More Than Touch

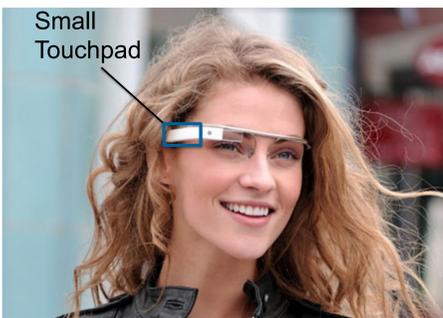## Understanding How People Use Skin as an Input Surface for Mobile Computing

Martin Weigel, Vikram Mehta, and Jürgen Steimle

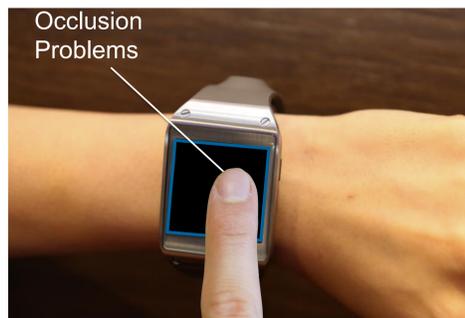M²CI — CLUSTER OF EXCELLENCE

Problem

On-body devices allow for fast access, notifications and control of digital information. However, they are too small for effective touch input.

Small Touchpad

[Google Glass]

Occlusion Problems

[Samsung Galaxy Gear]

On-Skin Interaction

We investigate skin as an input surface. Skin is the largest human organ, provides tactile cues and allows for eyes-free interaction.

Skin is more than a touchpad
- It contains sensory cells for multiple modalities, e.g. location, pressure, and pain
- Touch communicates emotions
- Skin is deformable
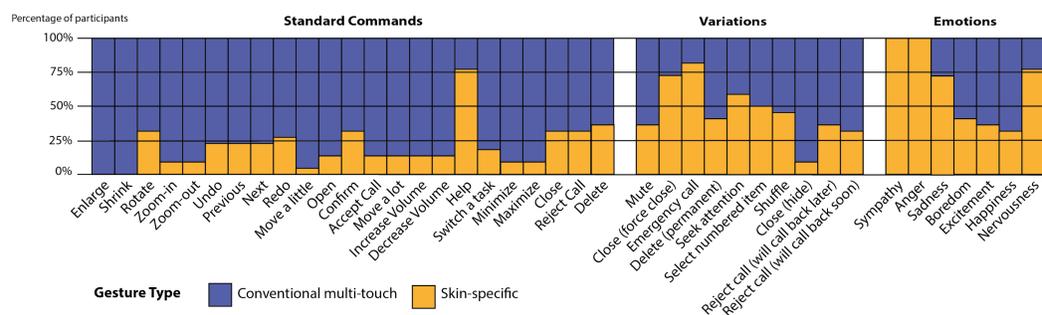- Provides a large surface for interaction

Main Dimensions of Study
What kinds of gestures do users perform on their own skin?
What are the characteristics of skin-specific input modalities?
What are the preferred locations?

Methodology
We asked participants to define and perform a gesture for a given referent (i.e., an action or a functionality) on their bare skin without hardware.

Multi-Touch and Skin-Specific Gestures

Percentage of participants

Standard Commands — Variations — Emotions

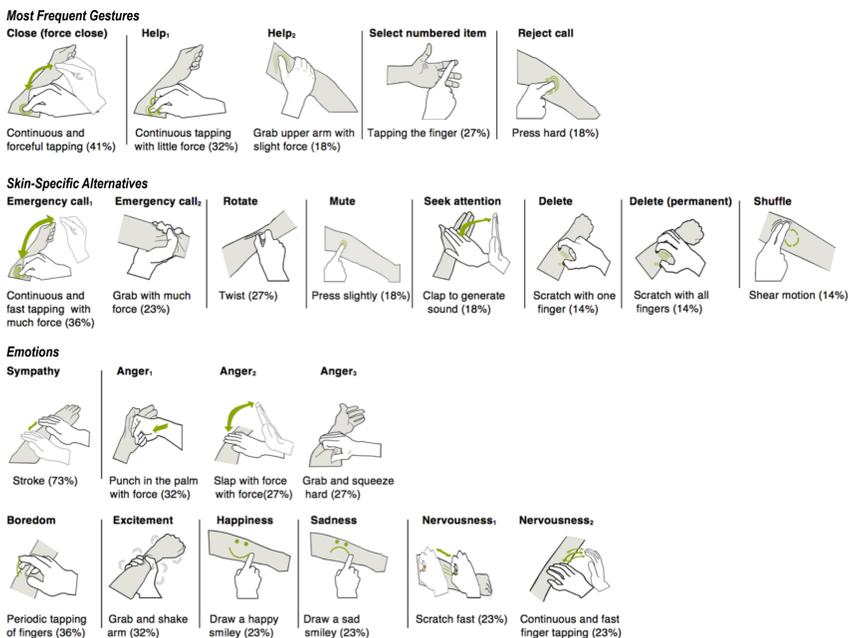Gesture Type: Conventional multi-touch — Skin-specific

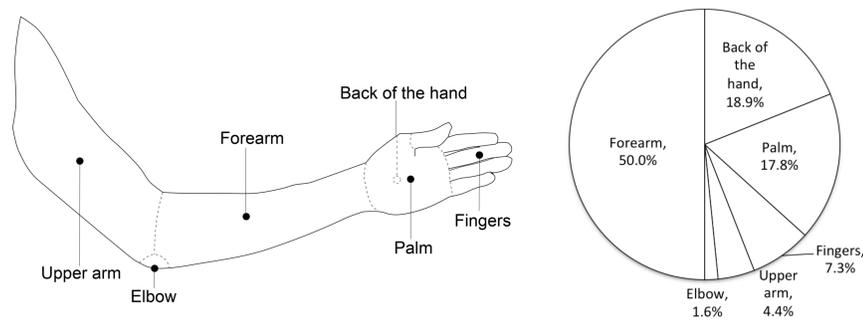*Conventional multi-touch* gestures were transferred from mobile devices to skin
Skin-specific gestures were used for
- Variations: Choosing between multiple options
- Emotions: Communicating emotions
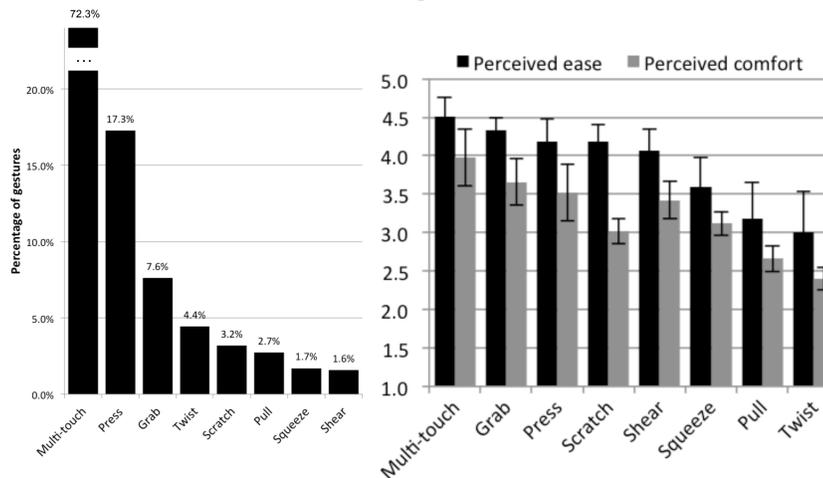
User-Defined Gestures

Most Frequent Gestures

Close (force close) — Continuous and forceful tapping (41%)
Help₁ — Continuous tapping with little force (32%)
Help₂ — Grab upper arm with slight force (18%)
Select numbered item — Tapping the finger (27%)
Reject call — Press hard (18%)

Skin-Specific Alternatives

Emergency call₁ — Continuous and fast tapping with much force (36%)
Emergency call₂ — Grab with much force (23%)
Rotate — Twist (27%)
Mute — Press slightly (18%)
Seek attention — Clap to generate sound (18%)
Delete — Scratch with one finger (14%)
Delete (permanent) — Scratch with all fingers (14%)
Shuffle — Shear motion (14%)

Emotions

Sympathy — Stroke (73%)
Anger₁ — Punch in the palm with force (32%)
Anger₂ — Slap with force with force (27%)
Anger₃ — Grab and squeeze hard (27%)
Boredom — Periodic tapping of fingers (36%)
Excitement — Grab and shake arm (32%)
Happiness — Draw a happy smiley (23%)
Sadness — Draw a sad smiley (23%)
Nervousness₁ — Scratch fast (23%)
Nervousness₂ — Continuous and fast finger tapping (23%)

Preferred Input Locations

Back of the hand — Forearm — Fingers — Palm — Upper arm — Elbow

Back of the hand, 18.9%
Palm, 17.8%
Forearm, 50.0%
Fingers, 7.3%
Upper arm, 4.4%
Elbow, 1.6%

Forearm: Easy to access, large input surface
Palm: Precise control, due to fine sensory feedback

Characteristics of Input Modalities

Percentage of gestures

Multi-touch 72.3%, Press 17.3%, Grab 7.6%, Twist 4.4%, Scratch 3.2%, Pull 2.7%, Squeeze 1.7%, Shear 1.6%

Perceived ease — Perceived comfort

Multi-touch, Grab, Press, Scratch, Shear, Squeeze, Pull, Twist

Most input modalities were perceived as easy to use

Deliberately Uncomfortable Input (e.g., twisting)
Used for important or irreversible commands