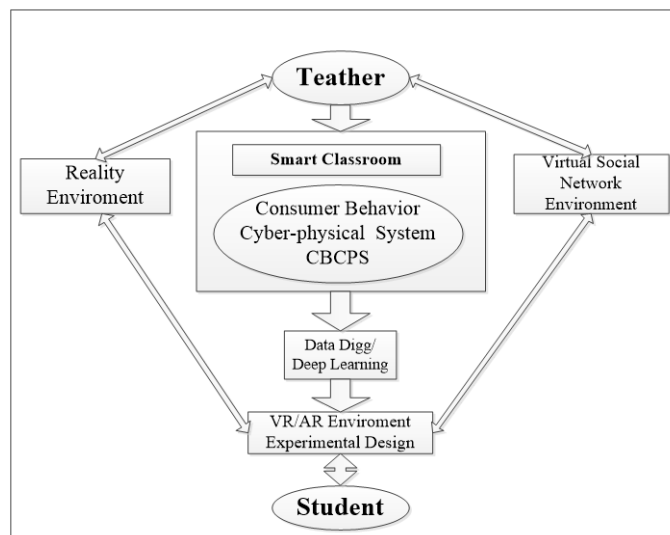


Fig. 1. CBCPS supported smart classroom VR Lab operation.

The specific experimental design and model are selected as follows:

A. Consumer behavior tracking and stochastic performance prediction based on deep learning

Set up the consumer behavior experiment scene of virtual simulation, distinguish the real laboratory scene from the virtual reality scene, and capture and track the state characteristics of the subjects in the physical scene of intelligent classroom in real time. Because there are many and complex factors affecting consumers' choices, Deep Belief Networks and Convolutional Neural Network are more suitable for data processing.

B. Random experiment design of consumer evaluation dynamic model

The consumer dynamic evaluation model based on typical consumer behavior test experiment can be relied on the real digital twin system, or can be fitted with the data of virtual social platform. Long-term and short-term memory network and recurrent neural network have good applicability in data processing and deep learning.

C. New product testing experiment based on deep learning

New product testing includes the application of consumer evaluation model, the behavior tracking of consumer context-awareness, and the design of multi-modal communication mechanism with consumer feedback. It is suitable for the mixed use of multiple in-depth learning models. In the experimental design of event impact, the recurrent neural

network is used as the pre-test arrangement of the pretreatment experiment.

D. Simulation of Consumer Psychological Emotional Cognition and Scene Perception

Cognitive computation of lagging consumer's psychological emotion strongly relies on data processing of text and image. Convolutional neural network and long-term and short-term memory neural network have strong applicability. In real-time consumer scenario perception computing, consumer's psychological and emotional perception needs deep belief network to realize deep learning.

The virtual simulation experiment design completed through the above in-depth learning can realize the front-end of VR and AR laboratory sensory simulation and the information exchange with the back-end of economic operation data simulation. The idea of near-field simulation of consumption decision-making is proposed to verify the commercial deployment and decision support of edge computing and fog computing under ubiquitous computing conditions.

V. CONCLUSIONS

This paper studies how to establish Cyber-physical consumer behavior system, through social context-awareness computing and in-depth learning technology to achieve digital virtual simulation of consumer scenarios, and complete real-time interaction and customer behavior testing of physical products and virtual products in the marketing experiment of economics and management. The contributions of relevant experimental designs are as follows:

- The research embodies the deep application results of smart classroom construction in the field of laboratory teaching. It provides strong support for the experimental teaching of business research methods, consumer behavior and network marketing courses in economics and management. Relevant experimental design projects can be deployed on the front line of virtual simulation teaching in this field.
- The research assumption and the guiding ideology of experimental design are prospective for the construction of Virtual Simulation Laboratory for economics and management. Digital processing of consumer behavior is accompanied by VR simulation of consumer scenes. It integrates University experimental teaching with virtual product design and market development of enterprises to achieves the combination of production, teaching and research.
- The research results achieve interdisciplinary communication. Digital simulation of consumer

behavior is the inevitable process of Cyber-physical technology from product digitalization to enterprise marketing digitalization. Virtual docking of Market Research scenario and engineering manufacturing process makes enterprise R&D process multi-modal VR.

- The practical significance of this research lies in the application of Cyber-physical in the virtual simulation experiment of economics and management, the realization of digital interactive teaching environment, and the formation of a demonstration sample of large data application in intelligent classroom.

The research results can provide platform support for core big data and dynamic digital-to-analog conversion simulation for the establishment of smart classrooms in the management laboratories, and the application of VR and AR technology in the experimental courses of management humanities can also form an effective promotion scheme, which can effectively help non-engineering disciplines to realize the construction of virtual simulation teaching laboratories. In the further construction of smart classroom, the teaching research results also become the near-line function module supplement of the cloud platform of smart classroom, which plays a reverse role in effectively exerting the potential efficiency of smart classroom and improving the level of laboratory data operation.

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