InfoPulse: a Wrist-worn Ambient Display

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ABSTRACT
This report describes the design process behind the creation of the InfoPulse, an innovative smartphone accessory. The InfoPulse is an ambient information display designed into the form factor of a standard wristwatch. Connected wirelessly to nearby smartphone, it receives and discreetly displays important information, like recently received text messages, emails and calendar alerts, to the user. Designed to function without interaction from the user, the InfoPulse acts as a handsfree email reading device, perfect to catch a quick glance without distracting too much from a user's primary task. The process culminates with the development of a physical prototype that demonstrates proof-of-concept functionality.

Keywords
Ambient information system, smartphones, ubiquitous computing, displays, wireless communication.

INTRODUCTION

Smart mobile devices, common examples being the RIM Blackberry, Apple iPhone and Nokia n95, offer users connectivity and communication options that were unheard of in previous generations of mobile phones. Offering the addictive lure of constant email and IM access, smartphones are found consistently in the pockets of students, business people, commuters and those with an affinity for new gadgets. As useful as they are, smartphones are usually quite large, bulky and heavy.

The increasing proliferation of smartphones poses several problems that are becoming more evident. The normal use of these devices in everyday situations may present a safety hazard, a distraction from a primary task or simply an inconvenience. Through an analysis of these flaws, several areas for improvement were found. The design process was used to determine the best course of action needed to overcome these deficiencies.

MOTIVATION

In the mobile device arena, multi-tasking entails juggling between separate physical tasks, like checking caller ID before answering a phone call while driving, changing a music track while biking down a busy street or even something as simple as checking email while in the midst of a phone conversation. For voice calls, Bluetooth headsets address some factors but offer no way of accessing the vast amount of text information that is available on modern smartphones. This project endeavours to design a similar device to enable mobile text display, creating a 'Bluetooth headset for email and SMS,' positioned as a companion piece of hardware to a smartphone.

The idea was initially influenced by a fairly common problem experienced by those who bicycle often on busy car-heavy streets. Normally when your cell phone rings or vibrates, it is trivial to reach down and answer the alert. But in a high pressure and potentially unsafe environment, one cannot spare the limb and attention necessary to execute this manoeuvre. This problem is amplified by visually complex operating systems (OS) or difficult one-handed operation on the smartphone itself. After discussing the problem with several bicycle and mobile phone users, it was clear that safety would be greatly improved by providing these users with an alternative means of monitoring incoming calls, SMS and email.

Users in other situations could also benefit from a similar solution. For those who move around constantly throughout the day, a smartphone is sometimes the only tool that enables them to keep in touch with the external world. Therefore, in business meetings it is common to hear the buzz of a smartphone, indicating an incoming email, followed by the user immediately pulling out the device to check the display. This action comes almost as a second nature to the habitual Blackberry user and usually presents quite a distraction to the remainder of the group members. This problem is caused by the limited information conveyed by initial vibration of the smartphone. The binary indicator does not allow the user to make the distinction between an important time sensitive SMS and intra-office forwarded email.

Allowing the user to make a more informed time-management decision is one of the basic benefits that this sort of device could offer. These simple scenarios demonstrate particular ways in which a smartphone companion display would help, but in essence any existing smartphone user in a position where it is inconvenient to use their phone traditionally would benefit from this device.

EXISTING SOLUTIONS

Over the last few years, sales of smartphones have greatly increased within the general mobile market. While Blackberry by RIM was one of the first to allow constant email access in a mobile form-factor, this feature is now common on all smartphones. Previously only found hanging on the belts of busy business men rushing through a downtown core, email capable devices are being snapped up by office-less workers, commuters, students and frequent travelers. It is estimated that over 116 million smartphones were sold in 2007 [1]. The capability for ubiquitous computing, through these increasingly capable mobile computing platforms, has finally reached the mainstream.

In the past, several attempts were proposed (and some executed) to realize a system of body-worn mobile devices designed to deliver information more directly to the user. Computer science students at the University of South Australia developed a prototype of a simple liquid crystal display (LCD) powered watch that was capable of displaying the output for several different applications [2]. It connects by Bluetooth to a 'Personal Server' or PerServ, a separate personal digital assistant (PDA) that would in turn be connected to the internet by WiFi.

Other research explores mobile personal data servers lacking input or output mechanisms but capable of wirelessly 'hijacking' nearby displays and keyboards. Intel Research developed a prototype of a lightweight portable server, the size of a deck of cards, designed to store all of the users computer files like email, documents, music and video [3]. It was designed to wirelessly serve these data to local screens or computers that the user was close to, eliminating the need to carry a bulky laptop but preserving the security and privacy that comes with the ability to physically guard data.

In the general market, only a few products have emerged which offer more personal and efficient access to mobile data. Fossil designed a companion watch for Sony Ericsson mobile phones in 2005 [4]. The second revision of the product line, the astutely named MBW-150 watch, connects over Bluetooth to a nearby mobile phone and shows an alert right on the watch face when an SMS or incoming call is received. According to specifications, this product should be able to function for up to 7 days on one charge.

DEVICE

A prototype device was developed to determine if the problems addressed above could be solved by a new device.

Requirements

- Increase user awareness of data being received by their smartphone by providing the user with real time access to information such as: incoming caller ID, SMS, email and music track information.
- Eliminate the need for the user to repetitively check or interact with their smartphone by allowing information to pass ambiently (without user intervention) from the smartphone to the user.
- Minimize any interference with regular activity by ensuring that any body worn device is slim and unobtrusive.
- Able to connect wirelessly to a nearby smartphone to receive data streams.
- Software running on the smartphone must be capable of prioritizing and filtering data sent to the device based on importance, keeping in line with the functionality requirement to limit user distraction.

Concept generation

In order for the display to be available to the user at any given time, the device must take on a form that the user could carry or wear at all times. As it has been made clear in the above sections, the form factor of a watch has always been seen as the main option. There were several reasons for this choice. From an efficiency standpoint, watches are accessible by the user without any particular physical interaction, allowing for hands-free operation. Watches are already an accepted article of wardrobe, though currently observed to be declining in popularity [5].

The purpose of this device is not to replace the large, high-resolution, colour screen of a smartphone but to complement it by providing an alternate text display location. Several screen technologies were applicable including monochrome graphical liquid crystal displays (LCD) and organic light-emitting diodes (OLED). LCDs are robust, affordable and easy to work with. Many small-scale electronics companies offer wide varieties of choices: black/white to colour, resolution, refresh rate, power consumption. Disadvantages particularly relevant to this application revolved around power consumption: LCDs work by modulating light that passes through the screen, so a backlight is needed to illuminate the screen in low-light conditions. A relatively new entry into the field of mobile screens are OLED displays. These displays are inherently more power efficient because light is created within the display by efficient LEDs, eliminating the need for a backlight. Unfortunately, OLED technology is still quite expensive, with rough estimates of small 1.5" screens being triple the price of a similar LCD [5]. For prototyping purposes, the choice was made to select a low-cost monochrome LCD screen, that could coincidentally be salvaged from the extraordinarily common Nokia 3310 cell phone. This screen draws only 1mA, though does not include a backlight.

User input on a device as small as a watch is very difficult. Existing solutions, like wristwatches themselves, rarely include many user adjustable features simply because it is difficult to provide a clear and user friendly method of interacting with such a small device. The calculator watch is a typical example. Acting upon Gaber's [6] principle of pervasive computing, which describes spontaneous networks created between devices intent on sharing available services and computing power, the device should be able to leverage the fact that it is connected to a more powerful input/output service (the smartphone). Inputs must be limited to yes/no confirmations and other simple choices. Implementations like the 'magic' button on the Apple iPhone microphone-headphone demonstrates how a simple binary input can be multiplexed to serve several different functions depending on the current application in use.

Several competing standards were available in terms of low power, short range (<3m) wireless communication. The Bluetooth standard was by far the most well known. Implemented in millions of devices worldwide, from cell phones to cars, it connects devices together spontaneously to share information. Unfortunately it depends on a larger power source than possible for a constantly communicating watch application. A standard Bluetooth Philips BGW203 Bluetooth module consumes at a minimum 8 mA in active mode [7]. To get around this consumption problem, other low power sensor applications like the Nike+ running activity monitoring system, take advantage of the Nordic line of radio frequency (RF) transceivers [8]. Nike designed a special interface dongle to receive data from their shoe sensor and relay it to an iPod. The Nordic sensor uses fractions of the power of a Bluetooth module since it is designed for much shorter distances. The design here somewhat mimics the setup of the Nike+ system: the watch will have a Nordic wireless transceiver built in while a separate dongle will be designed to plug into various smartphones to receive the signal.

To keep the whole system running together, a microcontroller interfaced between all subsystems. There are a multitude of microcontroller options and the basic requirements for low-power, size, weight, connectivity did not help to limit the options down too far. In lieu of a strong reasoning, a familiar option was selected: the ATmega 168 chipset within the open-source Arduino environment. The Arduino is easy to program in C and has a large public following online, offering many avenues for support. Since the Arduino has published printed circuit board (PCB) and schematics drawings available online, it is very easy to integrate it into a custom design.

Several competing battery technologies (nickel-metal hydride, lithium-ion and lithium-ion polymer) are available small applications. Lithium-ion (Li-ion) currently represents the most efficient form of energy storage, in terms of energy density or Watt-hours per kilogram, for a mobile device of this size. Li-ion's close cousin, lithium-ion polymer, has a similar chemistry but is slightly cheaper. Li-poly batteries are currently used in many mobile applications like cellphones and cameras. A 3 gram, 100mAh li-poly battery was selected for this application.

Prototype

The prototype was assembled through a period of several months at TU Delft. Since cost and availability were considered during design selection, most components were easy to buy from online electronic component suppliers.. Components were integrated together on a breadboard while Arduino software was written to allow the Nokia 3310 screen to interface with the microcontroller. After successfully testing the design on the breadboard, the design was implemented on a printed circuit board (PCB). Figures 1 shows the prototype in it's current form.

Fig. 1 Photo of the completed prototype in music track mode

CONCLUSION

The prototype presents a proof-of-concept version of a wrist-mounted ambient information display. Looking at the physical prototype, it is possible to see how this sort of design could be adopted by users. It presents information in a readily available format, giving users quick access to data that would otherwise be accessible solely on a smartphone screen. The display is capable of playing back preset example messages but currently lacks smartphone side software to relay messages in real time.

The future of technology in this sector rapidly shifts. Since the tech specs were locked down for prototyping back in June, equipment manufacturers have already released revisions of components in the design. Longer term plans from the Bluetooth Special Interest Group (SIG) towards Ultra-low Power (ULP) Bluetooth now appear to be much more relevant, especially if new smartphones released in 2009 begin to offer this connectivity option [9].

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