Usability of Security Measures in Ubiquitous Computing Environments

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Abstract

1. A description of the type of system for which you have created the design, focusing on any particularly usability issues that you'd like to address. 2. A top-level design or layout 3. At least two usage scenarios 4. Rationale for your design: relevant priorities, mental properties, interaction design concepts, guidelines, principles, theories, etc. 5. Usability metric "forecast" analysis of your design –if implemented then tested, what would be your design's strong metrics? Weak metrics? Explain your choices. Illustrate things as needed, with diagrams

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1 Introduction

Smartwatches promise to bring enhanced convenience to common communication, creation and information retrieval tasks. Due to their prominent placement on the wrist, they must be small and otherwise unobtrusive, which limits the sophistication of interactions we can perform. This problem is particularly acute if the smartwatch relies on a touchscreen for input, as the display is small and our fingers are relatively large. In this work, we propose a complementary input approach: using the watch face as a multi-degreeof-freedom, mechanical interface. We developed a proof of concept smartwatch that supports continuous 2D panning and twist, as well as binary tilt and click. To illustrate the potential of our approach, we developed a series of example applications, many of which are cumbersome or even impossible on todays smartwatch devices.

The wristwatch has been an ever-present wearable technology since its inception in the early 1900s, and has undergone continuous technical refinement since that time. Researchers have long viewed the immediacy and ubiquity of the wristwatch as a vehicle for computation, pushing its capabilities to ever-greater heights. In 2000, IBM demonstrated the first watch running a full operating system [20]. However, unlike smartphones, which can be scaled to a variety of sizes, smartwatches must be small and unobtrusive in order to remain socially acceptable, which has long limited their practicality.

Recently, smartwatches have experienced a resurgence of interest as electronics have become more powerful and power efficient, making them more practical and capable than ever before. Products like the Pebble smartwatch have been popularized in the public press, and prominent manufacturers such as Qualcomm, Sony, Motorola and Samsung.

n-air gestures can utilize area around the watch for input with minimal screen occlusion. For example, the Gesture Watch [8] and HoverFlow [9] used IR proximity sensors to capture gestures performed above a device. Ni and Baudisch [15] used a tiny, wrist-worn, high-resolution optical sensor to recognize gestures performed on top of it. Abracadabra [4] used free-space magnetic tracking to sense an instrumented finger near a wrist-worn device. However, these gesture-based techniques require specific clutching mechanisms, lack tactile feedback, and are generally indiscreet. Our approach hopes to mitigate these issues by providing users a physical, direct manipulation interface.

The approach we present complements contemporary smartwatch input mechanisms, namely touch, physical buttons and voice. Our approach does not hinder any of latter modalities, while simultaneously enabling new dimensions of input, which we view as a significant benefit. That being said, there are several drawbacks and limitations that should also be noted, which we now describe.

As with capacitive touch, buttons and voice, there is a danger of accidental input. This might occur by snagging on clothing or being pushed when e.g., the hands are resting on a table. Like other modalities, an unlock mechanism might have to be employed to reduce false activations. Indeed, a device could have one such mechanism shared by all input modalities.

In this work, we designed and implemented a new smartwatch interaction modality that uses the watch face as a multi-degree-of-freedom mechanical interface, enabling users to pan, zoom, navigate, select and perform other actions using simple physical controls. We demonstrated these capabilities with a suite of example applications, built around five interaction techniques. Our approach is inexpensive, potentially compact, and can complement existing inputs, such as physical buttons, touch and voice.

The popularity of smartwatches has increased rapidly in the last year. Smartwatches are being hailed as a new disruptive technology that might bring wearable computing to the masses. As smart watches are normally worn on the wrist, we see a big potential for them to digitally augmented gestures performed in day-to-day contexts.

In this paper, we describe the design and development of an application for a smartwatch to assist office employees in easily locking and unlocking doors, in acquiring room information and notifying others when they want to enter their office.

Because of the small screen we wanted to make the interaction fast. We decided to implement three types of physical gestures to support the most important functionalities. First, we provide the opportunity to perform a virtual knock with the same gesture as a real knock. Secondly, we support opening/closing doors using the gesture of turning your wrist, just like turning a key to open a door. Finally, the last gesture we provide is swiping your arm to bring you back to the home screen with room scanning functionality.

Knowledge workers tend to drop by each others offices regularly, for example, to ask for assistance or quickly discuss something. Even with the door open, knocking on the door is a common gesture to politely indicate your presence and check whether you are not interrupting the person. Using smartwatches, we could digitally augment these gestures, which can provide a number of benefits. For example, when a person is not in his office, knock gestures could still be recognized and transferred to that persons smartwatch. This allows office workers to keep a record of who came by and who they might have missed. Additionally, it is often annoying to interrupt a phone or Skype call to tell the person knocking on the door that now is not a good time. Depending on who is knocking on the door, it might be important enough to interrupt the phone call. Using our smartwatch applications, the person in the call gets a notification about the virtual knock, and can choose to deny their colleague access or let them in, without having to interrupt the call.

Keys (or keycards) are commonly used to open doors in office buildings. However, they also have several disadvantages: generic keys could still provide access to restricted rooms; they might be lost or forgotten (e.g. people could lock themselves out); or people might forget to lock the door, which could lead to theft of personal belongings or sensitive information. Our Office Smartwatch application tracks the identity of its users to provide more fine-grained access control. Using the users identity, we can restrict access only to the doors that they are allowed to open. Users do not have to remember to bring their keys, assuming they always have their smartwatch on their wrist. To prevent theft, doors could be automatically locked after a specific period of time and door entry and exit could be logged.

In our application, we have three kinds of feedback: visual feedback on the smartwatch display, audio feedback (e.g., a knocking sound when performing a virtual knock) and vibration in case of a notification. Also for smartwatches, visual feedback remains the most common way of providing feedback to users. In order to keep the display contents easy to grasp, we only show information that is essential, following the recommendations of Krkkinen and Laarni [8]

However, when the user looked at the screen, he only got feedback of the last gesture that was performed. To address this problem, we decided to add audio feedback and play a sound every time a gesture has been detected. Users should be able to immediately distinguish the performed gesture based on the sound they hear. For example, when a virtual knock gesture is performed, the device plays a real knocking sound. For the opening/closing gesture we decided to use a rattling keys sound. For going back to the scan functionality, we use a sibilant whoosh sound

Vibrations are only used sparingly, as they can be annoying to the user. Vibrations are only used for notifications: for notifying the user when someone is knocking on their door, when they need to attend a meeting, in case of an error, or when the user tries to perform an action without the right permissions (e.g. opening the bosss office door).

Smartwatches now provide users with access to many applications on smartphones direct from their wrists, without the need to touch their smartphone. While applications such as email, messaging, calendar and social networking provide views on the watch, there is normally no text entry method so users cannot reply on the same device. Here we introduce requirements for smartwatch text entry, an optimised alphabetic layout and present a prototype implementation together with preliminary user feedback. While raising some problems, the feedback gives indicates that reasonable quality and speed is achievable on a smartwatch and encourages our future work.

Before the widespread adoption of touch screen smartphones, 12-key physical keypad phones were the most common text entry method on small devices (sometimes much smaller than the current relatively large screen phones). Predictive technologies (e.g. [4, 10, 11]) interpreted the ambiguous keys (usually three or four letters per key) into words. This approach was shown to achieve around 10 words per minute (wpm) for novices and around 20-25 wpm for experts in controlled studies [12]. We investigated using this approach with reduced number of keys - initially targeting watches [3], but due to technological restrictions our system was implemented on a touchscreen handheld, and later, to reduce movement, on physical key phones [6]. While in theory ambiguous predictive text quality was very high (over 90many different words. Some of these sequences included pairs of common words that caused particular problems (e.g. on a standard phone keypad he and if were typed on the same keys, as were good and home). The early models of prediction were based on simple unigram dictionary models where the most common word matching a sequence was suggested. Nowadays, phones have much more power and memory so can easily support more complex prediction models, which greatly reduces the impact of ambiguity by taking the context of the words into account.

One system of particular note is ZoomBoard [17] that miniaturises the QWERTY keyboard onto a watch, with the user first zooming into an area then picking a letter. ZoomBoard achieved approx. 10wpm in studies and our work is essentially investigating whether predictive based approaches can surpass this using single taps per letter. Many domestic appliances such as TV guides and games consoles use a date-stamp inspired method, where the user scrolls through the alphabet and picks letters on a 2D line or 3D grid. In their early work on small device text entry Bellman and MacKenzie [1] showed this to be a slow entry method that was not particularly helped by dynamic optimisation.

Speech input is an obvious alternative but is still prone to problems with background noise, spoken accents and is less private and discrete than typing.

Interaction was defined as follows:

1. A tap on an ambiguous key enters that key number and updates the current word display to reflect the most likely word from the disambiguation engine based on the current number-key sequence.

2. A first tap on the cental zone adds a space, with subsequent taps rotating round alternative suggestions that match the ambiguous entry.

3. Swipes are defined as shown in table 1. In punctuation and numeric modes the zones 1...6 are replaced with alternative layouts. Where available, a rightwards swipe gesture can be used for word completion.

4. A long press on the centre zone enters edit mode to allow movement of the caret while a long press on the alphabetic keys will show extended characters for that key (e.g.)

As documented by Everett Rodgers in The Diffusion of Innovations, no fundamentally new product type succeeds solely based on the fact that its attractive; it succeeds because it does something genuinely useful at a price point low enough that people dont consider it a luxury. And then it becomes normal and even attractive because it was first useful.

There are 3 major functions of Wear: a Google Now-style "homescreen" with a scrollable list of cards, a rich-notification system that alerts you to information from your smartphone, and a series of contextual tools that pop up during certain activities (Call, Hangouts). All of these functions flow together when necessary, and they depend on a smartphone, if only for the data connection in some cases.

These will look a lot like the cards in the Context Stream: short snippets of relevant information, with an optional photo backdrop. Again, you'll be able to swipe to the right to see expanded information. An action button will let you perform commands on your phone without actually touching it, usually via voice, though the full capability of these actions hasn't been revealed yet.

Previously I have written about smartwatches and how I was unsure as to their use. I think that currently we are asking too much from them. At its very core, a watch is there to provide you with the time. We have many variations of watches, some offer more, quite a few can tell you the date or the day of the week, or even the current altitude.

When outside of a 10m radius of your attached phone, the watch will alert you to an incoming call, if you are unable to return to your phone to answer the call you will have an option to send a message to the caller informing them you will return their call soon.

Damn my infernal pants pockets. The salesperson at the store said they would be useful for storing small personal itemscar keys, loose change, lintbut he didnt warn me that theyd be a crappy place to keep my smartphone. Somehow, some way, whenever I need my phone the most, its lodged deep in my front pocket, entrenched and inaccessible.

Sound familiar? Indeed. So a smartwatch such as the Samsung Galaxy Gear would seem to solve a lot of problems. In theory, it puts a bunch of critical smartphone functions on your wrist, saving you the trouble of extricating your phone from your pocket to make a phone call, snap a photo, or run a few apps.

Its worth noting that when a smartwatch runs out of juice, you dont lose just the smart functions. The display dies, and you lose the ability to even tell time. At this point, you really need to appreciate the shiny brushed metal, because youre wearing nothing more than an expensive bracelet.

When one of your contacts calls your phone (well, your giant Galaxy Note 3 phablet), a notification appears on the Gear, showing the face and name of the person calling. You can accept the call with a swipe gesture, and then begin talking directly into the watch.

Multitasking

Smartwatch and NFC

Even today, mobility is for most of us still very much connected with the concept of the smart phone. But mobility has grown to much more than this single class of devices it is indeed the birthplace for a many new device categories. The most visible of these others categories so far are tablets, the second generation of mobile devices. But this is only the beginning. Smart watches and smart glasses are lurking around the corner, and are already emerging. We will enter the era of wearable computing the third generation of mobile devices which will be closer to us and more personal than any other device before.

I'm so tired of smart phones destroying the social function of eating a meal with others. Kids of all ages zone others out by pulling out their smartphones in both public and private places, as if telling everyone they are around that THEIR tiny little world is the most important by far. If the Apple Watch helps eliminate some of that hardware at the table, great. Maybe a small watch will keep the online engagement to smaller bites and less intrusive manners. If so, bring them on. If it makes everyone even more isolated and neglectful of the world around them, God help us.

Even today its apparent that these new classes of mobile devices do not replace the older ones, but rather complete them. Smart phones did not go extinct after the arrival of tablets, but tablets are superior to smart phones for functions like reading e-books or watching movies. It often depends on the context if a tablet or a smart phone is the better tool of choice. A ten inch tablet is mainly a couch device, while a smart phone can still be used for reading when being out of home. The trend is moving towards a multitude of mobile devices, each with a distinctive usage profile and all connected with each other. There is no single mobile device anymore the personal mobile device ecosystem is the more powerful Swiss Army knife.

Smart watches will have sensors and be close to our body to constantly measure our pulse and other body functions. The quantified self movement will gain further traction.

There will also be a major challenge for the class of wearable computing devices. That is the user interface. An adequate smart phone user interface was missing for a long time. An adequate UI was the major success factor of the iPhone, the reason it was superior to all other approaches at that time. The same challenge is ahead for the new class of devices. Touch screens are not adequate anymore for devices much smaller than a smart phone. One approach, followed by Google, is voice recognition. It still needs to be proved that this works well in practice, but it seems to be the proper approach for devices close to your mouth or face. For smart watches this differs. Probably only James Bond aficionados are going to start talking to their watch. Indeed, another kind of user interface is a better choice for devices at your wrist a technology which emulates the most intuitive movements we do with our hands and arms touching and pointing to something. This technology is NFC.

NFC, or Near-Field-Communication is a radio technology similar to RFID or Bluetooth, with the distinct feature that it requires close contact for transmission of data. At first glance a disadvantage, this brings the real power to NFC. Data transmitted is context-sensitive, by a touch on the target. This target can either be another NFC capable device or a so-called tag, a small, flat chip that contains a piece of data. When such a tag is touched with a NFC capable device the data can be read, and even a distinct action can be initiated. A smart poster containing NFC tags can have several touch points, one for showing the location of the next cinema theatres, another for playing a trailer video, and a third for purchasing tickets. Or a cafe could have a tag at its entry door for connecting with its Wifi (including transmitting a password for temporary access in the network) and downloading a coupon.

With NFC, a new type of user interface appears. It is not on the screen anymore, but deeply embedded in the real world. For smartphones, such technology was so far of limited success because it is convenient to control with the touchscreen. But for devices like a smart watch there will not be a screen of adequate size. Touching a NFC tag which initiates a context-dependent action is the easier thing to do, especially because the smart watch is on your wrist, and pointing to or touching something is one of the most intuitive human gestures, understood by everybody. With NFC and smart watches, this gesture has the potential to connect the real and the virtual world in a new and innovative way.

In office spaces, knowledge workers interact both with each other and with various analog and digital devices in the office. We think that the office environment opens up an interesting space to utilize smartwatches to support and digitally augment interactions.

gyroscope

As smart watches are normally worn on the wrist, we see a big potential for them to digitally augmented gestures performed in day-to-day contexts.

While the office environment offers a rich set of different interactions between humans and also between humans and various digital devices, we started our development of the Office Smartwatch by focusing on a specific use case. We explored various ways to support interactions usually performed when entering a room or getting information about specific office room. In various brainstorming sessions, we derived the following set of interactions to digitally augment commonly used gestures (see Figure 1). Because of the small screen we wanted to make the interaction fast. We decided to implement three types of physical gestures to support the most important functionalities. First, we provide the opportunity to perform a virtual knock with the same gesture as a real knock. Secondly, we support opening/closing doors using the gesture of turning your wrist, just like turning a key to open a door. Finally, the last gesture we provide is swiping your arm to bring you back to the home screen with room scanning functionality. Knowledge workers tend to drop by each others offices regularly, for example, to ask for assistance or quickly discuss something. Even with the door open, knocking on the door is a common gesture to politely indicate your presence and check whether you are not interrupting the person. Using smartwatches, we could digitally augment these gestures, which can provide a number of benefits. For example, when a person is not in his office, knock gestures could still be recognized and transferred to that persons smartwatch. This allows office workers to keep a record of who came by and who they might have missed. Additionally, it is often annoying to interrupt a phone or Skype call to tell the person knocking on the door that now is not a good time. Depending on who is knocking on the door, it might be important enough to interrupt the phone call. Using our smartwatch applications, the person in the call gets a notification about the virtual knock, and can choose to deny their colleague access or let them in, without having to interrupt the call.

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When doing gestures, it is difficult to see what is happening on the screen. During the development of our app, we noticed that when a gesture was performed, the device could have detected two different gestures in sequence. However, when the user looked at the screen, he only got feedback of the last gesture that was performed. To address this problem, we decided to add audio feedback and play a sound every time a gesture has been detected. Users should be able to immediately distinguish the performed gesture based on the sound they hear. For example, when a virtual knock gesture is performed, the device plays a real knocking sound. For the opening/closing gesture we decided to use a rattling keys sound. For going back to the scan functionality, we use a sibilant whoosh sound. Audio feedback will also be generated when someone needs to be notified, like receiving a virtual knock on his device. This is helpful because users might not look on their watch at all times. Vibrations are only used sparingly, as they can be annoying to the user. Vibrations are only used for notifications: for notifying the user when someone is knocking on their door, when they need to attend a meeting, in case of an error, or when the user tries to perform an action without the right permissions (e.g. opening the bosss office door).

Home Appliances As a handy side-benefit, that circular case (i.e. pocketwatches and wristwatches) also has fewer hard, pointy edges to tear and poke at our skin and pockets.

The elegance of maintaining a classic, circular face was a non-negotiable for them.

To operate, the Apple Watch needs to be paired with an iPhone, so theyve decided to willingly break UI continuity between these two closely cooperating devices. In other words, the Facebook icon on the phone and on the watch will always be different in a very fundamental way.

The fashion-will-fix-smartwatches narrative is a really compelling story. Its also completely wrong or, at minimum, flies in the face of decades of study about how new technologies get adopted. As documented by Everett Rodgers in The Diffusion of Innovations, no fundamentally new product type succeeds solely based on the fact that its attractive; it succeeds because it does something genuinely useful at a price point low enough that people dont consider it a luxury. And then it becomes normal and even attractive because it was first useful.

So if its not fashion, what is standing between today and the smartwatches-everywhere future? One thing: a great, unique interface that showcases how much better this new product type can perform both new and existing functions.

Unfortunately, neither the watch-emulating button interface of the Pebble nor the touchscreen-on-a-strap concepts from Google and Samsung hit the mark. They simply feel like a previous generation of interface slapped onto an emerging form which is exactly what they are.

After careful consideration of existing solutions, emerging and available technology, and the form factors constraints, I have identified four principles for designing good smartwatch interfaces. Using these principles, Ill evaluate the viability of three feature candidates to make smartwatches intuitive: voice, gesture, and contextual response.

First, the 4 Principles of Good Wearable Design 1. Glances, not stares: No smartwatch should ever command the attention, especially the eyesight, of a user for more than a few seconds at a time. Spending longer erodes any advantage over a smartphone 2. Interact once, display many times: Smartwatches should primarily provide displays of information and prompts for action rather than providing rich interactive elements, meaning they will show lots of information that is passively consumed. 3. Speed over accuracy: Consumer smartwatches should be flexible, fun, in-the-moment companions, which means they should make lots of ignorable suggestions rather than waiting to make a few suggestions that it deems perfectly right, as current predictive services do. 4. Pass the hallucination test: Smartwatch use can be perceived as novel behavior, but it cant present like Bluetooth headsets, which make it impossible to know who is on the phone and who is screaming at an imaginary friend on the street.

Ever since Apple launched Siri, its been expected that voice control would become the next big thing. Since smartwatches dont have room for even virtual keyboards, many have suggested that voice could make for an ideal mode of interaction.

In practice, its a dead-end. Voice is highly imprecise, as its reliability depends on being in a quiet place (which rules out virtually any public use case, defeating the point of a wearable). This means users need to carefully monitor and repeat commands to get what they want, which fails my first three principles of good design. Moreover, it fails the hallucination test horribly.

Heres why: One irony of todays touchscreen- or button-based smartwatches is that they cant be operated by the hand closest to them. Shakes, slaps, twists, arm flips, brushes, and other gestures could all make great methods for dismissing notifications, skipping messages or music tracks, and communicating with a simple yes/noand either arm could get involved. It could be argued that fitness bandsto date the most successful category of wearablesare controlled by gesture, as they use motion sensors to detect activity. Gesture control speaks to the first three principles: Its a glance-and-interact model focused around the speedy display of information that may be useful. And provided these gestures skew subtle, they would have no issue passing the hallucination test.

If contextual response is to be more than a roulette wheel of data analytics, however, it will require far moreand more accuratedata than we currently have, not to mention consumer control of it. As a result, contextual response UIs will likely be secondary to gesture at first, though they would improve and become more prominent over time.