

# Projectron Mapping: The Exercise and Extension of Augmented Workspaces for Learning Electronic Modeling through Projection Mapping

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## ABSTRACT

There has been research using software simulations to support the learning of electronic modeling by beginners. There have also been systems to extend workspaces and support electronic modeling on tabletop interfaces. However, in the case of software-based circuit operation, as it is not possible to operate the actual elements, the feeling of actually moving the elements is lacking. For this reason, we are proposing a system that extends the sense of reality in software simulators through the use of projection mapping. This will make it possible to actually give the impression of moving the elements by using a software simulator, and to achieve both high speed and a sense of reality through trial and error.

## Author Keywords

Projection Mapping; Electronics; Pseudo Lighting  
Understanding Electricity; Tangible user interface;

## ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI):  
Miscellaneous

## INTRODUCTION

The complexity of trial and error is an obstacle to beginners looking to learn electronic modeling. With trial and error, it is necessary to perform the same kind of hard-wired work, and that hard wiring itself may take a significant amount of time. A software simulator is one means of improving the speed of the trial and error process. However, with the illumination of elements in software, the sense of reality pales in comparison to the illumination of actual elements.

Therefore, we are proposing an augmented workspace that can extend the sense of reality in a software simulator. Using projection mapping, the real elements can be extended as if they are in operation. By using a touch panel display and projector in the system, it is possible to achieve both learning support and a sense of reality with the software. By using projection mapping to make the elements appear as though

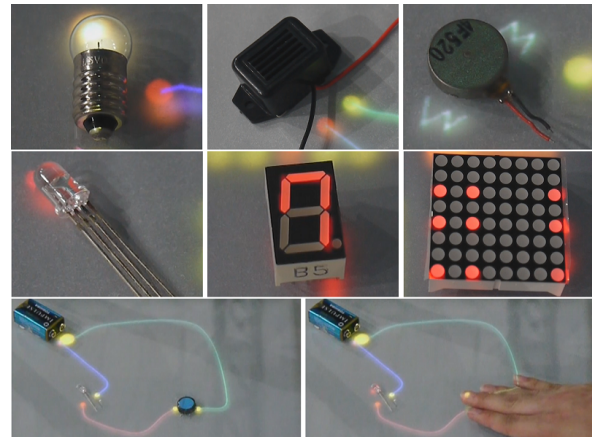


Figure 1. Electronic kits using projection mapping

they are actually shining, as shown in Figure 1, an intense experience is provided to the user. Furthermore, a tangible interface is used so that trial and error can be carried out at high speeds as in the software simulator. The user can create circuits using a drag operation.

## RELATED WORKS

Fritzing[3] and CCK[4] have adopted the approach of using software simulators to study electronic modeling. Fritzing carried out simulations by creating circuits using a software bread board. CCK, rather than a breadboard, is a tool that can freely create circuits to perform trial and error. In this way, trial and error can be attempted at high speeds using a software simulator. Furthermore, Conradi et al. extended the electronic modeling workspace in software, and proposed a Flow of Electrons in which electronic modeling takes place on a tabletop interface [2]. Conradi et al. stated that a tool kit was essential for supporting beginners and that an augmented workspace should be prepared, as well. However, software simulators, including Flow of Electrons, have been unable to provide an intense experience in which there is the “enjoyment of actual elements moving.” Therefore, we propose an augmented workspace that extends the feeling of reality in software simulators using projection mapping.

## APPLICATIONS

The user can perform hard-wiring by pulling a virtual jumper wire through a drag operation, without using an actual lead. The virtual jumper wire can be disconnected with a touch

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UIST'14 Adjunct, October 5–8, 2014, Honolulu, HI, USA.  
ACM 978-1-4503-3068-8/14/10.  
<http://dx.doi.org/10.1145/2658779.2659113>

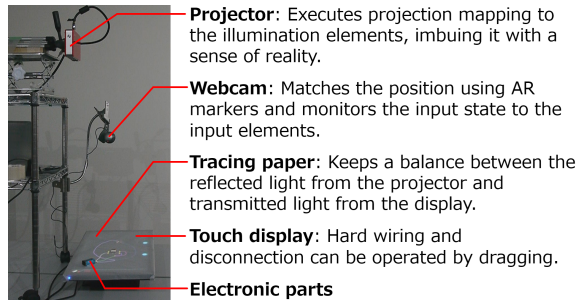


Figure 2. System

gesture as if you were snapping the wire. The currently supported elements are shown in Figure 1.

A touch panel display is installed horizontally and a projector is placed in the top section (Figure 2). The projector is fixed in a position so that the display range of the projector is exactly the same as the display. The web camera is installed in a position so that the entire display can be seen. The projector is mirrored on the display so that the position of the touch panel and the display location of the projector are matched.

### Input system

Input into this system is operated by the two operations of both the fingers via the touch panel display and, using the camera, an exaggerated operation in which the touch panel is not touched with the fingers but uses image recognition. The former is used for installation of virtual elements and hard wiring and disconnection of circuits. The latter is used for grasping the state of input elements, such as switches and variable resistance, etc. As the pixels in which elements exist can be obtained from the camera image, AR markers can be used to match the positions of the display area for the display and the camera image. Skin recognition is carried out using the hsv surface colors, and it is then determined whether there is input to the device. The switch state is reflected in the circuit state using image recognition (Figure 1).

### Projection mapping from the top

By carrying out projection mapping on output elements and light elements in particular, it is possible to make it look as though they are actually moving even if they are not actually electrically connected. It is not necessary to carry out projection mapping for all illuminated areas of the elements, and if projected in a way so that the illuminated areas overlap to a certain extent, it can appear as if they are illuminated. If the elements are specularly reflected, the area that you wish to illuminate may be artificially lit even if they are transparent. In the case of miniature lamps, as particles are displayed around the area that is being artificially lit, through projection of the illumination area using a single color, illumination with a sense of reality has been successfully achieved. Figure 1 shows the implementation results when projection mapping on to the illuminated elements using the respective proposed systems.

By projection mapping from above, the lower touch panel display is increased. Therefore, it is necessary to maintain a bal-

ance between the reflective light from the projector and the transmitted light from the display. For this reason, by laying tracing paper over the top of the display, a balance is maintained between the reflected and transmitted light. In this way, even if the projection is covered with a hand, it is possible to display the wiring state via the transmitted light from the display. This has almost no effect on touch input even via the tracing paper.

### Other output systems

The system rings an operating noise from the PC to express ringing of the buzzer or vibrator. In addition, the system displays an animation around the vibrator that makes it appear that it is shaking. Projection mapping is not carried out on batteries; however, it becomes the starting point for an electrical conductivity check within the program. The circuit simulator is linked to the Circuit Simulator Applet[1]. As there is a bug in the external simulator, a simple circuit judgment program can be integrated into the system to handle switchovers at necessary times.

### DISCUSSION

We believe that the proposed system combines both a sense of reality in which the elements are actually moving and a high speed software simulator. It is felt that illumination of the actual elements provides beginners with the impression and experience of elements actually moving, by illuminating the elements of the simulator within the display. Furthermore, as hard wiring and disconnecting is performed by dragging, as with a simulator, trial and error can be carried out simply.

We plan to further extend the electronic modelling environment using projection mapping. Currently, projection uses a single color. However, the actual elements are not illuminated equally. By performing gradation that matches the shape of the elements for projection mapping, we believe that projection mapping with an increased sense of reality can take place. Furthermore, we feel that by projecting the reflected light around the element with the projector, photo-real projection mapping can take place. Additionally, as there are few varieties of elements that are supported, we think that it will be necessary to increase the number of supported elements moving forward.

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