Fingernail Displays: Handy Displays at your Fingertips

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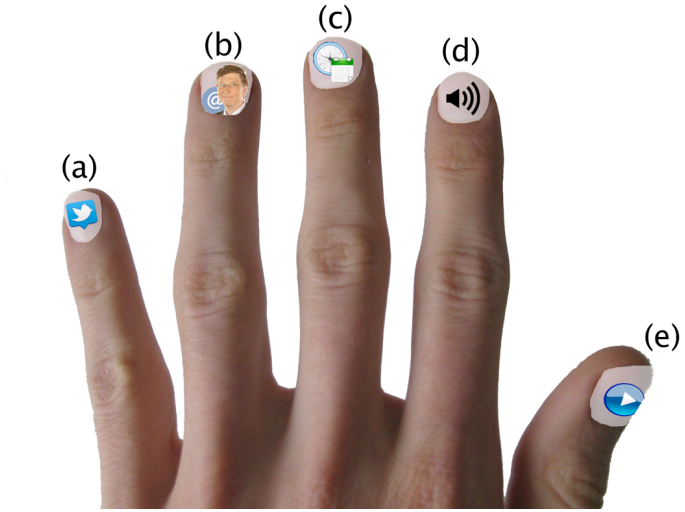

Figure 1: Fingernail Displays are tiny fingernail-worn displays. (a) Tweet, (b) e-mail, and (c) event notification; (d) volume slider and (e) play button.

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Abstract
Humans are mostly using their fingers to interact with their environment. We introduce our vision of Fingernail Displays: tiny displays that are worn on the fingernails. We describe and explore the following application scenarios of fingernail-worn displays: (1) FingerPhone, a standalone device for fast, lightweight interaction that is always at hand; (2) on-finger output on touch displays, which solves occlusion problems and provides in-place information; (3) fingernail displays as in-situ information display to provide additional information and controls on physical objects; (4) interactive, animated nail art that can adjust itself to the context. Finally we sketch the path towards making the vision of fingernail displays become reality.

Author Keywords
Augmented human; body-worn display; fingernail display; micro display; minimal display; wearable computing.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Fingernail Displays
Body-worn displays support mobile, ubiquitous interaction with the digital realm by augmenting parts

of the human body. Research about body-worn devices, e.g. hand- and forearm-worn displays [1, 2], is emerging, but did not augment the part of our body that is most relevant for tangible interactions: our fingers. Our fingertips are in direct contact with the objects we interact with and moreover allow fine motor manipulations.

We envision a display nail polish that the user can paint onto the fingernails (Fig. 1). The smart liquid dries within a few seconds and automatically configures itself to an active matrix color display. This polish creates small, robust displays that are always-at-hand and in direct contact with the objects and tools the user touches and grasps. These displays stand in a well-established tradition of decorating one's fingernails.

While such display nail polish does not exist today, advances in nanotechnology and novel display technologies (e.g. [3]) make us believe that this vision can ultimately be realized. In the near future, tiny rigid or flexible displays can be attached to the fingernail, similarly to how artificial fingernails are attached.

We describe our vision of fingernail displays in the following four scenarios: First, we describe their usage as *FingerPhones* to bring simple interactions that are commonly made with smartphones to your fingertips, without the need for using another device. Second, we describe their usage on *touch displays* to provide *on-finger output*, addressing the fat-finger and tool selection problems. Third, we describe their role as *in-situ information displays* to provide additional information and input capabilities on physical objects while the user is touching or grasping them. Finally, we discuss their advantages over traditional nail art as *aesthetic displays*.

Figure 2: Aligning multiple fingers and selecting a nail with the thumb expands the item, here a calendar event, to all fingers to reveal more information and controls.

FingerPhone

Fingernail displays provide a handy place to interact with digital data right on the finger, removing the need to resort to an external device while, unlike imaginary interfaces [4], still providing visual output. Fingernail displays are not going to replace other devices, but allow for easier and faster access to lightweight tasks that do not require much input or output.

Despite their small size, Fingernail Displays can offer a wide range of interactions. Finger gestures as described in [5], such as tabs, flips, and circling with the thumb on the finger pad, can be used to interact with the content on the nails. In addition to interactions that are limited to the fingers, fingernail displays lend themselves nicely to body-centric interactions: input is given by touching specific parts of the body, for instance when touching one's wrist, the fingernail displays the current time.

Fingernail displays are well suited to show *notifications* to create awareness of new e-mails, social media messages, and the status of family and friends (Fig. 1 a-c). These notifications can lead to fast, brief interactions. For example the user can tap an event notification to send a message to all other participants of the meeting to let them know that she is running a few minutes late.

In addition to notifications, fingernail displays can show up to five different control items at the same time (Fig. 1 d-e). These always-at-hand controls can simplify and speed-up common interactions. For example our

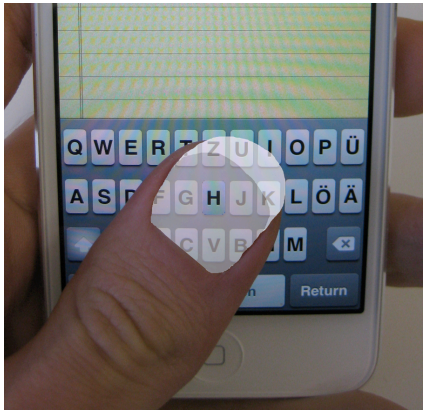

Figure 3: Simulating a transparent finger avoids fat-finger problems. The selected character is highlighted through the Finger Display.

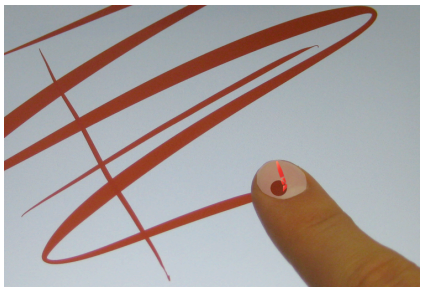

Figure 4: The function of the finger during touch input, here a red brush, is shown and can be manipulated in-place, directly on the fingernail.

fingernails can be used to control the playlist and volume of a music player, show frequently called contacts or they can act as a stopwatch. Embedding additional output and sensing capabilities allows for performing further interactions. For instance, when making a phone gesture, the user can make or receive a call.

For some interactions the display real estate of a single fingernail is too small. *Aligning multiple nails* can create a tiled display with more display real estate. The user can expand an item from one finger onto the tiled display by aligning four fingers and selecting the item to expand with the thumb. The additional space is then used to show more information and interaction possibilities. For example one fingernail shows the remaining time till a calendar event. Aligning more fingers reveals description, location, and an e-mail control to notify all participants when the user is running late (Fig. 2).

On-Finger Output for Touch Displays

The finger is our primary tool for interactions on touch displays. One considerable problem with touch interaction is occlusion of the underlying content. This leads to the *fat-finger problem*, which reduces the accuracy of touch input. Fingernail displays can avoid this problem by mirroring the display's content, i.e. simulating a transparent finger. Figure 3 shows text input on the virtual keyboard of a mobile phone. Instead of the common callout, the underlying character is displayed directly *on* the fingernail.

In many applications, the user can choose among multiple tools or functionalities that touch input is used for, e.g. differently colored pens and an eraser. The current function of the finger is usually indicated in menus or sidebars. In contrast, fingernail displays are able to show the finger's function *in-place*, directly on the finger, in the context of the current interaction. In Figure 4 the finger acts as a drawing brush on a tablet. As a real pen, it reveals its type, shape and color directly on the finger. The function is not only displayed on the tool, i.e. the finger, itself, but can also be changed by interacting with the finger; e.g., sliding changes the width of the brush.

Finally, the handy visual feedback on the fingernails can be used as *clipboards* to save and transport data and entire applications between different displays. After grabbing them from another display they remain as interactive icons on the fingernail, until they are released on another display.

In-Situ Information on Physical Objects

Our hands are our primary tools for interacting with physical objects. Fingernail displays can enhance interaction with those. Depending on the physical object they can act as a situated [6] or peephole display [7]. For instance, while scanning the lines of a foreign book with the finger, the underlying words are automatically translated and displayed in-place. When we grab the receiver of a telephone, the fingernails can show the faces of our most-frequently called contacts (Fig. 5). A contact can then be easily called by tapping on the corresponding nail. This in-situ information is provided without requiring additional effort by the user, just normal interaction with our environment.

Moreover, we can use fingernail displays to *grab widgets* of physical or digital objects that we do not permanently carry with us. The widget then becomes

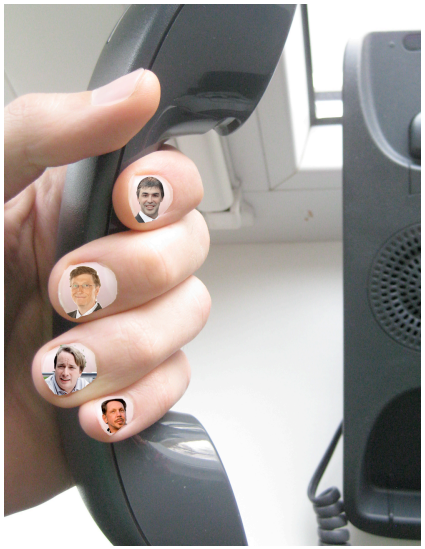

Figure 5: In-situ information, here the most frequently called contacts, is shown when physical objects are grasped.

permanently available at your fingertip, providing remote status output and input possibilities. For example a volume-widget can be grabbed from a physical loudspeaker or a music app on a computer device. The widget remains interactive and controls the volume without the need of walking to the speaker. Other possible widgets include light switches, thermostats or checking the current status of a washing machine that is located in the basement.

Aesthetic Displays

In many cultures fingernails are painted to express individuality and embellish the body. While unused for interactive functionality described above, fingernail displays can style the nails with dynamic content for aesthetic purposes. In contrast to permanent styling of traditional nail polish, displays can change the displayed pictures and even show animations and videos. This enables a more interactive and artistic form of nail art, since the displays can adjust themselves over time to reflect the current time of the day, the environment or the mood of the person.

Prototypical Realization and Future Work

We are currently developing a mobile prototype of the described fingernail displays. As displays we are using small, color micro-displays (≈1" diagonal). Each display is mounted onto one fingernail and is connected to a microcontroller, which is worn on the user's arm, powered by a rechargeable battery pack. The controller is sensing the interactions using a microphone on each finger. For our first prototype we are recognizing external objects through RFID, but may later use approaches that do not require any instrumentation of the environment, as in [8].

Acknowledgements

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Related research focusing on a single fingernail display was conducted independently and in parallel to our work and will be appearing in [9] and [10].

References

[1] Harrison, C., Ramamurthy, S., and Hudson, S. On-Body Interaction: Armed and Dangerous. *Proc. TEI '12.*

[2] Harrison, C., Tan, D., and Morriss, D. Skinput: Appropriating the Skin as an Interactive Canvas. *CACM '11 vol. 54.*

[3] Saakes, D., Inami, M., Igarashi, T., Koizumi, N., and Raskar, R. Shader Printer. *Proc. SIGGRAPH '12.*

[4] Gustafson, S., Holz, C., and Baudisch, P. Imaginary phone. *Proc. UIST '11.*

[5] Wolf, K., Naumann, A., Rohs, M., and Müller, J. Taxonomy of microinteractions: defining microgestures based on ergonomic and scenario-dependent requirements. *Proc. INTERACT '11.*

[6] Fitzmaurice, G. Situated information spaces and spatially aware palmtop computers. *CACM '03 vol. 36.*

[7] Yee, K. Peephole displays: pen interaction on spatially aware handheld computers. *Proc. CHI '03.*

[8] Yang, X., Grossman, T., Wigdor, D., and Fitzmaurice, G. Magic Finger: Always-Available Input through Finger Instrumentation. *Proc. UIST '12.*

[9] Su, C., Chan, L., Weng, C., Liang, R., Cheng, K., and Chen, B. NailDisplay: Bringing an Always-Available Visual Display to Fingertips. *Proc. CHI'13.*

[10] Wimmer, R. and Echtler, F. Exploring the Benefits of Fingernail Displays. *Proc. CHI EA'13.*