SemFeel: A User Interface with Semantic Tactile Feedback for Mobile Touch-screen Devices

【Main Content】:

Place motors in different locations of the device to produce different tactile effects

【SemFeel】:

SemFeel has five vibration motors embedded in different locations on the back of the mobile touch screen device (especially the top, bottom, right, left and center of the device)

11 vibration modes

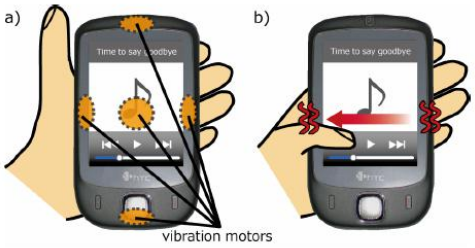

Figure 1: The SemFeel system concept: a) Multiple vibration motors are embedded in the backside of a mobile touch-screen device. b) The system generates vibration from right to left as feedback in response to when the user touches the "previous track" button.

【Experiments】:

Experiment 1:DISTINGUISHABILITY OF PATTERNS

In this experiment, we asked the participants to determine which of the eleven vibration patterns shown in Figure 4 was being generated by the system at a time (each time, the pattern was generated only once).

Procedure： The participants were given the explanation of the system and instructed to hold the prototype mobile device with their non-dominant hand and to use a mouse with their do-minant hand to interact with the application on the com-puter. They were then asked to perform a practice set that used the same tasks as the test sessions. They could con-tinue to practice until they felt comfortable with the tasks and system. On the average, the participants practiced for about five minutes. After each block, the participants were allowed to take a short break. In total, the entire experiment took about 45 minutes.

Results： Our experimental results show that despite the short number of exercises, participants can still distinguish between 11 modes, except that the accuracy in the counterclockwise direction is 83.3-93.3% (average 89.6%).

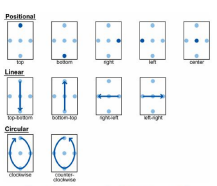

Figure 4: The eleven vibration patterns implemented on the prototype. For the linear and circular patterns, the vibration motors are activated sequentially, as the figure shows with the smoothing explained in Figure 5.

Table 1: The confusion matrix for *Pattern* in the first experiment. The numbers in bold font represent the number of occurrences of the user responses. The numbers with parentheses show the percentage of the occurrence of the user responses in each stimulus.

Stimulus \ User Response	top	bottom	right	left	center	top-bottom	bottom-top	right-left	left-right	clock-wise	counter-clockwise	total
top	113 (93.3)		4 (3.00)	1 (0.83)	1 (0.83)		1 (1.67)					120
bottom		103 (85.8)	8 (6.67)		9 (7.50)							120
right			107 (89.2)		13 (10.8)							120
left	2 (1.67)			112 (93.3)	6 (5.00)							120
center	1 (0.83)	2 (1.67)	3 (2.50)	1 (0.83)	109 (90.8)	2 (1.67)	2 (1.67)					120
top-bottom						110 (91.7)		3 (1.67)	3 (2.50)	1 (1.67)	3 (2.50)	120
bottom-top	4 (2.50)						110 (91.7)	1 (0.83)	3 (2.50)	1 (0.83)	1 (0.83)	120
right-left					1 (0.83)	3 (2.50)	2 (1.67)	107 (89.2)	1 (0.83)	4 (3.00)	2 (1.67)	120
left-right					2 (1.67)	1 (0.83)	2 (1.67)	1 (0.83)	106 (88.3)	2 (1.67)	6 (5.00)	120
clockwise										100 (83.3)	16 (13.3)	120
counter-clockwise						2 (2.50)		1 (0.83)		41 (34.2)	76 (63.3)	120
total	119	105	122	114	141	119	117	113	113	152	105	1520

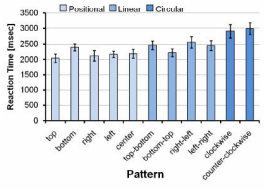

Figure 7: The reaction time across the categories of the vibration patterns in the first experiment. In this and all later charts, the error bars indicate the 95% confidence intervals.

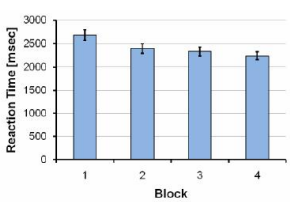

Figure 8: The reaction time across *Block* in the first experiment.

Experiment 2:USER PERFORMANCE ON INPUT TASKS

We designed the second experiment to examine user perform-ance in a realistic application with the SemFeel technology. In particular, we wanted to compare the accuracy of user input when using the SemFeel prototype against user inter-faces that offer no tactile feedback or tactile feedback using only a single vibration source.

Procedure： First, the system showed participants a four-digit number in blue on the computer screen (right of Figure 9). Next, we asked participants to type the number on the mobile touch screen device using the numeric keypad shown on the left side of Figure 9. Participants can type by releasing their thumbs from the screen, and the numbers entered will appear on the computer screen (right of Figure 9). When the participant releases their thumb outside of any key, the character "X" is displayed. This experiment studied three haptic feedback conditions: none (no haptic), haptic feedback provided by a single vibration motor (single haptic) and haptic feedback provided by SemFeel technology (or haptic feedback provided by multiple vibration modes). We Call it "multi-touch."

Results： Our second experiment showed that SemFeel can support more accurate with numeric keyboard applications compared to a user interface without any haptic feedback and a user interface with a single vibration source that has haptic feedback in an eyeless setting. Interaction. In addition, participants can learn vibration patterns under multi-tactile conditions in a short period of time. Our second study also showed that user interfaces with haptic feedback are slower than user interfaces without haptic feedback. This is what we expect, because participants often adjust their touch points on the screen based on haptic feedback to press the correct key. However, participants cannot make such adjustments without haptic feedback.

Figure 9: The applications used in the second experiment: left) the numeric keyboard on the prototype mobile device; right) a screen shot of the application running on a Windows computer.

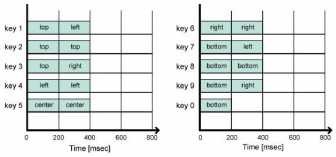

Figure 10: The mapping of the vibration patterns for the numeric keyboard used in the *Multiple Tactile* condition. Please note that the assignment of the vibration patterns is based on the spatial relationship of the keys (*e.g.*, the combination of top and left vibration is assigned to key 1).

Figure 11: The setup for the second experiment. The experimenters asked the participants to hold the prototype mobile device under the table in order to reproduce an eyes-free situation.

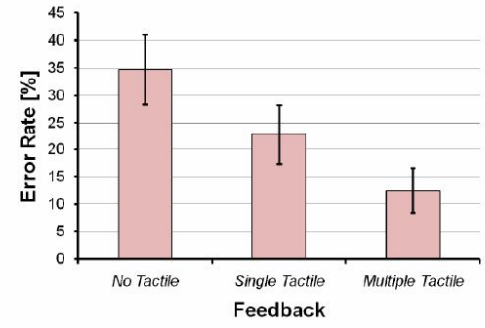

Figure 12: The error rate across *Feedback* in the second experiment.

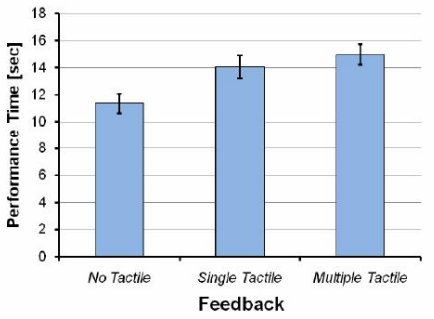

Figure 13: The performance time across *Feedback* in the second experiment.

【APPLICATIONS】:

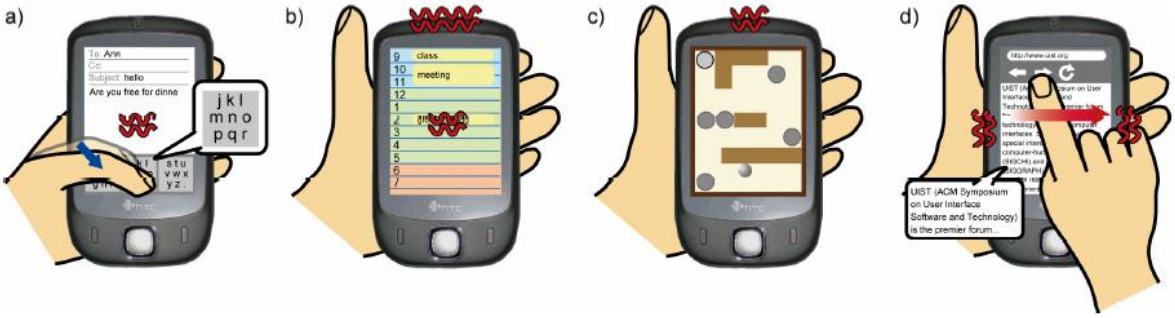

Figure 14: SemFeel applications: a) An alphabetic keyboard. The right, center and left vibration patterns are associated with three large keys which the user can touch and make a gesture to type a letter; b) A calendar application. The top, center, and bottom vibration motors are used for representing the morning, afternoon, and evening in a particular day, and the duration of the vibration generated by each vibration motor represents the availability of each time period (longer vibration means less available); c) A maze game. Users can interact by tilting the device, and when the ball hits the wall, the vibration is generated; and d) A web browser for people with visual impairment. Audio feedback is used for reading out the content of a webpage, and tactile feedback is used for providing information about the controls in the web browser application.

【Important Refrence】:

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