Urine Computer Interaction to Avoid Spattering: Study of Urination Handling

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ABSTRACT
To prevent spattering accidents during urination, an electrophone system is proposed. This system informs whether the urine flow reaches a "safety area." Eight sensors are mounted in this safety area. To define the safety area, spatter is checked based on the position of the urine flow. We determined appropriate distances and sizes for the targets and examined the data conforming to Fitts' Law. Then an electrophone prototype is built that generates sound feedback. The user controls their urine flow and enjoys the sounds. Future applications are discussed such as behavioural therapy or health care.

Categories and Subject Descriptors
H.5.2 User Interfaces

General Terms
Design, Human Factors

Keywords
Urinal, Musical Instrument, Evaluation

1. INTRODUCTION
Urination is the most important physiological phenomenon in our life. Everyone urinates approximately four to six times every day. However, men sometimes fail to control their urine flow, and the urine splashes because of distractions. In particular, it is hard to target a "safety area" that prevents spattering accidents, which can cause distress. In this research, we are trying to assist men to concentrate more on urination and make urination more pleasurable. In this paper an electrophone system is suggested. The system can increase their focus to improve urine flow control (Figure 1).

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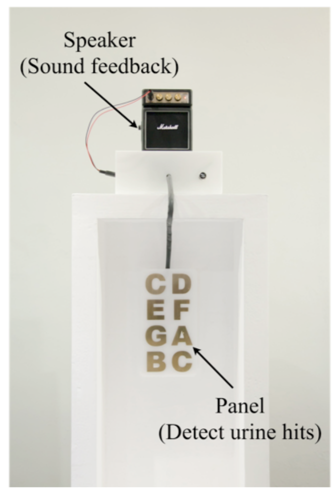

Figure 1. Prototype version of our electrophone for urinal.

1.1 RELATED WORK
There are three types of existing projects dealing with ways to control urine flow: a target sticker-type project, ball-type project, and game-type project with a display.

The target sticker-type project uses a sticker in the urinal, which displays a bug or target mark [1]. Users target the sticker to focus their attention. The target sticker-type project is effective and easy to set, although users give it up easily because of the lack of feedback.

The ball-type project uses a wired ball in the bottom area of the urinal [2]. Although this project is also effective at maintaining the attention of the user, they easily lose interest because the wired ball repeats the same action over and over.

The game-type project uses a sensor, speaker, and display [3]. Recently, Toylets was released by SEGA, Inc. [4]. Toylets consists of a super high frequency sensor, IR reflective sensor, speaker, and display. The sensors estimate the amount of urine and the speed of the urine flow. The speaker and display are used to provide feedback during urination. Toylets was developed for

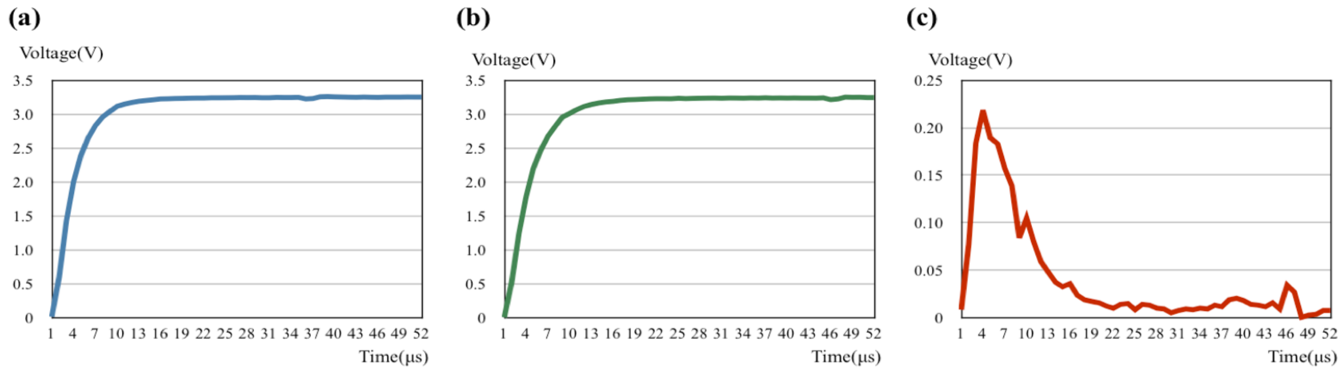

Figure 2. Step response time of sensor.

(a) and (b) show the step response time of a capacitance sensor without water and with water, respectively. (c) shows the absolute difference between the conditions without water and with water.

entertainment. However, the user must watch the display for feedback related to the amount of urine and its speed. To concentrate on controlling the urine flow, the user needs to watch the position of the urine flow while simultaneously paying attention to the visual feedback provided by the system.

2. OUR GOAL

In this research, our goal was to prevent spattering accidents during urination. To avoid spattering accidents, men must concentrate on their urination. Thus, we propose a system and device that provides feedback to keep the men's attention, along with a sensor that determines whether the urine flow reaches a safety area that will ensure the prevention of spattering accidents. A sound feedback is adapted to our system, This feedback does not disturb the men's attention, and the feedback can be modulated according to the sensor value.

To define the safety area, we investigated the spatter according to the position of the urine flow. Appropriate distances and sizes for the target objects were determined using an experiment based on Fitts' Law.

In the following sections, we describe the experiments that were used to determine the configuration of our device for preventing spattering accidents. The sensors and human factors are evaluated with Fitts' Law. Finally, applications and future work are discussed.

3. DETECTING URINE HIT

3.1 Sensors

The sensors were limited to those that could be mounted on normal urinals. To check whether the urine flow reached a safety area, the following sensors were examined:

· Distance Sensor using IR LED and PSD (position sensitive detector)

This distance sensor could detect the reflected IR values to determine the distance between the sensor and an object. We checked whether distance sensors (GP2U0A21YK and GP2U0A02YK) could detect urine flow by conducting a water flow test. In this test, a water stream was directed toward the sensor area 10 times and the sensor values were recorded. These distance sensors could not detect the water flow because IR light go through the water.

· Pressure switch

A pressure switch opens or closes an electrical contact when a certain set pressure has been reached on its input. A high sensitivity pressure switch (FlexForce A201-1),which can sense 4.4 N. is also tested to use our system. However, this sensor could not be switched in our water flow test because of the low pressures.

· Capacitance-type touch sensor

A capacitance-type touch sensor creates a variable capacitance to detect strain. This type of sensor is most often applied to low pressures. Our water flow tests utilised a capacitance-type touch sensor made of shiny brass plates (50 × 50 mm), which we then adopted for our device.

3.2 Our System

As discussed in the previous section, a capacitance-type touch sensor is adopted to detect urine. The step response time of this sensor is described in Figure 2.

Figure 2(a) and Figure 2(b) show the step response time of the capacitance sensor without water and that with water, respectively. Although the graphs are similar to each other, the durations of the transient states differ. The absolute difference between Figure 2(a) and Figure 2(b) is shown in Figure 2(c).

Our system detected the existence of water using the voltage at 5 μs, because the difference between the two conditions (with water and without water) became the largest at that time.

4. EXPERIMENTS

4.1 Safety Area

In order to decide on the size of the safety area (the area that results in the least spattering), we examined the volumes of spilled water while aiming at various areas in the urinal. A water gun is used instead of the urine flow. The water gun gives a flow of 7 ml/s, which is the average male urinary flow rate [5]. The height of the water gun was 785 mm, which was based on the average length of the inner side of a man's leg [6]. The area consisted of a 7 × 3 checked pattern with 100 mm × 100 mm rectangles.

The results are shown in Figure 3. The bottom line of area G was 150 mm above the ground. Thus, the height of the top line of area A was 850 mm. As expected, the safety area was the centre of the urinal, slightly under the aiming position (650 mm to 450 mm).

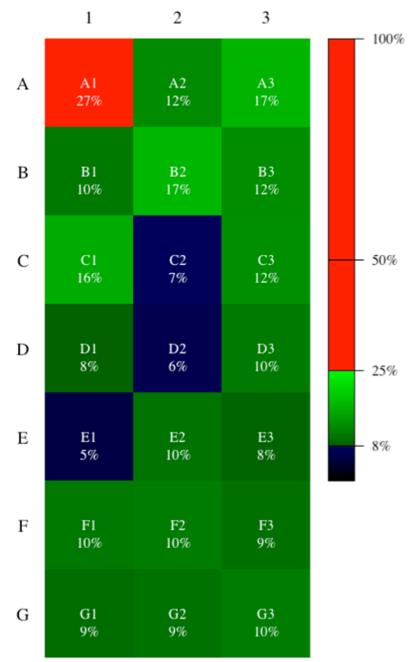

Figure 3. Safety area of urinal.
Each area is described by the area number (A1, A2, etc.) and volume rate of the spilled water.

4.2 Movability

After selecting the safety area, the movement time at various distances is examined. We asked an experimenter to move a water gun as fast as possible, alternately shooting the two vertical lines drawn in the urinal. Four distances (50 mm, 100 mm, 150 mm, and 200 mm) were examined, with 5 trials for each. As shown in Figure 4, the average movement time decreased with the distance.

Our goal is to provide comfortable sound feedback for the users, and the ideal distance should be determined by the tempo of the music to play. The distance is set to be smaller than 150 mm, because the movement time should be lower than 0.5 s at our desired tempo.

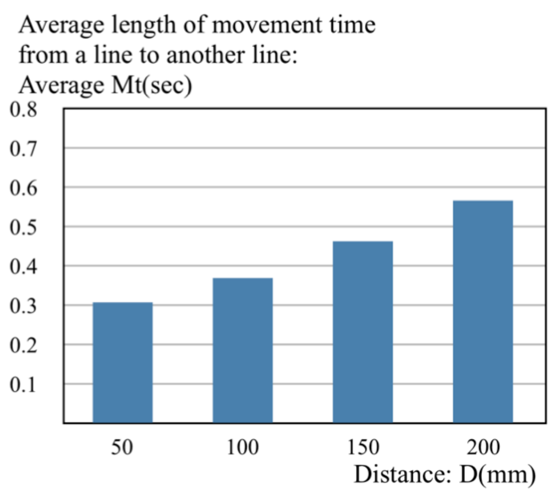

Figure 4. Average lengths of movement times for various distances.

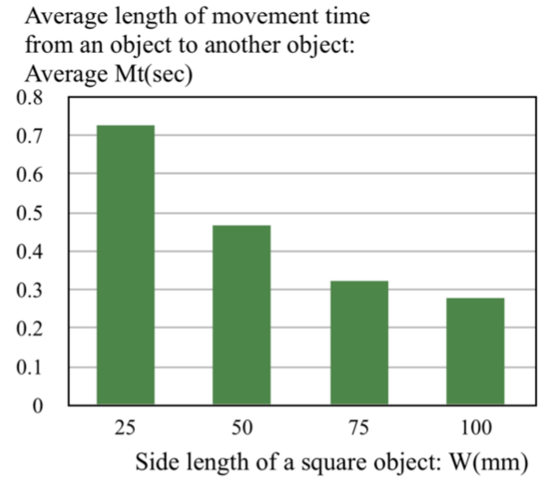

Figure 5. Average lengths of movement times for various distances.

4.3 Target Size

This section discusses how we fixed the distance to the targets at 100 mm in consideration of the safety area and then determined the size of the targets.

With various target object sizes, the movement time is measured. After mounting two targets with 100-mm centre-to-centre spacing, we asked users to move the water gun as fast as possible while shooting the targets alternately. Four sizes (25 mm, 50 mm, 75 mm, and 100 mm) were examined, with 5 trials for each. As shown in Figure 5, the average length of the movement time increased as the side length of the target became smaller.

From sections 4.2 and 4.3, we conclude that in order to aim at the targets rapidly, they should be large and sufficiently close. Because our desired movement time is less than 0.5 s, the target size must be larger than 50 mm.

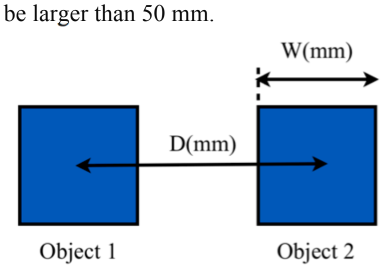

Figure 6. Configured prototype panel.

4.4 Fitts' Law

Using the acquired data discussed in the previous section, we investigated how urination handling fit into Fitts' Law. Fitts' Law is a powerful model that can be applied to GUI handling [7]. According to Fitts' Law, the time (Mt) to move to a target object of width W that lies at distance D is

$$Mt = a + b * \log_2(1 + D/W) \quad (1)$$

where a and b are constants determined through linear regression. The parameters are calculated for various target object sizes W (mm) for a fixed distance D (100 mm) using the least-square technique (Figure 6). The scattered plot of the data with the linear regression results is shown in Figure 7. When a = –0.090 and b = 0.3527, the correlation coefficient for the data becomes 0.9711. This result shows that Fitts' Law also applies well to urination handling.

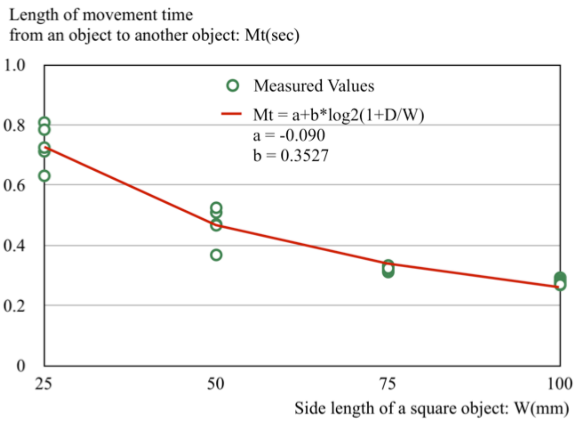

Figure 7. Fitts' Law for urination handling.

5. SYSTEM CONFIGURATION

From the experiments described in section 4, a prototype urinal user interface is developed (Figure 1 and Figure 8).

Our prototype has 8 capacitance-type touch sensors to detect the urine hit timing and position. These sensors show letters of the alphabet to indicate musical notes. They are mounted in a panel that fits into the safety area selected in section 4.1.

The distances and sizes of the sensors were designed based on the results of experiments described in sections 4.2 and 4.3. The centre-to-centre spacing of the targets is 60 mm, and the size of each target is 50 mm.

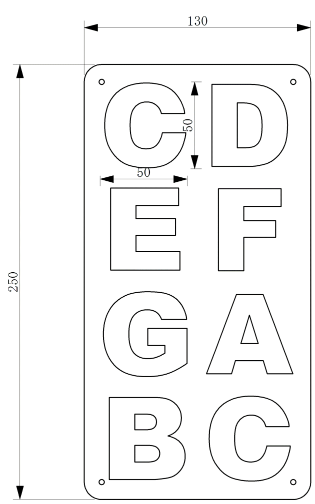

Figure 8. Configured prototype panel.

With this design, the panel can be mounted in the safety area of the urinal. At the same time, the distance and size were selected to handle the flow more rapidly.

Sound feedback is generated based on the sensor values. During urination, the user pays close attention to their urine flow and enjoys the sounds.

6. DISCUSSION

6.1 Applications

Our system can be applied to improve sanitation. That is, our system motivates users to aim properly at the safety area, and thus reduces spattering.

In addition, it can be used as a potty trainer for children. This system can help create an enjoyable environment for children learning to use the toilet. Moreover, it could be applied in behavioural therapy for autistic people or those with mental health issues to teach them where and when to go to the restroom.

It might be possible for this system to be applied as an easy-to-use health check system for diabetes or other diseases. Although an investigation would be needed in relation to the appropriate sensors and physiological data to examine the feasibility, this possibility is worth examining.

6.2 Future Work

In future work, we will conduct experiments to determine how well our system and device prevents spattering accidents during actual urination. Moreover, a pedal will be included like those used with a piano or organ to encourage users to stand closer to the urinal.

In addition, investigate those involving a learning system for children, health care, and behavioural therapy applications will be needed. In collaboration with hospitals and nursing institutions, we are going to advance the study of Urine Computer Interaction.

7. ACKNOWLEDGMENTS

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