MitsuDomoe: Ecosystem Simulation of Virtual Creatures in Mixed Reality Petri Dish (2)

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ABSTRACT

In this study, we propose the use of mixed reality (MR) for the purposes of biological education. Our objective is to create an interactive edutainment MR framework for users to learn about nature and human beings. MitsuDomoe, an interactive ecosystem simulator of virtual creatures in a petri dish, comprises three species of primitive artificial creatures. MitsuDomoe simulates the predation chain of the virtual creatures in the petri dish, and users can interact with this ecosystem via the petri dish interface. Users can also experience immersive observation by wearing HMD. By combining the MR petri dish and immersive virtual reality (VR) interfaces, we synergistically improve user understanding of the experience.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality;** *Virtual reality* • **Applied computing → Interactive learning environments**

KEYWORDS

Mixed reality, virtual reality, ecosystem, predator–prey model, predation cycle, science education, petri dish

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1 INTRODUCTION

In this study, we propose the use of mixed reality (MR) for biological education. Our objective is to create an interactive edutainment MR framework for users to learn about nature and human beings. As shown in Fig. 1, MitsuDomoe is an interactive ecosystem simulator of virtual creatures in a petri dish. This virtual ecosystem consists of three species of primitive artificial creatures and simulates the predation cycle of these virtual species in the petri dish, as illustrated in Fig. 1.

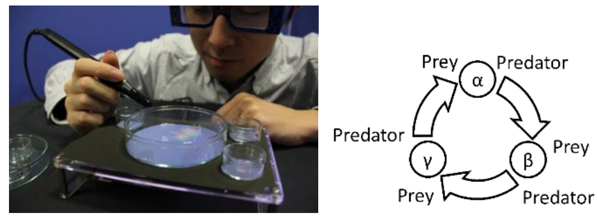

Figure 1: MitsuDomoe system and the predation chain.

"Mitsudomoe," the name of a Japanese abstract symbol depicting a swirl with three elements, refers to the cyclical, and typically eternal, relation among the elements.

In related studies, Ishii and Shinoki developed a "simple eco-ball" as an educational tool for a study unit on "nature and the human" for junior high school students in Japan [Ishii et al. 2009]. The eco-ball is an experimental fish tank in a closed sphere, which simulates a miniature ecosystem. They placed small fish, crayfish, and aquatic plants in the simple eco-ball, which is filled with air, fresh water, and sand. With this tool, students are taught that environmental balance is important for all organisms. Our MitsuDomoe project introduces new interactive MR tools for science education.

2 ECOSYSTEM SIMULATION MODELS

Conway's "Game of Life," which is based on cellular automata, shows the complex dynamics of cells whereby each cell expresses a primitive artificial life according to a simple rule [Gardner 1970]. More recently, Kamimura et al. developed an improved chase and escape model for modeling the behavior of two groups that are chasers and their targets [Kamimura et al. 2010]. A number of predator–prey models have been proposed for simulating population dynamics in a system. Of these, Lotka-Volterra equations describe the competition between two species that are predator and prey [Weisstein 2016].

Both the predator–prey and chaser–escapee models treat the relations between the two different species as asymmetric, with opposite functions. In contrast, our proposed model assumes a symmetric and cyclical relation between three species that have essentially the same functions, as shown in Fig. 1. In this scheme, the species have a predator–prey relation, but each species can behave as both predator and prey. Based on this cyclical competition scheme, the simulated ecosystem establishes a fair rule for all species.

We define a behavior model for these virtual creatures in the ecosystem by two state-transition layers. The first layer represents the internal states, as shown in the life cycle in Fig.

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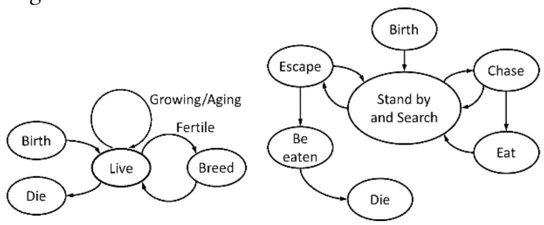
2(a). The other represents the external states, which comprise the action states during alive, shown in Fig. 2(b). These layers work together.



(a) (b)

Figure 2: Behavior model: (a) Life cycle. (b) Action states.

Users can interact by changing five groups of parameters with respect to each state and transition, as shown below:

1) Life-cycle-related parameters
2) Mobility parameters
3) Searching action parameters
4) Perception range
5) Initial number and distribution of creatures

To create a wide variety of dynamics, we change the parameters of a single simple behavior model applied to each species. Different parameter sets characterize different species, such that some behave like carnivorous creatures, others are herbivorous, and others are found in mass groups of small creatures such as insects or microorganisms.

The particular parameters are hidden from the users. Instead of the parameters, we present the users easily comprehensible factors to be controlled. The factors are fertility, mobility and sensing factors. By tuning these factors, species can be changed to exhibit offensive or defensive behaviors.

3 SYSTEM AND USER INTERFACE

Figure 3 shows the system configuration, in which there are two interface subsystems for participating in the experience—the MR petri dish and immersive virtual reality (VR) interfaces.

Users interact with the ecosystem via the interactive petri dish display. There are four petri dishes on an LCD module, and users can observe the ecosystems in these dishes. Figure 4 shows the petri dish display. The large dish at the center is the primary dish inhabited by the three species, and the three small surrounding dishes supply species samples. Users can transfer creatures from the small dishes to the primary dish using a pipette-like device. User can control the control factors by dropping virtual chemical from a factor control palette into the small dishes.

Because the petri dish interface enables users to experience an MR space, that is, virtual creatures in physical petri dishes, it can provide users with the sense and enjoyment of performing experiments in a laboratory.

With the VR interface, users can also experience immersive observation of the simulated world. As shown in Fig. 5, by combining the MR and the immersive VR interface, we synergistically improve user understanding of the experience, because the observation target can be seen simultaneously from both the outside and inside. The use of this interface in group learning will further enhance its benefits to students who can exchange ideas based on each viewpoint.

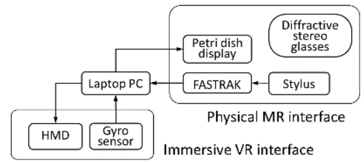


Figure 3: System configuration.

Figure 4: Petri dish display. Figure 5: Group use.

4 CONCLUSIONS AND FUTURE PLANS

In this study, we developed a novel prototype system for the purposes of biological education, comprising a circulating predation model and MR and VR interfaces.

We have conducted user demonstration studies with professionals and the public to establish proof of concept of the project at Laval Virtual 2017 in March. There are about two hundred participants joined our demonstration. In general, we have confirmed this MitsuDomoe system prototype to serve as a new technical platform for augmenting the creative experience of users in science education.

In the next research phase, we will make detailed tests of the qualitative behaviors and quantitative descriptions in the model and develop it to a higher level of sophistication. And the validity and feasibility of this concept should be further determined with reference to issues in the target domain—science education. And we will also develop other variety of the system based on the same concept.

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