Future User Interfaces for Mobile Devices

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ABSTRACT

Delivering mobile communication and information services anytime, anywhere on devices which have become increasingly feature-rich, complex to use and smaller in size, poses significant challenges for the mobile user interface (UI). Vodafone Group R&D is actively investigating a number of emerging technologies that could address these challenges and resolve current usability issues.

This paper highlights current research activities and trends in technology enablers for future mobile user interfaces and presents a vision on potential developments in this area driven by the need to improve the human-terminal interaction and provide simplified use of mobile terminals and services.

Keywords

User interface, mobile device, human-terminal interaction, usability, keypad, display, natural interaction, ubiquitous communications, context-adaptive UI.

1. INTRODUCTION

Current mobile devices integrate a wide range of advanced applications, such as e-mail and browsing, as well as consumer electronic functionality, such as image/video capture, gaming, music, etc. The complexity resulting from this increasing functionality combined with the shrinking form factor of the device is causing usability problems to mobile users [1]. As a consequence many mobile users only embrace a small number of the services offered through their device. In view of this, the current mobile UI needs to evolve to provide greater flexibility and ease of use which ultimately result in optimal usability and blissful convenience in a variety of user environments.

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The forthcoming sections present a number of technology developments that could shape future interfaces and address the highlighted problems. The challenges involved in the realization of these novel UI concepts are also outlined.

2. EVOLUTION OF UI COMPONENTS

2.1 Keypad

Whilst device capabilities continue to evolve dramatically, the user interface is still based around the conventional keypad layout plus a variety of selection and directional keys. Each key is overloaded with multiple layers of functions for controlling dozens of features, as well as three or four alphabetical characters to enable text entry. An internal web survey carried out by Vodafone R&D on the subject of text entry indicates that users are frustrated with current input methods. The results show that users take text entry implementations into consideration when buying a device and may be willing to pay more for solutions that enable improved text entry. However, the majority are not prepared to compromise on device size or carry a peripheral device. A number of emerging keypad input technologies, including speech recognition, innovative keypad layouts and virtual or projected keyboards, were investigated as part of the research study aimed at improving text entry. The results show unambiguous keypads, which have a distinct key for every character, are more popular with users. These solutions provide speed, high accuracy, ease of use, reliability, no word ambiguity, language versatility and a quick learning curve. Other top user requirements for a good text-entry solution include the ability to enter text with one hand, in a discrete manner and in various environments, such as eyes-busy, hands-busy and while on the move. While testing various text entry techniques in different usage scenarios, it became apparent that no single input method wins out against all others. For instance, virtual keyboards provide a familiar way to enter text. On the other hand they require a flat surface and restrict mobility.

Input through the keypad interface has become even more difficult as the keypad area is squeezed to make space for larger displays. In fact, the keypad could soon be a UI element of the past. Instead, the mobile user interface might consist of a touchscreen, almost as big as the size of the device itself, with additional control keys on either side of the screen. The touchscreen approach provides an easy way for navigating and accessing services, entering text as well as maximizes the display size.

2.2 Displays

Emerging data services, such as Mobile TV, could benefit from larger displays. Investigations carried out by Vodafone R&D on the human visual system indicate that an immersive TV viewing experience relies on filling the eyes' focusing field of view to limit other background distractions. For example, a 32″ widescreen TV viewed at 2.44m results in a viewing angle of about 16° horizontally covering the full focusing field of view of the eye and so creating an immersive viewing experience. The same degree of immersiveness can be achieved on a mobile device with a screen diagonal of 3.5-4.3″ for viewing content at 25-30cm. However this is almost double the size of a typical mobile device. On the other hand, the 1.8-2.0″ screens currently provided by 3G phones reduce the viewing angle to 7-8° resulting in a video experience which is far from immersive. A good compromise is to use a screen size of 2.2-2.8″, which provides a reasonable 10-14° viewing angle coupled with an acceptable form factor.

In the near future, flexible materials could allow large displays to be "rolled" into small devices or even allow the device casing itself to become a display, enabling large display functionality on small form factor devices [2]. The integration of flexible display technologies in mobile handsets could be seen over the next few years, albeit with low colour capabilities, resolution and refresh rates. Early applications could include e-books and still images, however full colour video capable displays are still a few years off.

Head-mounted displays provide an alternative approach to conventional mobile displays [3]. This technology scans high resolution video images onto the retina creating a virtual plasma-size TV screen as viewed from seven feet away, reducing the eye strain often associated with viewing images on a small screen over an extended period of time. The images can be projected in either the left or right eye, increasing user mobility at the expense of a partially obstructed view of the real world. The mechanism used to relay the video data from the handset to the head-mounted display is a major issue of this technology. For instance, the use of cables would limit mobility. On the other hand, the use of wireless technologies such as Bluetooth would severely impact the battery power consumption.

3. NATURAL INTERACTION

In addition to developments in the main UI components, there is an increasing interest in natural interaction, through speech, haptics, gestures, etc., in an attempt to improve current UIs by leveraging human senses. The focus on natural interaction anticipates an extension, rather than a replacement of traditional input and output channels.

3.1 Speech Interfaces

Speech recognition and text-to-speech technologies for human-terminal interaction have been extensively researched for several years. This work has been further fuelled by the introduction of legislation in some countries that bans handheld use of a mobile device while driving. This type of environment is seen as one of the most promising enablers for in-car mobile services and terminal control, as well as the most challenging in terms of background noise. Another major driving force behind the use of speech for human-terminal interaction is the recognised necessity to develop mainstream terminals and services that address the requirements of people with special needs.

Terminal-based speech recognition solutions that enable the user to make calls, navigate menu structures and control applications using voice commands are already in the market [4]. These speaker-independent, language-dependent solutions are constrained by the terminal processing power and only perform well within a restricted context and for a limited vocabulary. Current solutions are completely software-based but in the near future, the technology will be embedded in silicon chips with increased processing power, resulting in improved performance and robustness to noise [5].

In the last few years, research has shifted towards speech-to-text conversion that enables natural speech input for applications such as SMS dictation. Current solutions constrain the user experience with a limited dictionary of words and manual error correction. In order to deliver optimum recognition performance, such solutions require training prior to use which represents a usage barrier [6].

Results from an internal survey conducted by Vodafone R&D indicate that there is user demand for this technology. However, the success of speech interfaces in mobile handsets is limited by unrealistically high user expectations of the technology performance and also by the social acceptance of using such an indiscrete mode of input in public.

3.2 Interpretation of Emotion

The human-terminal interaction could also be enhanced with the integration of another natural communication channel, namely the human emotional state. Recent studies in this area are focusing on how the detection of emotion and attitude could be exploited to supplement verbal and textual communications [7]. For example, increasing levels of emotion in the tonality of a person's voice or the pressure of the hand grip could be used to prompt a virtual assistant in a customer care application to route the call to a human operator.

3.3 Haptic Interfaces

Haptic sensations elicit cognitive and emotional responses from users that sight and sound alone cannot accomplish. Investigations carried out by Vodafone R&D indicate that when combined with audio and visual information, tactile feedback could be very useful in augmenting applications such as mobile gaming and phone navigation. However mixed feedback was obtained when this technology was applied to voice and textual communications. The main issues were the representation of emotions with various touch patterns and the ability of the user to sense and differentiate among the touch patterns associated with different emotions. An emotional-oriented tactile language would require some practice to get familiar with.

An analysis of the user feedback collected on text entry input suggest that touchscreen input as well as emerging text entry solutions, such as virtual and projected keyboards, could be improved by tactile feedback, such that when a soft virtual key is pressed, the screen vibrates giving the user a more realistic impression that a key press has been registered.

3.4 Gesture Input

Various studies demonstrate the potential of gesture input for providing a fast, natural method of interaction [8] that could supplement conventional input methods. The technology behind gesture input is the accelerometer, a motion sensor which detects and measures motion. This technology can be integrated in mobile handsets and can enable the user to intuitively and rapidly navigate through multiple pages, scroll, flip pages, zoom in and out, etc, simply by tilting the device. Compared to keypad input, gesture input offers the advantage of analogue control, which is particularly fitting for gaming applications and volume control. Nevertheless, it is an unfamiliar interaction method that requires dexterity and also some getting used to. Hence, it remains to be seen whether this innovative way of interacting with the device will gain user acceptance.

4. UBIQUITOUS COMMUNICATION AND INFORMATION ACCESS

User interfaces need to develop to facilitate anytime/anywhere communication and make information available to services and users independent of the application or device in use. One way to achieve this is to utilize the capability of different devices in the environment to assist with rendering content and with the human-machine interaction. For instance, in the car environment the mobile device could leverage the car display and speakers as assistive rendering systems for content. The challenges involved in achieving this are many and Vodafone R&D is working with the car industry to explore ways for providing the mobile user with seamless connectivity and the ability to enjoy the latest multimedia capabilities of the handset inside the vehicle while addressing safety concerns over driver distraction.

4.1 Device Interconnectivity

Scenarios such as the one described above need to rely on consistent and simple interconnections between the mobile device and other devices (such as consumer electronic devices and PCs) belonging to different environments (home, car, office, etc.) to enable seamless interworking. Bluetooth headsets for pure mobile voice communication are already common and as the trend shifts to integrated voice and data consumption, future interfaces will need to support the exchange of rich media between different rendering and capture devices. Furthermore, DRM and microbilling are required to support a ubiquitous content management solution whereby the mobile terminal, by making use of the SIM, could control the portability and use of digital content on a number of devices belonging to the user. In addition to data transfer, interconnectivity could allow the mobile handset to remotely control various consumer electronic devices as well as act as a communication module for a range of devices.

Device interconnectivity and interworking also have positive implications for wearable devices. Developments in this area include cameras mounted in sunglasses or other pieces of clothing which enable the user to instantly capture moments of everyday life with comfort and convenience. Such a concept could take mobile blogging to a new dimension. On the other hand, concerns on privacy and inappropriate usage could build on the current backlash against mobile terminals.

4.2 Context-adaptive UI

The need to support mobile services anywhere and anytime places heavy constraints on the interface and is a major influencing factor in future UI design. As a result, there may be a shift towards flexible interfaces that adapt content, services and the interaction method to the context in which they are going to be used. The adaptation is based on the user situation characterized by information elements, such as location, environment and activity, that could be captured through sensors integrated in the device.

Context-adaptive UIs will also need to support the dynamic transfer of a particular task between interconnected devices in a seamless manner. The idea is to enable the user to continue with an activity while being able to move freely between different environments populated by different devices that support different and perhaps more appropriate interaction methods. Such a concept would need to rely on different sensor capabilities in the mobile device as well as ambient sensors and machine-to-machine dialogue.

5. CONCLUSIONS

The mobile UI plays a key role in the user experience. This paper has highlighted various factors that influence UI design and has touched on various emerging technologies that could set the future direction for the evolution of the UI.

Studies on text entry technologies have shown that this area is subject to significant research. Users with differing text habits and backgrounds have different requirements for text entry methods and there is no one technology that meets all the user requirements. In the short term, the display is likely to become the dominant UI component in the terminal form factor, incorporating more of the functionality of the conventional keypad through the use of touch. The trend towards natural human-terminal interaction to supplement existing modes of input and output is expected to initially focus on speech interfaces, gesture input and tactile feedback. Despite improvements in the state-of-the-art solutions and their suitability for specific environments, speech and gesture input provide an indiscrete way of interacting with the device and may struggle to gain user acceptance.

As the mobile handset becomes increasingly ubiquitous, context awareness is expected to play a significant role in UI adaptation as well as in the interconnectivity and interworking with other devices for rich media transfer and task migration aimed at exploiting richer input/output channels and delivering an enhanced user experience.

6. ACKNOWLEDGMENTS

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