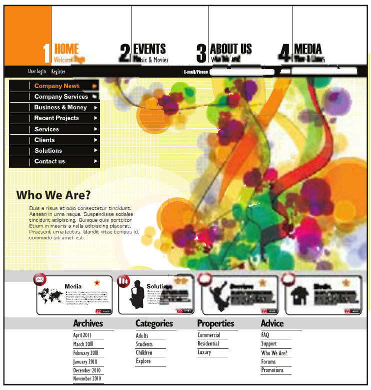

Chapter 19

Mobile computing

Contents

Aims

Mobile computing is probably the largest area of growth for designing interactive systems. Mobile computing covers all manner of devices, from mobile phones, to small laptop computers, tablets, e-book readers and tangible and wearable computing. Many of the design principles that we have presented remain true for mobile computing, but the huge variety of different devices that have different controls and different facilities make designing for mobiles a massive challenge.

Mobiles are an essential part of ubiquitous computing, discussed in Chapter 18. There, the emphasis was on integrating mobile technologies with background systems. In this chapter we look at the life cycle of designing for mobiles and at the issues that this particular application of human-centred interaction design raises.

After studying this chapter you should be able to:

- Understand issues of context-aware computing
- Understand the difficulties of undertaking research of mobile applications and specifying the requirements for mobile systems
- Design for mobile applications
- Evaluate mobile systems, applications and services.

19.1 Introduction

Mobile computing devices include the whole range of devices – from laptops to hand-held devices – mobile phones, tablets and computational devices that are worn or carried. A key design constraint with mobile technology is the limited screen space, or no screen at all. Other significant technological features include the battery life and there may be limitations on storage, memory and communication ability. Many of the screens on mobiles are not 'bit-mapped', so GUIs that rely on the direct manipulation of images on the screen cannot be used. All sorts of people will be using the device and, of course, it will be used in all manner of physical and social contexts. This is significant as it means that designers often cannot design for specific people or contexts of use. On the other hand, mobiles offer a whole range of novel forms of interaction, by employing different screen technologies and more sensors than are found on traditional computers.

Because of the small screen it is very difficult to achieve the design principle of visibility. Functions have to be tucked away and accessed by multiple levels of menu, leading to difficulties of navigation. Another feature is that there is not room for many buttons, so each button has to do a lot of work. This results in the need for different 'modes' and this makes it difficult to have clear control over the functions. Visual feedback is often poor and people have to stare into the device to see what is happening. Thus other modalities such as sound and touch are often used to supplement the visual.

There is no consistency in the interfaces across mobiles – even to the point of pressing the right-hand or left-hand button to answer a call on a mobile phone. There are strong brands in the mobile market where consistent look and feel is employed – e.g. Nokia has a style, Apple has a style, etc. Style is very important and many mobile devices concentrate on the overall experience of the physical interaction (e.g. the size and weight of the device). The new generation of smartphones from manufacturers such as Apple, Nokia, Google and BlackBerry have provided better graphical interfaces, with the many devices now including a multitouch display. Netbooks provide more screen space, but lose some of the inherent mobility of phone-sized devices. Other devices use a stylus to point at menu items and on-screen icons.

Many mobile devices have various sensors embedded in them that can be used to provide novel forms of interaction. Many devices include an accelerometer, compass and gyroscope to sense location and orientation and designers can make use of these to provide useful and novel interactive features. For example the iPhone turns the screen off when you bring the phone to your ear. Other devices make use of tilting when playing racing games (Figure 19.1).

(a) (b) (c)

Figure 19.1 Some mobile devices: (a) Samsung Galaxy Note II; (b) Motorola Droid 4; (c) Lenovo IdeaPad Yoga

(Source: (a) David Becker/Getty Images; (b) David Becker/Getty Images; (c) David Paul Morris/Bloomberg/Getty Images)

The iPhone also introduced the first touchscreen in 2007 and this allowed them to dispense with a traditional keyboard. The touchscreen provides a pop-up keyboard. While some people love this, others do not, and BlackBerry and Nokia continue to use physical keyboards.

Many mobiles have a Global Positioning System (GPS) that can be used to provide location-specific functions. This allows the device to provide details of useful things nearby, to provide navigation and to automatically record the position of photos, or where messages have been left. And of course many mobiles include cameras, audio players and other functions.

Different devices have different forms of connectivity, such as Bluetooth, Wi-Fi, GPRS and 3G. While these provide various degrees of speed, access and security issues, they also gobble up the battery.

There are also issues concerning the cost of mobile devices and there are a bewildering array of calling plans, add-ons and other features that some people will have and others will not. All this variety makes designing for mobiles a big challenge.

Figure 19.2 Amazon Kindle e-book reader

(Source: James Looker/Future Publishing/Getty Images)

Besides general-purpose mobile devices there are many application-specific devices. E-book readers (Figure 19.2) are mobile devices with a number of hardware and software features optimized to reading e-books. These include different screen technologies that make reading much easier, page-turning functions and the ability to annotate the text by writing with a stylus. There are also applications in laboratories, medical settings and industrial applications.

19.2 Context awareness

Mobiles are inherently personal technologies that have moved from simple communication devices to entertainment platforms, to 'information appliances', to general-purpose controllers. It would be impossible to give a comprehensive description of mobile applications as there are so many, ranging from the quite mundane such as note taking, to-do lists, city guides and so on to the novel applications that are being made available day by day. What is more interesting is to look at the new forms of interaction that mobiles offer and at applications where there is a need for mobile devices.

i-Mode

BOX 19.1

i-Mode is a multimedia mobile service first established in Japan through the NTT DoCoMo company in the late 1990s. It differs from most mobile services because it was created as an all-in-one package. NTT DoCoMo coordinated the platform vendors, the mobile handset manufacturers and the content providers through a simple business model to provide a bundle of always-on on-line services. Ease of use is a critical component of i-Mode, along with affordability, and this has proved enormously popular in Japan, in particular, where there are over 50 million subscribers. The content is controlled by DoCoMo, with news from CNN, financial information from Bloomberg, maps from iMapFan, ticket reservations and music from MTV, sports and other entertainment from Disney, telephone directory service, restaurant guides and transactions including book sales, ticket reservations and money transfer. Whether the model transfers to other societies is not yet known, but O_2 have just started offering an i-Mode service in Ireland and the UK.

Mobiles offer the opportunity for interaction to be tailored to the context in which it takes place. Context-aware computing automates some aspects of an application and thus introduces new opportunities for interaction. Context-aware computing is concerned with knowing about the physical environment, the person or persons using the device, the state of the computational environment, the activities being undertaken and the history of the human–computer–environment interaction (Lieberman and Selker, 2000). For example, a spoken command of 'open' could have different effects if the person saying it was staring at a nearby window, if that window was locked or not or if the person had just been informed that a new e-mail had arrived.

If the environment is computationally enabled (see Chapter 18), for example with RFID tags or wireless communications, then the state of the computational environment may deliver information about the physical environment (e.g. what type of shop you are near). If the local environment is not so enabled then the mobile device can take advantage of GPS location. Picture recognition can be used to identify landmark buildings, and sounds can be used to infer context, as can video.

In an excellent case study, Bellotti *et al*. (2008) describe the development of a context-aware mobile application for Japanese teenagers. The aim was to replace traditional city guides with a smart service delivered over a mobile device. Their device, called *Magitti,* knew about the current location, the time and the weather. It also recorded patterns of activity and classified items in the database with tags associated to generic activities (eating, shopping, seeing, doing or reading).

Botfighters 2 is a mobile phone game that uses the player's location in the real world to control their location in a virtual one, and allows them to engage in combat with others nearby (It's Alive, 2004). Botfighters 2 is played on a city-wide scale and uses the mobile phone network to determine proximity to other players (rather than having detection capabilities in the player's device). Figure 19.3(a) shows the interface to Botfighters 2 running on a mobile phone, with the player's character in the centre and nearby opponents to the left and right. Figure 19.3(b) shows a player of the game *Can you see me now*?.

Players of Botfighters were required to wander the city waiting to be alerted to another player's proximity. Several examples of ubicomp games where accurate location was important were produced by Blast Theory (2007) – a group of artists who work with interactive media. A main feature of these games is collaboration between

(a) Java Interface to Botfighters

(b) Chasing players in *Can you see me now*?

Figure 19.3 Mobile and context-aware games individuals moving through a real city, and individuals navigating through a corresponding virtual city via PCs.

In another example of context-aware mobile computing, Holmquist *et al*. (2004) report on a mobile interface used in their A-Life application, designed as an aid to avalanche rescue workers. Skiers are fitted with a number of sensors monitoring such things as light and oxygen levels, and in the event of an avalanche these readings are used to determine the order in which to help those trapped. The interface shown in Figure 19.4 shows the priority of all skiers within range, and allows access to their specific sensor readings.

There are many examples of context awareness in digital tourism where a mobile device is used to display information about a tourist site, or to provide a guide to the site. Here specific locations can be geo-tagged to indicate to people (through their mobile phone, or other device) that there is some digital content that can be accessed at that location; e.g. the phone may start vibrating when the user is at a certain location. Video or textual information about the location can then be provided.

Wireless sensor networks are another example of where a mobile device is wholly necessary for context-aware applications. When a person is in a WSN they have to be able to detect the devices that are there and the functionality that they have. It is the interaction of people, the computational environment, the physical environment, the history of the interaction and the activities people are engaged in that provides context.

Figure 19.4 PDA interface for A-Life system

(Source: Holmquist *et al.* (2004) Building intelligent environments with Smart-Its, *IEEE Computer Graphics and Applications*, January/February 2004, © 2004 IEEE (Photographer: Florian Michahelles))

19.3 Understanding in mobile computing

Recall that one of the processes in developing interactive systems is 'understanding'. This concerns undertaking research and developing requirements for the system or service to be produced. Undertaking research of people using mobiles and establishing requirements for new mobile applications and devices is the first part of the mobile design challenge. As discussed in Chapter 3, the main techniques for designers are to understand who they are designing for (where the development of personas is particularly useful), and the activities that are to be supported (where scenarios are particularly useful). There is a need to understand current usage and to envision future interactions. The methods adopted must be suitable for the technologies and contexts of use; some of these may be situated in the actual or a future context, other techniques may be non-situated, for example having a brainstorming session in a meeting room.

In the context of mobile computing, observing what people are actually doing can be quite difficult as the device has a small screen that typically cannot be directly observed and the device provides a personal interaction. However, observing wider contextual issues and behaviours is more easily accomplished. For example, one researcher observed teenagers' use of their phones in shopping malls, on buses and in cafés. The aim of this study was to find out what teenagers did with mobile phones. It was not directly concerned with understanding usability issues or for gathering requirements for some new application. Here the teenagers being observed were unaware they were part of a study and so this raises a number of ethical issues. In other situations, people such as travelling sales staff may be explicitly shadowed by a designer. Some of the naturalness of the setting is lost, but the designer can observe in much more detail.

Of course, different methods will be useful for understanding different things. Jones and Marsden (2006) draw on work by Marcus and Chen (2002) to suggest five different 'spaces' of mobile applications:

- Information services such as weather or travel
- Self-enhancement applications such as memory aids or health monitoring
- The relationships space for maintaining social contacts and social networking
- The entertainment space, including games and personalization functions such as ringtones
- M-commerce (mobile commerce) where the emphasis is on commercial transactions.

BOX 19.2

Interacting with a parking meter

The parking meters in Edinburgh and other cities allow people to interact through a mobile phone. After registration of a credit card number, people phone a central number and enter the parking meter number. This enables the parking meter for use, with the cost being debited to the credit card number. Ten minutes before the paid-for time is about to run out, the system sends a text message to the phone, alerting the person that their time is about to expire and so hopefully avoiding a parking fine.

Another method for investigating issues in mobile computing is to get people to keep a diary of their use. Clearly, much use of mobile technologies takes place in quite private settings when the presence of an observer could be embarrassing (e.g. in bed). However, diary studies are notoriously difficult to do well. Participants need to be well motivated if they are to record their activities correctly, it is difficult to validate the diaries and participants may make fictitious entries. However, it can be a suitable way to collect data about current usage. One researcher used diaries in this way, but placed people in pairs in order to help the validation. While the results were informative, there were some notable problems. For example, person X sent a text message to person Y at 2 am, but person Y does not record receiving a message.

Of course, diaries can be cross-referenced to the phone's own record of texts sent and received, but ethics and privacy then become an issue. If these issues can be overcome, then capturing data from the mobile device itself is an excellent way to investigate current usage. There is ample data on number of calls, types of calls, duration, location and so on. What is missed from such data, however, is context. Where the person was, what they were doing and what they were thinking when they engaged in some activity is lost.

High-level conceptual scenarios can be useful to guide understanding. Typically these are abstracted from gathering stories from the target customers. Mitchell (2005) identified wandering, travelling and visiting as three key usage contexts for mobile phone services. Lee *et al*. (2008) identified capturing, storing, organizing and annotating, browsing, and sending and sharing as conceptual scenarios for a mobile photo application. These scenarios can be used as the basis of a structured data collection tool, focus groups or role-playing studies. Mitchell's mobility mapping technique combined the three contexts with social network analysis of who was communicating with whom and where activities took place.

In the case study by Bellotti *et al*. (2008), they needed to gain an understanding about the leisure activities of teenagers. The aim of the project was to supply new service information in order to recommend particular activities. They conducted six different types of research focusing on the questions:

- How do young Japanese spend their leisure time?
- What resources do they use to support leisure time?
- What needs exist for additional support that might be provided by a new kind of media technology?

They report on their methods as follows. This demonstrates the importance of using a variety of methods so that data can be verified and so that different understanding will be provided through different methods of research and requirements.

> **Interviews and mock-ups (IM):** Twenty semi-structured interviews with 16–33-year-olds and a further 12 interviews with 19–25-year-olds examined routines, leisure activities and resources used to support them. We first asked for accounts of recent outings and then for feedback on *Magitti* concept scenarios and a mock-up.
>
> **Online survey:** We conducted a survey on a market research website to get statistical information on specific issues. We received 699 responses from 19–25-year-olds.
>
> **Focus groups:** We ran three focus groups of 6–10 participants each, concentrating on mobile phone use. In these we presented a walkthrough of the *Magitti* mock-up and its functions to gather detailed feedback on the concept.
>
> **Mobile phone diaries (MPD):** To get a picture of the daily activities of 19–25-year-olds, we conducted two mobile phone diary studies, first with 12 people for one Sunday, and then with 19 participants for a seven-day week.
>
> **Street activity sampling (SAS):** We conducted 367 short interviews with people who appeared to be in our target age range and at leisure in about 30 locations in Tokyo and surrounding areas at different times and days of the week. We asked people to report on three activities from their day, choose one as a *focal activity*, classify it into one of a number of pre-determined types and characterize it in terms of planning, transportation, companionship, information requirements, familiarity with the location, and so on.
>
> **Expert interviews:** We interviewed three experts on the youth market in the publishing industry to learn about youth trends in leisure, and information commonly published to inform and support their activities.
>
> **Informal observation:** Finally, we 'hung out' in popular Tokyo neighborhoods observing young adults at leisure. SAS interviewees reported going out on average 2–3 times a week. Average commutes to leisure took 20 to 30 minutes, but it was not unusual to commute for an hour or more.

Challenge 19.1

You have been asked to develop a mobile device and application for people who go running or jogging. How would you go about the understanding process? What research would you do and how would you do it?

19.4 Designing for mobiles

Most of the major suppliers of mobile devices supply useful guidelines for interface and interaction design, and system development kits (SDKs) to ensure consistent look and feel of applications. Apple, Nokia, Google, BlackBerry and Microsoft compete with one

← Interface guidelines are also discussed in Chapter 12

another to offer the best designs, applications and services. Microsoft, for example, have guidelines for developing applications for pocket PCs, such as:

- Make the text for menu commands as short as possible
- Use an ampersand rather than the word 'and'
- Use dividers to group commands on a menu
- Keep the delete command near the bottom of the menu.

Figure 19.5 Windows mobile 6 professional

(Source: Lancelhoff.com)

Even with these guidelines, anyone who has used a pocket PC application will know that menus can get long and unwieldy. The task flow on mobiles is particularly important as the screen quickly gets cluttered if there are several steps that need to be undertaken to achieve a goal. Other useful general guidelines include 'design for one-handed use' and 'design for thumb use'.

Development environments are a useful aid to developers. For example, Visual Studio from Microsoft is used to develop mobile as well as desktop applications. It provides a pocket PC emulator, so that designers can see what the design will look like on the small screen of a pocket PC (Figure 19.5). The problem with developing applications on a full-sized PC, however, is that it does have a big keyboard, it is not portable, it is high-performance with lots of storage and memory and it uses a mouse for pointing rather than a stylus or one of the various navigation buttons, jog-wheels, thumb scanners and so on. These differences can make the use of pocket PC applications quite different from the simulation, or emulator, on a PC.

Jones and Marsden (2006) discuss the concept of mobile information ecologies. This concerns the contexts within which mobile technologies need to operate. They point out that mobile devices have to fit in with other devices such as desktop computers, televisions and other home entertainment systems. Increasingly they have to fit in with public technologies such as ticket machines, checkouts and other self-service systems. Mobiles need to fit in with display devices such as big screens and data projectors. Mobile devices have to fit in with physical resources and other technologies such as radio-frequency identification (RFID) and near field communications (NFC). They need to work with network availability and different communication standards such as Bluetooth and Wi-Fi. The mobile has to contend with varying spaces of interaction, from sitting in a café to walking briskly through a park. And they have to fit into the multiple contexts of use that computing on the move has to deal with. An iPhone behaves quite differently in the searing heat of the summer in India than it does in the cold of Finland. And try using a Nokia S60 whilst wearing gloves!

Jones and Marsden (2006) also provide a thorough discussion of the issues raised by designing for small screens.

The Magitti case

Returning to the case study from Bellotti *et al.* (2008), the Magitti's Main Screen is shown in Figure 19.6. They describe the design and their design rationale as follows:

> The main screen [Figure 19.6] shows a scrollable list of up to 20 recommended items that match the user's current situation and profile. As the user walks around, the list updates automatically to show items relevant to new locations. Each recommendation

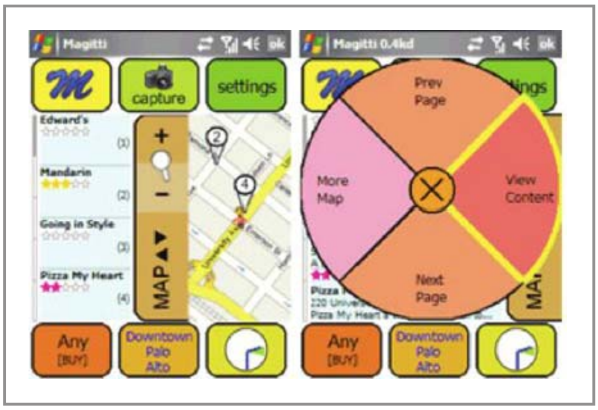

Figure 19.6 Magitti interface design

(Source: Bellotti, V. *et al.* (2008) Activity-based serendipitous recommendations with the Magitti mobile leisure guide, *Proceedings of the Twenty-sixth Annual SIGCHI Conference on Human Factors in Computing Systems*, 5–10 April, Florence, Italy. © 2008 ACM, Inc. Reprinted by permission)

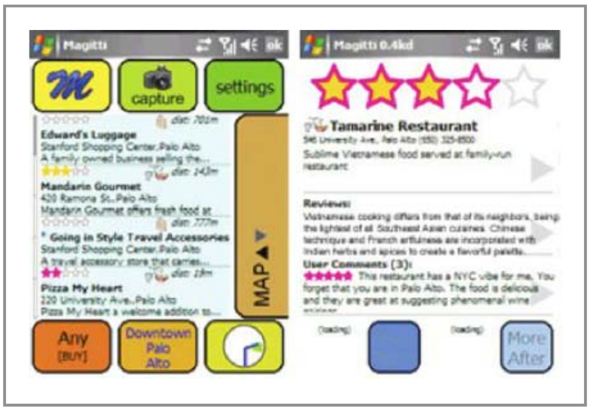

Figure 19.7 Magitti screen

(Source: Bellotti, V. *et al.* (2008) Activity-based serendipitous recommendations with the Magitti mobile leisure guide, *Proceedings of the Twenty-sixth Annual SIGCHI Conference on Human Factors in Computing Systems*, 5–10 April, Florence, Italy. © 2008 ACM, Inc. Reprinted by permission)

is presented in summary form on the Main Screen, but users can tap each one to view its Detail Screen [Figure 19.7, right]. This screen shows the initial texts of a description, a formal review, and user comments, and the user can view the full text of each component on separate screens. The Detail Screen also allows the user to rate the item on a 5-star scale.

To locate recommended items on the Main Screen, users can pull out the Map tab to see a partial map [Figure 19.7, right], which shows the four items currently visible in the list. A second tap slides the map out to full screen. The minimal size and one-handed operation requirements have a clear impact on the UI. As can be seen from Figures 1 and 2 [reproduced here as Figures 19.7 and 19.6], large buttons dominate the screen to enable the user to operate Magitti with a thumb while holding the device in one hand. Our design utilizes marking menus on touch screens to operate the interface, as shown in the right side of [Figure 19.7]. The user taps on an item and holds for 400ms to view the menu; then drags her thumb from the center X and releases over the menu item. As the user learns commands and their gestures, she can simply sweep her thumb in that direction without waiting for the menu to appear. Over time, she learns to operate the device without the menus, although they are available whenever needed.

Challenge 19.2

Find a novel application on your mobile and discuss the design with a colleague. Is it usable? Is it fun to use?

19.5 Evaluation for mobile computing

The evaluation of mobile applications offers its own challenges. One method is to use paper prototypes of designs physically stuck onto the face of a mobile device. Yatani *et al*. (2008) used this technique to evaluate the different design of icons for providing navigation support, as illustrated in Figure 19.8. Bellotti *et al*. (2008) used questionnaires and interviews to evaluate the success of their Magitti system.

Figure 19.8 Paper prototypes of icon designs

(Source: Yatani *et al.* (2008) Escape: a target selection technique using visually-cued gestures. *Proceedings of the Twenty-sixth Annual SIGCHI Conference on Human Factors in Computing Systems, 5–10 April, Florence, Italy.* © 2008 ACM, Inc. Reprinted by permission)

Navigation in a wireless sensor network

← Specknet WSNs are described in Chapter 18

In order to illustrate the use of mobiles within a ubiquitous computing environment such as a wireless sensor network (WSN) and demonstrate an approch to evaluation, we have included work by Matthew Leach, a PhD student at Edinburgh Napier University. This related to work on navigation discussed in Chapter 25 and work on ubicomp environments discussed in Chapter 18.

Matthew Leach evaluated a mobile virtual soundscape that would allow people to gain an overview of data distributed in a simulated 'Specknet' WSN. He was interested in how people could gain an overview of the regions of interest generated in Specknets, in order to prioritize their interaction. Recall that a Specknet is a wireless network of tiny computational devices known as 'specks'. A key feature about moving through Specknets is that the specks cannot be seen and they do not have their own display. Moreover, they do not have any representation of the physical world. The tools required to navigate in such an environment need to support gaining an overview of an environment and the types of object that were in that environment. The person needs to understand the spread of objects in an environment, their significance and the distance and direction they are from the current location.

The scenario chosen for the evaluation was a chemical spillage. Specks would be spread over the area of the spillage and would register whether the chemical was a liquid or a powder. An investigator would use a mobile device to interrogate the Specknet. The variables of distance, direction and significance can be presented in a number of modalities, with a few examples presented in Table 19.1. An individual may be surrounded by data in 360 degrees and three dimensions. Therefore the options presented in Table 19.1 aim to minimize the use of screen space, while providing a 360 degree overview.

The visual option represents a peripheral display where the edge of a screen appears to glow if a region of interest is off to that side, with a bright glow indicating close proximity, and a colour scale used to convey significance. The tactile option imagines a set of vibrotactile motors arranged around the edge of the interaction device where the choice of motor activated could convey direction, the strength of vibration could convey distance, and pulse tempo could convey significance (using the Geiger counter metaphor). The audio is in effect an audible version of the tactile option, but with the option for spatialized sound to convey direction.

Table 19.1 Modalities of gaining an overview

	Visual	Tactile	Audio
Distance	Brightness	Strength	Volume
Direction	Screen edge	Motor activation	3D sound
Significance	Colour	Pulse tempo	Repetition tempo

Not presented in Table 19.1, but of vital importance, is that mixed types of specks may be present in the network. This information would be important in prioritizing regions of interest; for example, in a situation where two types of chemical were spilt, high concentrations of either may be of importance, but also a region where both are present may be of higher importance (if their combination created a more dangerous chemical). Inclusion of this information matches the model of data-flow in Specknets, which identified that representation of data must convey both type and value.

← This model is presented in Section 18.5

Ultimately it was decided to use sound as the method for gaining an overview, because the sense of hearing is our natural omni-directional sense (Hoggan and Brewster, 2007). The choice of audio also allowed a method for conveying the type of speck through the choice of sound. Although it has potential benefits, sonification also has limitations (Hoggan and Brewster, 2007). These were considered to ensure that they do not compromise the intended goal of the tool:

1 *The sense of hearing provides less detail than the sense of sight*. The sounds will only be used as an overview, identifying areas that warrant closer inspection visually, and so only need to convey limited information.
2 *Systems of generating virtual sounds through headphones are primitive compared to real-world sounds*. Previous experiments have established that headphone representations are adequate for localizing sounds and interpreting data although the accuracy of both at the same time is less well established.
3 *Human hearing is well equipped for discerning the azimuth of a source, but poor at determining elevation*. Additional features may be required if the system is to be used in an environment with a range of elevations (e.g. a multi-storey building), but as an initial investigation this study will assume all sources are on a horizontal plane.

Different types of specks will be represented by different sounds. Pitch can then be used to indicate value: higher pitch means higher value. To convey direction it was decided to use the spatial rendering of sounds, but to reinforce it with another dynamic system. The chosen mappings are shown in Table 19.2.

Table 19.2 Sound study final audio encoding choice

Information	Type	Value	Distance	Direction
Encoding	Sound	Pitch	Volume	Sequence and spatialized

The design of the dynamic direction system is shown in Figure 19.9. An arc continuously sweeps around the participant, with a unique (in the audio interface) sounding when the sweep passes directly in front of the direction in which participants are facing. The principal task for participants in an evaluation experiment was to listen to an audio environment, and to then draw a map of the specks distribution (location and type). Each participant performed this task twice, once with an environment containing six objects, and once with an environment containing ten objects.

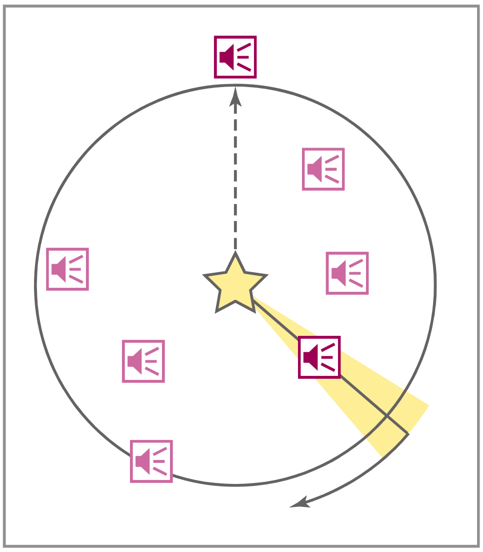

Figure 19.9 Sound study final dynamic system

The evaluation criteria are:

- To what extent did the tool allow people to gain an overview of the data? – To be assessed by asking study participants to produce maps of the data distribution, and determining their accuracy. Comparison between maps will allow trends to be identified, and any failings to be identified.
- Were people able to prioritize information? – To be assessed by tasking study participants with selecting the highest values present in the datasets. The number of actual correct selections will be compared against the probability of doing so by chance.
- Did participants identify any issues in the usability of the tools? – To be assessed through questionnaire, probing users' confidence in use and opinions of features.

Figures 19.10 to 19.13 show an analysis of the distribution maps drawn by participants. The coloured circles represent the location, value (radius) and type (red for powder blue for liquid) for the chemical sounds. The representation uses the same scaling as the training images that participants were exposed to. Lines represent errors between where participants marked sound locations and their actual locations. General trends in the errors were the marking of sound locations counter-clockwise to their true locations, seen most notably in Figure 19.11, and a tendency to place the sounds closer to the centre. Both complex sets included a pair of liquid sounds placed in close proximity. Participants using complex set 1 (Figure 19.12) did not distinguish between these two sounds, only marking one, while those using complex set 2 (Figure 19.13) did identify two separate sounds. When using the complex sets some participants failed to identify low-value sounds at a distance, specifically the bottom-right liquid value.

Discussion

The sweeping arc in effect negated the need for participants to move their head, since it explored the soundscape for them. Participants reported confidence in identifying distance and direction; the confidence for direction was higher than that for distance.

Use of pitch to convey value did not greatly increase confidence in recognizing regions of high and low concentration. Success in selecting high values in the soundscape was also relatively low, being in the order of 37.5 per cent for full success, and 62.5 per cent for partial success (when a graphical aid was not used). The consistency between results suggests that difference in participants may play a larger role than the number of items being sonified. To increase the robustness of the system, the method

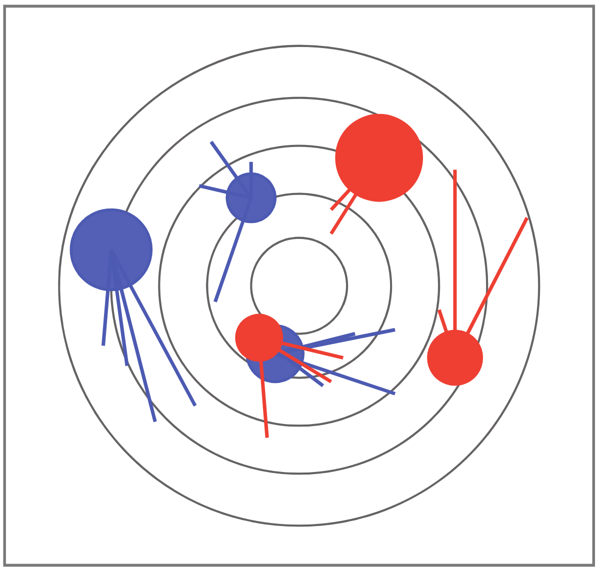

Figure 19.10 Basic set 1 – audio maps

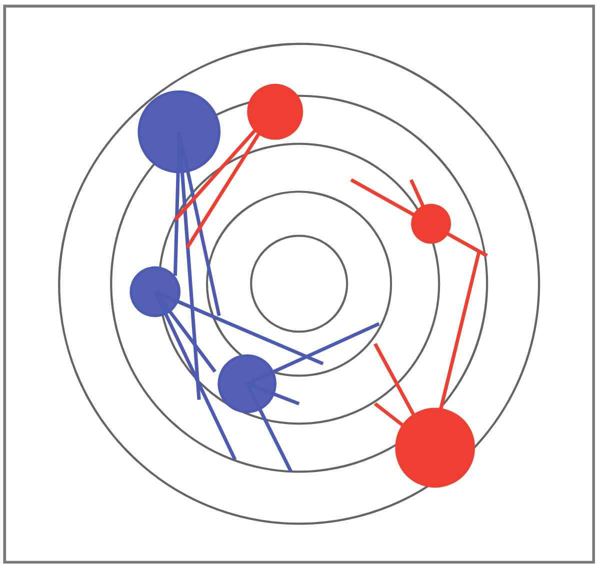

Figure 19.11 Basic set 2 – audio maps

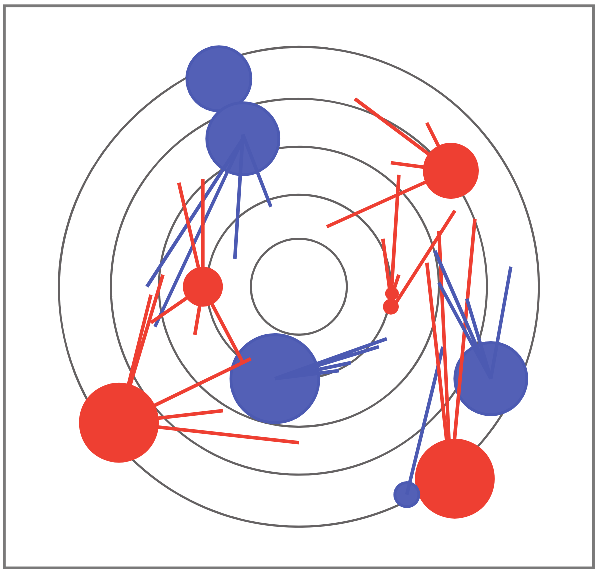

Figure 19.12 Complex set 1 – audio maps

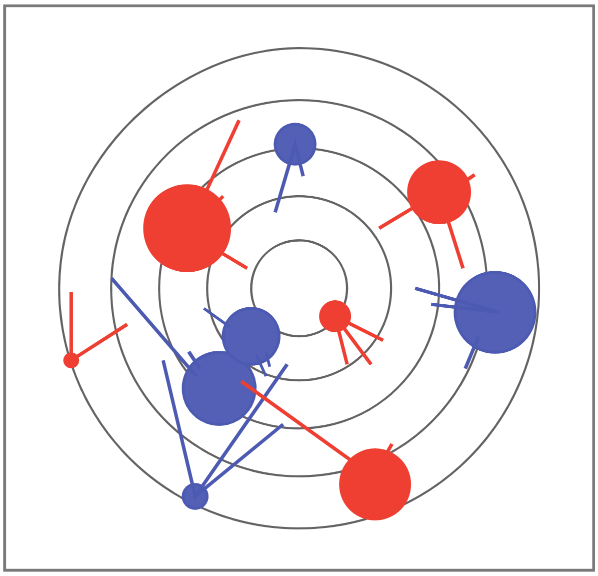

Figure 19.13 Complex set 2 – audio maps

of choosing different pitch values for different levels could be adjusted. For example, since in this case the highest values were important, pitch may be scaled higher at high concentration values, using a logarithmic scale.

The diagrams produced by participants were relatively accurate considering that they had limited exposure to *ideal* maps. As the sound density increases, the potential for interference between them becomes an issue. In the current system, sounds at a distance are particularly vulnerable, with participants failing to differentiate two close-proximity sounds (while other participants could differentiate equivalent sounds when closer to centre – and thus louder), and only 1 in 5 identifying a low-value sound masked by a higher-valued one. However, if the aim is to identify the highest values in a sonification, then a full understanding of distribution may not be required.

Overall the sonification of data demonstrated potential in providing an overview of its distribution, offering an omni-directional representation without visual attention, in environments where people would be surrounded by data and are mobile.

Challenge 19.3

What methods of evaluation would you use if you were asked to evaluate a prototype iPhone app?

Summary and key points

Mobile computing offers particular challenges for designers as the context makes it hard to understand how people use mobiles in the first place and how they might like to use them in the future. Design is constrained by the features of the target device. Evaluation needs to focus on key issues.

Exercises

1 You have been commissioned to develop an application for an outdoor museum that visitors can download onto their mobiles to provide information and guidance as they go around the museum. How would you plan the development of this project?

2 Design an application for students that provides relevant information to them on their mobile device.

Further reading

Jones, M. and Marsden, G. (2006) ***Mobile Interaction Design.*** Wiley, Chichester.

Yatani K. Partridge, K., Bern, H. and Newman, M.W. (2008) Escape: a target selection technique using visually cued gestures. ***CHI'08: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.*** ACM Press, New York, pp. 285–94.

Getting ahead

Bellotti, V. Begole, B., Chi, E.H., Ducheneaut, N., Fang, J., Isaacs, E., ***et al.*** **(2008) Activity-based serendipitous recommendations with the Magitti mobile leisure guide.** ***CHI'08: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.*** ACM Press, New York, pp. 1157–66.

Web links

The accompanying website has links to relevant websites. Go to **www.pearsoned.co.uk/benyon**

Comments on challenges

Challenge 19.1

I would start with a PACT analysis (see Chapter 2) to scope out the design space. You will need to understand all the different technologies that are available from manufacturers such as Nike (look at their website). You probably want to measure speed, distance and location. People might want to meet up with others, so would want mobile communications possibilities and awareness of where others are. You would interview runners, join a running club and survey their members. Prototype ideas and evaluate them. Chapter 7 has many techniques for understanding and requirements generation.

Challenge 19.2

There is no answer for this, but refer back to Chapter 5 on experience design and Chapter 4 on usability for some things you should consider.

Challenge 19.3

Refer to Chapter 10 for general material on evaluation, but also think about the particular issues of evaluation in a mobile environment. You might add some software to the iPhone to record what people are doing with the application. You can try to observe them using it, or interview them directly after they have used the application.