PuyoSheet and PuyoDots: Simple Techniques for Adding “Button-push” Feeling to Touch Panels

Masaaki Fukumoto
NTT DoCoMo Research Labs.
3-5, Hikari-no-oka, Yokosuka-shi, Kanagawa-ken,
239-8536 JAPAN
fukumoto@acm.org

CHI 2009, April 4–9, 2009, Boston, Massachusetts, USA.
ACM 978-1-60558-247-4/09/04.

Abstract
Two simple techniques for touch-panel based portable information devices are proposed. A soft-gel based transparent film named “PuyoSheet” placed over a touch panel provides button-push feeling to the fingertips. Another configuration, soft-gel based small dots, named “PuyoDots”, is attached to the backside of a handheld device provides button-edge and button-push feelings to the fingertip(s) that hold the device. Preliminary evaluations indicate that proposed techniques improve “usability” and “preference” without deteriorating input speed or error rate compared with an ordinary touch panel device.

Keywords
input device, touch panel, tactile, haptics

ACM Classification Keywords
H5.2. Input devices and strategies, Haptic I/O

Introduction
Touch panel devices that interact well with graphical user interfaces are widely used in information systems. However, the surfaces of touch panel devices are made of hard materials such as plastic or glass, and so their

operation feels different from ordinary push-button based mechanical keypads. This difference is particularly noticeable when many characters are input via a software-keyboard. For this reason, some users are annoyed by touch panel based systems.

Many systems that add "tactile feeling" to touch panel have been proposed. However, these systems require special actuators and electrical power, and so are not so easy to use with small and low-power handheld devices.

A simple solution is to attach small transparent bumps onto each key position of the software-keyboard. This, however, restricts the design of the GUI, and the displayed image is distorted when the software-keyboard is not used. In addition, unexpected tactile feelings are generated when the fingers are dragged over the bumps.

PuyoSheet

PuyoSheet[1] is simple technique for adding "button-push" feeling to ordinary touch panel devices. A transparent urethane soft-gel film is attached onto the surface of the touch panel (**figure 1**). When the user pushes the touch panel with a fingertip, gel film distorts and sinks slightly. So the user feels a "button-push" like tactile feeling at the fingertip. The upper surface of the gel-film is covered with a thin transparent plastic film that offers low friction to the fingertips when dragged across the touch panel.

[1] "Puyo" is Japanese onomatopoeia that expresses "soft" and "cute" impression. Pronunciation is "pooh-yo".

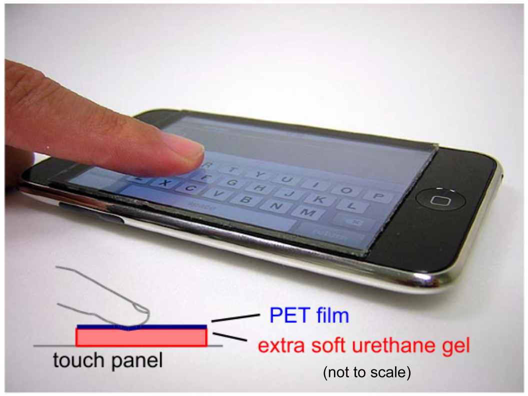

figure 1. PuyoSheet (0.95mm thick urethane gel + 50μm thick PET film)

There are no bumps on the surface of the touch panel, so the GUI can be freely designed, and no unexpected tactile feelings are generated when dragging.

PuyoSheet is compatible with both of resistive and capacitive touch panel devices. PuyoSheet can also be used with a touchpad device that has no display. In this case, transparency is not required.

PuyoDots

PuyoDots is another technique to improve the tactile feeling of touch panel based handheld devices. Small urethane soft-gel pads are attached to the **backside** of the handheld device (**figure 2**). The pads' surfaces are coated to reduce stickiness. Pads are arranged where the fingertip(s) rest when holding the device. When the top surface of the touch panel is pushed by the finger ((1) in **figure 3**), the pads slightly distort (2), and tactile information is felt by the holding fingertip (3). This tactile information is received at the same time as the touch panel is pushed. Therefore, the user feels

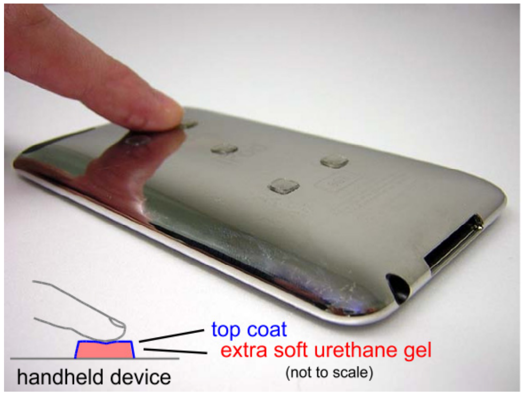

figure 2. PuyoDots (5mm square, 0.5mm thick urethane gel)

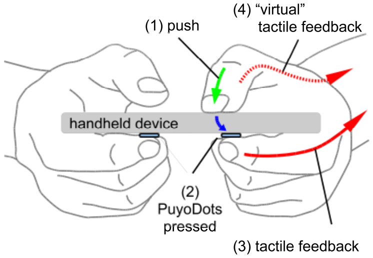

figure 3. How PuyoDots work.

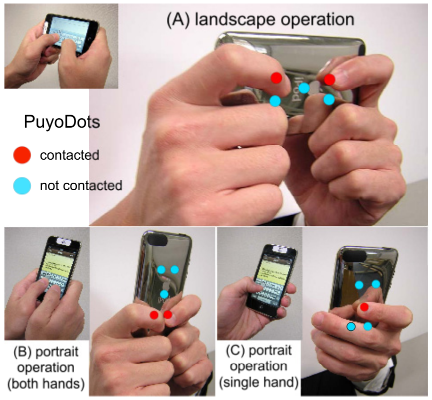

figure 4. Operating styles with PuyoDots

that the front side finger, which is pushing the touch panel, is receiving "virtual" tactile information (4). The edges of the pads also provide tactile feelings that reproduce those generated by the edges of mechanical keytops.

PuyoDots does not cover the top surface of the touch panel, so the display image, if any, is not disturbed. In addition, the user usually operates the software-keyboard without changing holding posture, therefore, tactile feedback of all characters on the software-keyboard can be generated by just one or two PuyoDots; an appropriately arranged small number of PuyoDots can support various operating styles (**figure 4**).

PuyoDots can also be used for a cue to hold the device more securely, especially when the device is operated in an unstable situation.

Evaluation

The performance and impressions of PuyoSheet and PuyoDots were evaluated in a comparison with an ordinary touch panel based handheld device. The six conditions shown in **figure 5** (A,B,C,D,E and K) were examined. Conditions A to E ("iPod Touch") used the touch panel. Conditions B to E used PuyoSheets of different thickness (0.5mm, 1.0mm and 1.5mm). Only condition-E used five PuyoDots (5mm square, 0.5mm thick) on the backside (see figure 2). All PuyoSheets consisted of 50μm thick PET film. The hardness of the urethane gel used in all PuyoSheets and PuyoDots was zero degrees on ASKER-C scale. Only condition-K ("HTC Z") had a mechanical keypad.

Procedure

(1) The subject held the selected target device using landscape style (see figure 4). In condition-E, the subject was asked to place his/her fingers on any of the

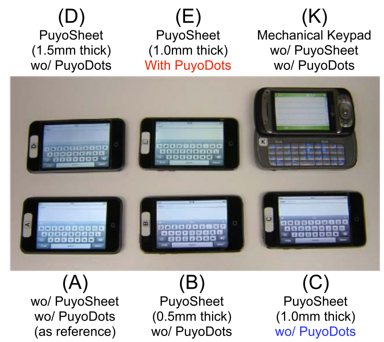

figure 5. Conditions of tested devices

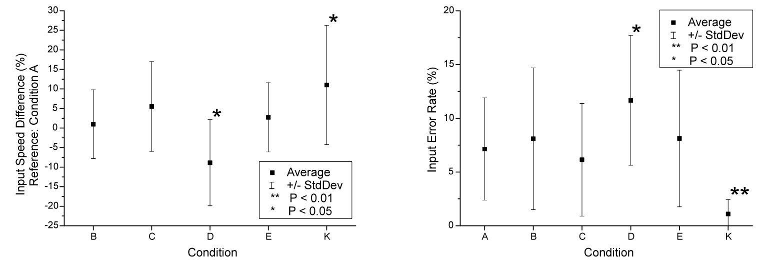

figure 6. Left: Input speed difference (%, Reference: condition-A), Right: Input error rate (%). Error bars show +/-standard deviation from average. Double asterisks (P<0.01) and single asterisks (P<0.05) indicate significant difference from condition-A (by the two sample t-test).

PuyoDots on the backside of the device.
(2) A pre-learned sentence[2] was continuously typed in 10 times. Input speed and error rate were measured. (3) Same presentation was repeated for six target devices. (4) Finally, the subject answered a questionnaire. The order of target device presentation was counterbalanced for all subjects. Almost all subjects (10 male and 2 female adults) had experience in using iPod Touch and mini-qwerty PDAs.

Results

Figure 6 (left) shows the input speed differences of each condition. In this graph, input speeds were normalized for each subject by using the subject's condition-A (ordinary touch panel) performance as a reference. None of the conditions showed any significant difference from condition-A (by the two sample t-test, P<0.01). **Figure 6** (right) also shows the input error rates of the conditions. Only condition-K (mechanical keypad) had significant difference from condition-A (by the two sample t-test, P<0.01). These graphs indicate that the proposed method (PuyoSheet and PuyoDots) did not significantly influence input performance compared to a normal touch pad device.

Figure 7 shows the answer distribution of each question; "Which device has good key-push feeling?" (left), "Which device has good usability?" (center), and "Which device do you prefer?" (right). In all questions, subjects rated each condition with a number (5: best, 1: worst). At least one condition must be rated as 5 and one as 1, same ratings for different conditions were allowed. **Table 1** also shows the number of subjects who rated good and bad scores for condition-B to K compared to condition-A (normal touch panel). The left graph indicates that many subjects felt that condition-K (mechanical keypad) had good, and condition-A (normal touch panel) had bad "key-push" feeling. **Table 1** (upper row) also indicates that many subjects felt that PuyoSheets (conditions B,C,D and E) and PuyoDots

[2] "thequickbrownfoxjumpsoverthelazydog"

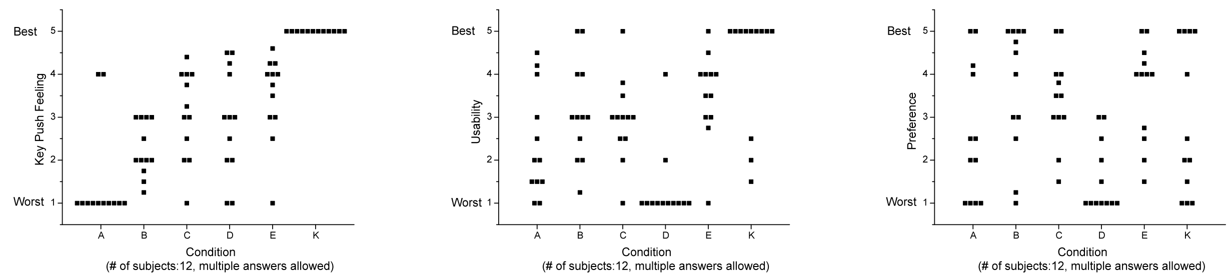

figure 7. Answer distributions (Left: "Which device has good key-push feeling?", Center: "Which device has good usability?", Right: "Which device do you prefer?") (best=5, worst=1) ▪: score for one subject

(condition-E) had better key-push feeling than the normal touch panel. This table (last column) also indicates that PuyoDots (condition-E) offered improved key-push feeling compared to condition-C (which has same thickness PuyoSheet, without PuyoDots). Table 1 (middle and lower rows) indicates that PuyoSheets (conditions B,C and E) and PuyoDots (condition-E) also offered improved usability and preference scores, however, the excessive thickness of PuyoSheet (1.5mm in condition-D) degraded usability and preference (many subjects reported that condition-D slowed their input speed and disturbed pointing accuracy). We note that "preference" (see right graph of figure 7) varied greatly among subjects, and some users rated 0.5mm and 1.0mm thick PuyoSheets (conditions B and C) and PuyoDots (condition-E) as better than the normal touch panel (condition-A).

Discussion

Some subjects rated PuyoSheet and PuyoDots as having less key-push feeling and usability than the ordinary touch panel. Many of these subjects were expert iPod Touch users, and so were familiar with

		A→B	A→C	A→D	A→E	A→K	C→E
Key push feeling	Good	**10**	**10**	**8**	**10**	**12**	**8**
	Bad	2	2	3	2	0	2
Usability	Good	**9**	**7**	2	**8**	**10**	**7**
	Bad	3	4	**9**	4	2	4
Preference	Good	**9**	**9**	3	**9**	**6**	**6**
	Bad	2	3	**8**	3	5	4

(Number of subjects: 12)

table 1. Answer distributions of improvement and deterioration for each condition

		A	B	C	D	E	K
Preference	Best	3	4	2	0	2	4
	Worst	3	1	0	6	0	3

(Number of subjects: 12, multiple answers allowed)

table 2. Answer distribution of best and worst rated conditions about "preference"

"glass-like" surfaces. In addition, some subjects scored PuyoDots (condition-E) as having less usability and preference than condition-C (same thickness PuyoSheet, without PuyoDots). The typical operating style of such subjects is shown in **figure 8**. The subjects usually held the device tightly by its edges, and no fingers contacted

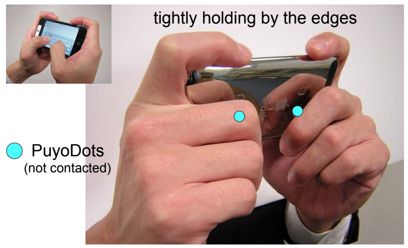

figure 8. Unsuitable operation style for PuyoDots

figure 9. PuyoSheet with soft textured device (Chumby®)

the backside of the device. So they are uncomfortable with condition-E (the subjects must place their fingers on the PuyoDots).

Related Works

"ActiveClick"[1] and "TouchEngine"[2] used small actuator(s) to add click feeling. "CC Switch"[3] placed transparent mechanical switch section(s) onto a touch panel. "SurePress"[4] used the whole touchscreen as a big push button. "Tactile Driver"[5] covered the touchscreen with an actuated transparent panel. Several vision-based soft surface touch interfaces for detecting pointing action and force vector have been mentioned. "GelForce"[6] and "ForceTile"[7] used marker-filled soft gel. "PhotoelasticTouch"[8] utilized the photo-elastic effect and "SLAP"[9] used FTIR (frustrated total internal reflection).

Conclusion

PuyoSheet and PuyoDots did not significantly improve either input speed or error rate. However, some subjects much preferred them over the ordinary touch panel (see **table 2**). They reported that PuyoSheet and PuyoDots were "comfortable". So we are planning to quantitatively measure comfort by using biological information such as R-R interval time of heartbeat or brain wave. PuyoSheet and PuyoDots are also suitable for toys or household goods that require fun and cozy characteristics (**figure 9**).

References

[1] M. Fukumoto, et al., "ActiveClick: Tactile Feedback for Touch Panels", CHI '2001, Ext. Abstracts, 2001.

[2] I. Poupyrev, et al., "TouchEngine: a tactile display for handheld devices", CHI '02 Ext. Abstracts, 2002.

[3] M. Mamiya, et al., "A New Way to Overcome the Uneasy Operation of Touch-Sensitive Displays by Incorporating Click Mechanism CC Switch", HCI '97.

[4] "SurePress™" by RIM Limited. http://demos.blackberry.com/9530/na/us/gen/

[5] "Tactile Driver" by Hitachi Human Interface Lab. http://hhil.hitachi.co.jp/products/tactiledriver-e.html

[6] K. Vlack, et al., "GelForce: a vision-based traction field computer interface", CHI '05 Ext. Abstracts, 2005.

[7] Y. Kakehi, et al., "ForceTile: Tabletop Tangible Interface with Vision-based Force Distribution Sensing", SIGGRAPH New Tech Demos, 2008.

[8] T. Sato, et al., "PhotoelasticTouch: See-through Gelatinous Interface using LCD and Photo-elastic Effect", Proc. of WISS2008 (in Japanese).

[9] M. Weiss, et al., "SLAP: Silicone Illuminated Active Peripherals", Tabletop 2008 Ext. Abstracts, 2008.

[10] "Chumby®" by Chumby Industries, Inc. http://www.chumby.com