*Proceedings of the 2023 Winter Simulation Conference*
*C. G. Corlu, S. R. Hunter, H. Lam, B. S. Onggo, J. Shortle, and B. Biller, eds.*

# A VIRTUAL TRAINING SYSTEM USING DIGITAL TWINS BASED ON DISCRETE EVENT SYSTEM FORMALISM

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## ABSTRACT

With the advancement of technology in education and training. It has become commonplace to conduct virtual rather than physical training to save time and money. In addition, various training hardware and software have been proposed to give immersive experiences to trainees to enhance the training effects in various domains. The training system can be regarded as a digital twin system, which collects data from the trainee, analyzes the data in the cyber world, and gives proper feedback to the trainee. This research proposes a virtual training system using digital twins based on discrete event system formalism. Especially, we focus on developing a cost-effective digital twin and helping the trainer to develop an evaluation system by composing models. The training system utilizes the webcam to collect skeleton data from the trainee and evaluate the data by composing discrete event system models.

## 1 INTRODUCTION

A virtual training system gains traction since the system offers a similar experience to trainees and can save time and money compared to live training.(A. Azar, 2020) Therefore, a system designer should consider how to give an immersive experience to the trainees and how to help the trainer evaluate the trainee effectively. Various technologies and training methods are being proposed in the field of education and training to offer trainees with realistic experiences and highly effective training. One such example is simulation training, which involves using virtual reality headsets.(T. Kaarlela, 2020) These systems can be viewed as a type of digital twin system and can provide a realistic experience for trainees, but the limitation is that they can be costly and time-consuming to build. This research proposes a cost-effective training system using digital twins using computer vision technology and a discrete event system that can be described using discrete event system (DEVS) formalism. Using computer vision technology, a trainer may utilize a cost-effective camera to extract trainees' skeleton data and transfer it to evaluation models in cyberspace. After receiving skeleton data, the system analyzes the trainee's temporal movements and sends feedback back to the trainee. Also, the proposed training evaluation system is a model-based evaluation system based on the DEVS formalism. The evaluation system can be easily configured by combining models in response to changes in evaluation methods or training content.

## 2 VIRTUAL TRAINING SYSTEM USING DIGITAL TWINS BASED ON DISCRETE EVENT FORMALISM

To construct a digital twin system as a training system, we designed the system in two parts: event generator and event evaluator. The event generator utilizes a cost-effective camera to capture the trainee's behavior

and generate an event consisting of skeleton data of the trainee. We designed the event generator to obtain the skeleton data as a discrete event system that captures a trainee's image. Then, the event generator utilizes the computer vision algorithm to extract skeleton data from the image and generates output events. Then, the system relays the event to the event evaluator. As a discrete event system, the event evaluator receives the event and checks the event against the desired behavior. Figure 1 shows the diagram of the DEVS models, which contains the event generator and event evaluator.

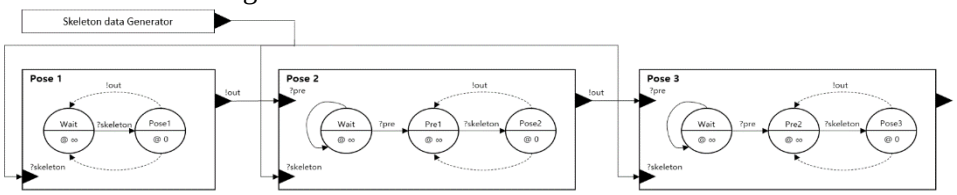


**Figure 1. Diagram of Event Generator and Event Evaluator**

As shown in Figure 1, the top left figure shows the event generator that generates skeleton data by invoking a computer vision module periodically. The three models at the bottom of the figure show the event evaluator models. Each model receives the skeleton data, but to determine which actions the trainees should take sequentially, the models are activated from left to right based on the trainees' actions to evaluate the trainees' behavior. That is, assuming that the trainee needs to perform a series of actions over time, the model that checks whether the first action has occurred and evaluates the following action if it has occurred is activated to manage the training process. As illustrated in the figure, when a trainer wants to add action to the evaluation system, the trainer may easily concatenate the evaluation model to reflect the trainer's needs.

To check the effectiveness of our method, we developed a training system for cardiopulmonary resuscitation(CPR) for nursing students. Since all nursing students are required to obtain CPR certification before graduation, we designed the system for nursing students to perform training efficiently. The training system was built by acquiring the user's skeleton information using a mobile phone and combining the evaluation model based on the DEVS formalism. The assessment models are implemented to check average user posture, arm positioning for chest compressions, and execution time based on the Korean Cardiopulmonary Resuscitation’s guidelines.

## 3 CONCLUSION

This study proposed a virtual training system using digital twins based on discrete event system formalism. Since the system relies on the DEVS system formalism, a trainer may extend an evaluation system effectively by composing the DEVS models. Also, By designing environmental scenarios, we proposed a cost-effective training system that utilizes digital twins and artificial intelligence technology by using mobile devices rather than specialized equipment, unlike the method provided through virtual reality devices. For future research, a model-driven scenario generation and its environment may be considered

## ACKNOWLEDGMENTS

This work was supported by Institute of Information & communication Technology Planning & Evaluation (IITP) grant funded by the Korea government(MSIT) (No.2022-0-00194, Analysis and Research of 5G Standard Patents)

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