# Switch++: An Output Device of the Switches by the Finger Gestures

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## ABSTRACT
Regarding human-machine-interfaces, switches have not changed significantly despite the machines themselves evolving constantly. In this paper, we propose a new method of operability for devices by providing multiple switches dynamically, and users choose the switch that has the functionality that they want to use. *Switch++* senses the mental model of the operating sensation of switches against the users finger gestures and changes the shape of the switch and its affordances accordingly. We design the interface based on the raw data.

### Author Keywords
Switch; Interfaces; Affordances; Gestures.

### ACM Classification Keywords
H.5.2. User Interfaces: Input devices and strategies.

## INTRODUCTION
Interfaces in devices such as vehicles and household appliances possess many buttons and switches. In modern devices that contain a lot of various functions, it becomes important for the user to be able to distinguish between them. However, interfaces with many switches can contain a lot of information, which can confuse users and easily lead to human error [1]. The possibility that a pushing error can cause a serious accident is high because there are many switches in for example the inside of a car or the cockpit of plane. Regarding human-machine-interfaces, switches have not changed significantly despite the machines themselves evolving constantly, and much research is focused primarily in the advancement of machine functionality and performance rather than switches.

Previous studies of switches have described evaluations of the sense of pushing and about verifications of factors that result in a pushing error. However, it appears that there are few studies regarding the attributes of existing switches - such as sensitivity and physiological evaluation - that have been carried out. Therefore, new research about these facets of switches is essential.


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Switches can have various feelings of operation - for instance, a push switch, a dial switch, a toggle switch, or a rocker switch. For example, one would use a push switch or rocker switch when turning on the power, or use a dial switch when adjusting the volume on a music player. In other words, the type of switches used will differ depending on what a user is operating. The user must recognize a certain amount of information and use them properly because existing switches have only one mode of operation. In this study, we focused on these differences between the sensation of operating the switches and expressed several operating sensations so as to decrease the number of the switches. Therefore, we propose a new method of operability for devices by providing multiple switches dynamically, and users choose the switch that has the functionality that they want to use.

## RELATED WORK
The switch needs to change shape to enable expression of a number of operating sensations in a single switch. Haptic Chameleon by Michelitsch et al. [2] provided multiple operating sensations by changing the shape of the knob section. However, representing various operating sensations by only changing the shape of the knob section is difficult. Therefore, in our research we did not provide multiple operating sensations by changing the switch itself, but conducted a study using the feelings of his or her accustomed operation using existing switches. We made the device capable of four types of input: push by using a push switch, horizontal knob by using a dial switch, vertical knob by using a toggle switch, and grasp by using a joystick.

There are many studies about an interface providing affordances through shape change. Affordance refers to how to use things and how they function and was concepts introduced by Norman [3]. It is an important element of interface design. inFORM by Follmer et al. [4] provided dynamic physical affordances through a shape display. Morphees by Roudaut et al. [5] is a hand-held device that provided affordances through shape change. In this way, changing the shape in accordance with the user s situation provides a mental model of the machines by affordances through the shape. Metamorph by Bailly et al. [6] analyzed the users mental model against a keyboard shortcut and provided the aspects of keyboards as new interfaces. Our study is similar to these studies in that the interfaces have an operability suitable for affordances, however *Switch++* senses the mental model of the operating sensation of switches against the users finger gestures and changes the shape of the switch and its affordances accordingly. Therefore, *Switch++* strengthen the interaction between human and machine.

## METHOD

In this study, we categorized user interaction as input and output. Firstly, a user imagines a suitable switch for operating feeling and makes a gesture using their fingers according to the type of switch they wish to use. This is the input stage. Secondly, the device provides the shape of the switch according to the gesture made. This is the output stage (Figure1).

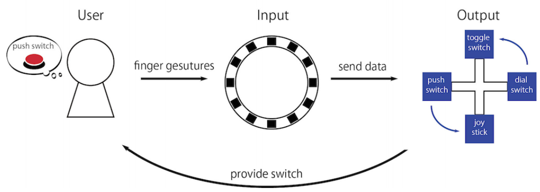


**Figure 1. The relationships between "use" and "input", and "output".**

### Input

In this research, we detected the finger gestures using 12 photoelectric sensors (RPR-220). These sensors were tilted o 45 degrees, placed in a circle and controlled by an Arduino Micro. Four types of gestures were detected: push, horizontal knob, vertical knob and grasp. The push gesture corresponds to a push switch, the horizontal knob gesture corresponds to a dial switch, the vertical knob gesture corresponds to a toggle switch and the grasp gesture corresponds to a joystick (Figure2). Ten participants performed one gesture 50 times, thus we providing 2000 row data in total. Figure3 reflect the result from the collected raw data.

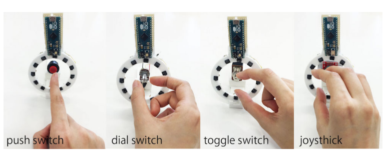


**Figure 2. The finger gestures.**

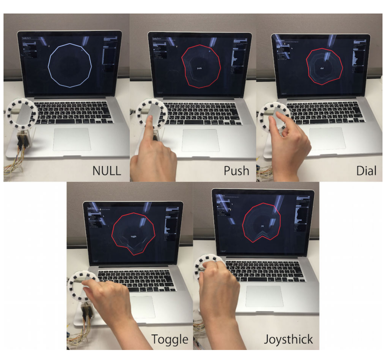


**Figure 3. The result of the collected raw data.**

### Output

Based on the raw data, *Switch++* offered the shape of the switch along the gestures. A stepping motor (SM-42BYG011-25) rotated four switches and a linear stepping motor (39BYGL215) presented the chosen switch by sensing the users gestures so that the user can then use it (Figure4). Two motors were moved by using the stepping motor driver (L6470), and the combined 12 photoelectric sensors from input stage, and were controlled by an Arduino MEGA 2560 (Figure5).

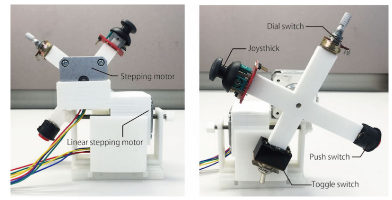


**Figure 4. The architecture of output device.**

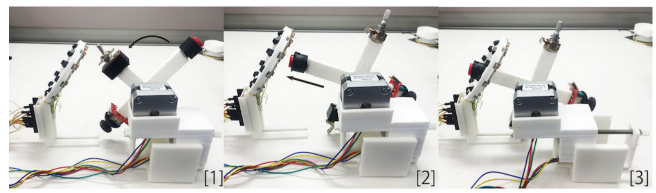


**Figure 5. The output flow diagram.**

## CONCLUSION

We analyzed the raw data by using the Weka Toolkit. We used a support vector machine (SMO), a k-nearest neighbor algorithm (IBk), a Bayesian network (Baysnet), and multilayered neural network (Multilayer Perceptron). As a result, the correctly classified instances were 86.6% by SMO, they were 95% by IBk, they were 81.85% by Baysnet , and they were 90.85%.

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