

Tactile Feedback for Mobile Interactions

[Stephen A. Brewster, Faraz Chohan, Lorna Brown - 2007]

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Motivation

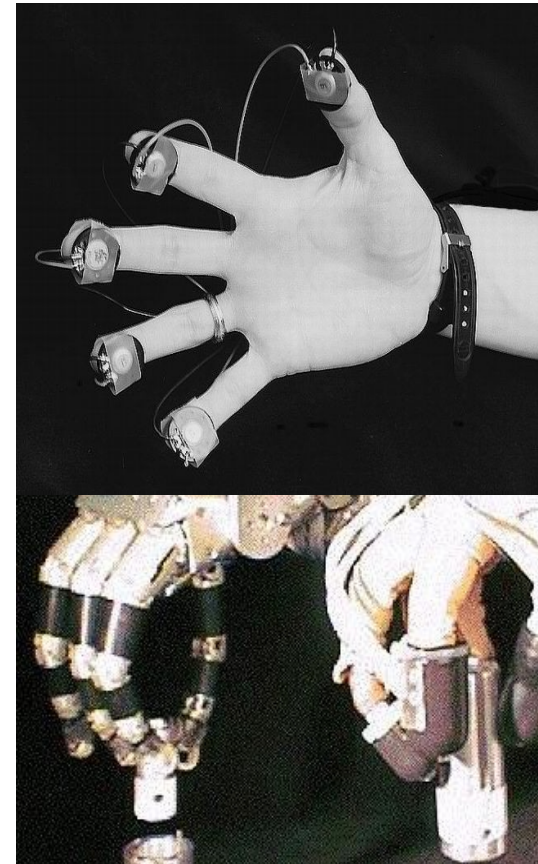
- Study investigating the use of vibrotactile feedback for touch-screen keyboard on PDA.
- PDA device small \Rightarrow Keyboards hard to use (key $< 1\text{cm}^2$ for an HP iPAQ PDA).
- Entering text on a PDA with finger or stylus while moving :
 - Bumpy buses, train, tramway,
 - People often want to read/send e-mails, browse websites on their way to work.



Studies on the same field (1)

[R. Voyles, G. Fedder, and P. Khosla, 1996]

- Our ability to manipulate objects relies heavily on the **contact** (touch and force) information we gather.
- Modular tactile **sensor and actuator** system for observing human demonstrations of contact tasks.
- 3 interchangeable parts:
 - Intrinsic tactile sensor : measuring net force/torque,
 - Extrinsic tactile sensor : measuring contact distributions,
 - Tactile actuator : displaying tactile distributions.
- Using electrorheological gel for actuation.



Studies on the same field (2)

- Some examples of the use of tactile displays to improve desktop interface :
 - Tactile feedback improve pointing interactions when using a mouse [Mackenzie].
 - Tactile stylus to use on touch screens and PDA [Lee et al].
 - Design of sophisticated tactile displays for handheld computers [Poupyrev et al, Luk et al].
- None have been **formally** studied \Rightarrow tactile displays beneficial in practical situations ?

Studies on the same field (3)

- **Formally studied solution** : Tactile progress bar indicating the progress of a download via the time difference between two tactile pulse [Brewster and King].
- The **assets** are :
 - Users performed better with tactile progress bar.
 - Attend to the feedback and type at the same time.
- **Solution with sound [Brewster]** :
 - People could walk without paying attention on the graphical display.
 - Sounds increased the amount of data people could enter on a PDA and reduced subjective workload.

Description of the system

- **PDA** : HP iPAQ using *stylus* with vibrotactile actuator on the top-right corner.
 - Many mobile devices already have vibrotactile actuators, but little used (ringing phone on silent mode).
- Based on Brewster's sound feedback PDA.
- **2 stimuli** (800 ms, 250 Hz) :
 - **Success Tacton** : Button correctly pressed then released.
 - **Error Tacton** : Slip or double tap error occurred.

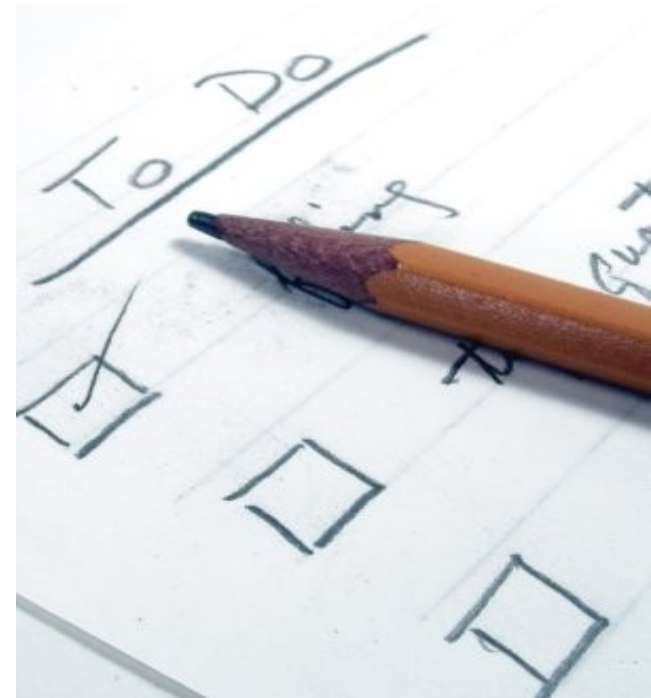


Approach

- **Solution attempt** : Using touch-screen keyboard on PDA device with *vibrotactile feedback*.
- **Aim** : Impact text entry on iPAQ by comparing PDA with standard buttons/PDA with tactile feedback:
 1. on *laboratory*.
 2. on an *underground train* (realistic use).
- *Impact* of the actuator studied, not the location.
- Does the vibrotactile feedback on PDA have an influence on:
 - text quantity,
 - error rate,
 - error correction ?

Error categories, experiment variables

- While typing, some error could occurred :
 - Wrong letter : bad letter chosen (mistake) or train movement.
 - Slips : stylus down on one letter then lifted to another.
 - Double taps : double letter entered (vibrations of the train).
- Dependant variables are :
 - Amount of text entered,
 - Total number of errors (characters that were not on the poem),
 - Number of errors that were uncorrected by users.



Experiment 1 : Setup

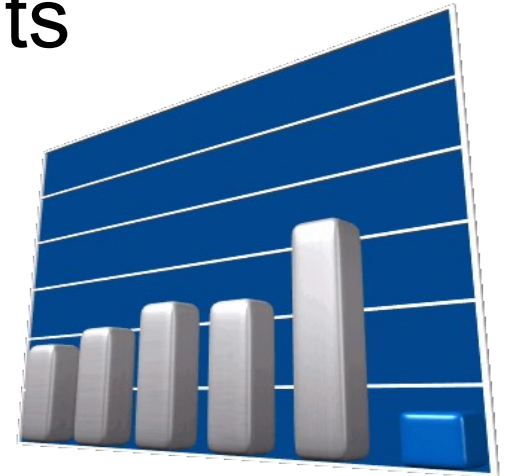
- An external vibrotactile actuator is added to the iPAQ, experiment on *laboratory*, with 12 right-handed participants typing a poem.



- It is expected that the vibrotactile actuator creates :
 - ↗ Number of lines entered,
 - ↘ Total errors,
 - ↘ Number of errors uncorrected.

Experiment 1 : Results

- As expected :
 - ↗ Number of lines entered ✓
 - ↘ Total errors ✓
 - ↘ Number of errors uncorrected ✓
- **Tactile feedback participants were generally performing much better than without the vibrotactile actuator.**
- Vibrations from the tactile feedback did not affect typing in a negative way (participants entered more text in tactile condition).



Experiment 2 : Setup

- Same experiment as E1, but on a *train in motion*. 6 participants, same text should be typed in.
- **Aim** : Assess the effect of tactile feedback in a more realistic scenario.
- Same results as in E1 expected.
- Using Nasa TLX workload sheet.



Experiment 2 : Results

- Impact reduced as expected :
 - ↗ Number of lines entered, no difference with the E1 results 📄
 - ↘ Total errors, no difference with the E1 results 📄
 - ↘↘ Number of errors uncorrected with more being corrected in the tactile condition as in the lab study ✅
- **Conclusion :**
 - Tactile feedback was **less beneficial** when users were mobile.
 - Much vibrations masked benefits found in lab.
 - Feedback **useful** for correcting errors.
 - Nasa TLX : Tactile feedback reduce almost all of the workload factor ⇒ **beneficial**.

Comparison with sonic enhancement

- Brewster also developed earlier a sonic version.
- Study on walking people \neq seated people on lab/subway.
- The results found with vibrotactile feedback **match** some of those found with the sonic one :
 - More data entered,
 - NASA TLX : large reduction in workload.
- Noisy environments : sounds cannot be heard \Rightarrow **unacceptable** in a subway.



Conclusion

- Tactile feedback provides **significant benefits** for keyboard interactions on touch-screen devices, both in static or mobile situations.
- Large reduction in workload with extra feedback when users were mobile ⇒ **extra assistance**.
- **Feedback on the phone** : use of finger or stylus.
- **Easy and cheap solution** : most of mobile phones already include vibrotactile actuator.

- **Following research** :
 - Fall or trip while using ?
 - Audio, tactile and both combined ?

Discussion

- Experience (10 min) too short - Mental fatigue for a long using ?
- Brewster tested text entry, do you see other use of the tactile feedback ?



Sources

- Tactile feedback for mobile interaction : S. Brewster, F. Chohan, L. Brown
- <http://www.nrl.navy.mil/aic/ide/NASATLX.php> Nasa TXL workload.
- http://en.wikipedia.org/wiki/Cooper-Harper_rating_scale
- http://www.ri.cmu.edu/pub_files/pub1/voyles_richard_1996_3/voyles_richard_1996_3.pdf
Design of a Modular Tactile Sensor and Actuator Based on an Electrorheological Gel

➔ **That's all folks !**