Phygital Field: Integrated Field with Visible Images and Robot Swarm Controlled by Invisible Images

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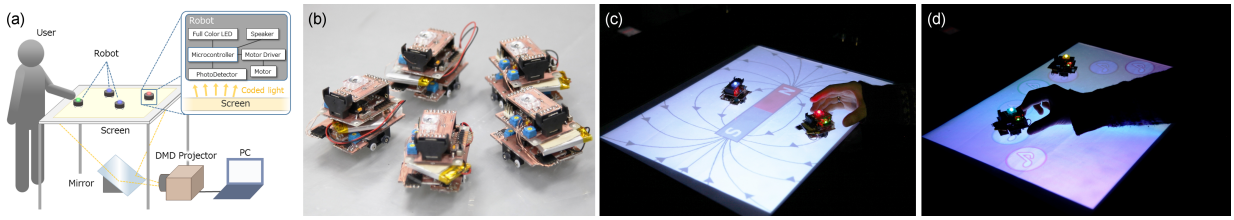

Figure 1: *(a) System Configuration, (b) Appearance of robots, (c) An application of magnetic field, (d) An application of music game field*

1 Introduction

Forming images by using a swarm of mobile robots has emerged as a new platform for computer entertainment. Each robot has colored lighting, and the swarm represents various abstract patterns by using the lighting and the locomotion.

The aim of our research is to create a novel display field named "Phygital Field," which integrates the physical world created by robot swarms and the digital world produced by a graphical display. To integrate them, we used a pixel-level visible light communication (PVLC) projector [Kimura et al. 2008], which can superimpose data patterns on pixels by human-imperceptible high speed flicker. This data patterns contains coordinates, control instructions, and more types of information that you want to program. By combining a swarm of robots and the graphical display, each type of image can be augmented.

So far, several types of systems for the symbiosis of robots and computer graphics have been proposed [Sugimoto et al. 2005]. Compared with these works, Phygital Field has three technical innovations: an initialization-free and marker-free display method, the simplicity of the total system, customizable data transmission.

2 Technical Innovations

The first is an initialization-free and marker-free display method. The robots can always recognize their own positions and states by interpreting data patterns in pixels. With this feature, users can add and remove robots at will and control robots without positional displacement even when they operate at high speed.

The second is the simplicity of the total system. Robots require only photo detectors for sensing, so we can make them very small. 3D sensors or cameras are not necessary to track the positions of robots. These features are very important for configuring a robot swarm system easily.

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SIGGRAPH 2015 Posters, August 09 – 13, 2015, Los Angeles, CA.
ACM 978-1-4503-3632-1/15/08.
http://dx.doi.org/10.1145/2787626.2792604

The third is customizable information transmission. It is possible to create various displays simultaneously by combining the general control information of a projector and interpreters of robots. The robots of our system are able to present light and sound effects. Thus, they can output simultaneous multiple effects of lights and sounds. In the same way, it is easy for a user to design the effects and control the information required for the content.

3 Implementation and Applications

Our system comprises a tabletop screen containing a color high speed DLP® projector and a swarm of mobilerobots [Fig.1(a)]. Each frame has three types of bit sequence: synchronization, data, and brightness adjustment. These frames can be seen as one colored image to a human. The robots comprise a full-color LED, a speaker, two motors and wheels, two photo sensors, a LiPo battery, and a microcontroller [Fig.1(b)].

Figure 1(c) is an application of augmented robot swarm. Each pixel has a force data like magnetic field of physics, so movement of robots is restricted in accordance with the virtual magnetic field. Furthermore, when a user adds a new robot into the field, the robot can start moving immediately, thanks to our system's initialization-free and marker-free display method. Figure 1(d) is an application of graphic display augmentation. The data including type of musical instruments and pitch is embedded in particular regions. When the robots enter the region, appropriate sounds can be heard from appropriate locations in the projected image.

In this paper, we proposed an integrated display method connecting the physical and digital world to enrich each type of image. The seamless connection between them and keeping it are important issues in various fields such as tactile and tangible interface. We believe that our method will also contribute in these fields.

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