

SPAs (Smart Phone Applications)– a New Form of Assistive Technology

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Abstract

This paper describes how the special built-in features of modern smart phones can be used to open up the potential of these devices for use as assistive technologies in supporting the independence and Quality of Life of vulnerable people. It describes, through a number of relevant examples, how low-cost, downloadable applications enable the camera, the microphone, the accelerometer, the GPS receiver and the touch-screen, to be used for specific assistive purposes. They are capable of providing useful support to a range of vulnerable groups including people with sensory disabilities, diabetics, and people suffering from mental health problems, epilepsy or communication issues. It is likely that m-care services using smart phones will be offered in tandem with home telecare services to extend the independence of service user from the home to the outside environment.

Introduction

Over the past 15 years, mobile phone ownership and use have rocketed in the developed world. A phone has become a constant companion to the majority of people, including increasing numbers of older people. The potential for mobile phones to become key components in the health delivery and education programmes of developing countries is well-established. A number of projects have demonstrated how the most basic of mobile phone functions, namely two-way speech and text messaging, can influence health promotion strategies whilst becoming a low cost method of delivering reminder messages relating to appointments, therapies and medication requirements. The speed with which this medium has been adopted in the Third World may be due to a number of factors including:

- The relative absence of an alternative wired communications infrastructure of the type found in developed countries
- A shortage of physicians which inevitably means that it is usually difficult to find expertise quickly and locally
- The portability of handsets which enable them to be carried by individuals at all times and in all places, and
- The low cost of basic handsets which are often donated by people in developed countries as they upgrade their own handsets.

The term mobile health (or m-health) is emerging both as a discipline in its own right and, more logically for developed countries, as a subset of the tele-technologies that are becoming increasingly important in making health services more effective and efficient in bring healthcare closer to the

home. The benefits are often demonstrated by the potential for removing the need for the customer (i.e. the patient) to travel long distances to the provider (usually a doctor) to be examined in a specialist facility (such as a clinic or a hospital). But the mobile phone is far more than a means of communication; it offers access to information, advice and real-time news relating to health matters and much more. It can provide health professionals with information about clinical practice and about their patients through searches of the literature and electronic health records. Whether or not they should be reclassified as medical devices is becoming an interesting question for both the healthcare and the telecommunications industries.

M-care (or mobile care) has been less well-defined but is no less important to society as it involves multi-faceted support for independence and well-being for people wherever they happen to be. Thus, m-care offers an opportunity of extending telecare services from the confines of the home and into the world at large where the majority of people spend a great deal of time, both at work and for the leisure activities which benefit their Quality of Life. Mobile telephones can become assistive devices through software downloads without having to change their appearances in order to benefit people with a disability of any form. This has the potential to remove the stigma that can be associated with assistive technology by embracing the principles of universal design and allowing disabled people to use identical devices to people who don't have to overcome challenges to their independence.

In order to reduce the temptation to include low level mobile phone applications in this paper, we choose to limit the hardware to the type of mobile device usually referred to as a "smart phone". This will be discussed further below.

Smart Mobile Phones and Applications






The use of mobile devices by new groups including teenagers and college students led to hardware modifications and improvements that would allow improved social interaction and networking. These were achieved through the addition of a camera and improved messaging options. On the other hand, business users sought access to the Internet and a means of receiving and sending e-mails. The Personal Digital Assistant (PDA) emerged to support mobile business applications and attracted its own group of enthusiasts. Many PC office software programs were created or adapted for these devices so that the PDA became a smaller and more portable version of a desk-top computer, but limited by screen size and access to peripherals. Fast and continuous access to the Internet was essential, so the users quickly embraced mobile developments. Meanwhile, the growth in popularity of Internet sites such as Twitter, and a desire for continuous updates on sports matches (including football scores) by non-business users also encouraged an "always-on" approach to messaging for the whole population. Thus, many of the features of the PDAs also became standard on new mobile handsets designed for the general population. PDAs have now evolved into "smart phones" that are characterised by a high level of built-in hardware features including large amounts of memory, high processing power and operating systems that allow both multi-tasking and the downloading of programs.

Table 1: Features of a Modern Smart Phone

| Smart Phone Feature |
|--|
| <i>3 G, Bluetooth and wi-fi communications</i> |
| <i>High quality directional microphone</i> |
| <i>Wide bandwidth speaker</i> |
| <i>Digital voice recorder</i> |
| <i>MP3 player</i> |
| <i>Tri-axial accelerometer</i> |
| <i>GPS antenna and receiver</i> |
| <i>Multi-megapixel camera(s)</i> |
| <i>Electronic temperature chip</i> |
| <i>Magnetic and electric field sensor</i> |
| <i>Large liquid crystal touch-screen display</i> |
| <i>Vibration unit</i> |
| <i>Flash illumination source</i> |
| <i>Real-time clock and timer</i> |

Programs can be run either using the web to provide real-time information and date or, independently in a standalone mode and in locations where communications are not available – an important factor when limitations of coverage are considered (see below). Some of the features of smart phones are shown in Table 1 to which other sensors and technologies (such as near field communications) will also become standard shortly. Sales of smart phones across the world had exceeded 400 million by the second half of 2010 with a near 100% year on year increase, and quickly approaching a point where one in five new mobile phones can be described as “smart” using the definition provided above.

Table 2: The Major Operating Systems in Use in Smart Phones

| Name | Owner | Market Share (mid 2010) | Examples |
|-------------------|--------------------|-------------------------|---|
| 1. Symbian | Nokia | 36.6% |  |
| 2. Android | Google | 25.5% |  |
| 3. iOS | Apple | 16.7% |  |
| 4. Blackberry OS | Research In Motion | 14.8% |  |
| 5. Windows Mobile | Microsoft | 2.8% |  |

Most smart phones use 1 of the 5 popular operating systems listed in Table 2. They can be compared with respect to speed, power use, multi-tasking and access, but all can meet the requirements for advanced m-care. Thus, their uptake in this area may depend on the design aesthetics, size, weight, price and the availability of the relevant applications and hardware platforms that support them. Hopefully, the best apps will be available for all platforms but this may depend on future strategies.

The market leader for handsets remains Nokia with their Symbian operating system. However, they have only recently signalled a serious intent to attack the m-care and m-health markets. Android phones are manufactured by a large number of companies including the South Korean giants, Samsung and LG who manufacture about a quarter of all smart phones at this time. Some of their handsets employ the Microsoft Windows 7 operating system. iPhones (and iPads and similar devices manufactured by Apple) are the only users of the iOS, which is a more bespoke system with its own supporters. The Taiwanese company, HTC, has introduced a number of attractive and powerful smart phones also using a variety of operating systems.

Before 2008, the only applications stores for smart phones were operated by independent organisations such as Handango and Phload. Then the Apple App store opened, followed by an Android store, and, more recently, a Blackberry store, a Symbian Store and a Windows Mobile store. There are now application stores run by handset manufacturers from Samsung and LG through to Motorola and Nokia as well as a group operated by the providers of mobile service such as O2, Orange, Vodafone, and T-Mobile. In the future, when the reliability and limitations of these apps have been validated in appropriate trials, they may be prescribed by GPs or by social workers, or other professionals who have assessed a person's needs and risks to independence. Of course, self-payers (the worried well) may emerge as an additional group who will download this apps especially as the average download price of healthcare related applications remains under US\$10; but this may change as niche markets are found, and as software becomes more user-friendly and reliable.

Overcoming Sensory Deficits

There will soon be nearly 2 million people in the UK with a visual disability, many of whom have cataracts and age-related macular degenerative disease. Many other older people struggle to read small print and to see the outlines of shapes. Good lighting, magnifying glasses and speaking devices can help to compensate for their deficiency. Figure 1 shows screenshots from a smart phone using the digital camera to enlarge labels for easy reading, and to identify the colour of objects by comparison with a standard palette. This can also help the 8% of people who are believed to be colour blind. Other apps can be used for prescribing reading glasses and to identify objects.



Figure 1: Screenshots from *Eye Glasses* and *Retina* Apps

Eyesfree is a navigation aid for blind people and visually impaired people. It uses the smart phone's camera to detect and identify obstacles and the GPS facility to provide location context.

It is estimated that there are 8.7 million people with a hearing impairment in the UK but less than half are prepared to wear an electronic hearing aid at all times. Many have not been properly tested, perhaps as a result of the difficulties in having a test performed. The **Uhear** app is a clever self-administered test that can be used for digital hearing aid prescriptions. However, a separate device may not be needed if the **SoundAMP** app is employed to amplify speech and to make it clearer. It has a 30 second replay button which allows the user to hear again the words that they might initially have missed. Screenshots from these apps are shown in Figure 2.



Figure 2: Screenshots from the *Uhear* and *SoundAMP* Apps

Detecting Accidents and Incidents

It is recognised that exercise and going out of doors has many benefits to the health and well-being of the individual. However, some people worry about going out in case they have a fall or, if they are prone to epileptic seizures, they collapse while they are on their own. One in three people aged over 65 will suffer a fall every year, some of which cause fractures to the hip or wrist, while others, though not injurious, lead to people being on the ground for an extended period of time, unable to get up without help, especially if they are alone when the accident occurs.

Epilepsy is a condition characterised by sudden disturbances in the electrical impulses of the brain, causing the individual to suffer a seizure. About 1 person in every 130 suffers from epilepsy at some stage of their lives; nearly half a million people in the UK are affected though the vast majority manage their condition very successfully using medication. However, a seizure can occur at any time, so a reliable method of detection can provide reassurance and encourage people with epilepsy to live independently and to go out unaccompanied.



Figure 3: The detection of a fall and its location using ifall together with an Epdetect alert

The accelerometer in a smart phone is used in the *ifall* application to both detect a fall followed by an impact and a long lie, and to report the location of the accident using the smart phone's GPS capability. In the same way, the *Epdetect* application monitors the wearer's movements, distinguishing between normal movement and movement associated with a Tonic-clonic seizure. Figure 3 shows how the *ifall* application tracks a fall event and locates the faller, and also shows a screen shot from the *Epdetect* app that allows a person suffering a seizure from cancelling a call the family or to the emergency services.

The GPS location system can also be used to find emergency facilities or to simply contact the relevant emergency services as the numbers used depends on which country the person happens to be in at the time. Figure 4 (left) shows the *Emergency Dial!* App that can provide emergency service dialling information in 130 different countries while *First Aid Corps* (centre) pinpoints the location of the closest automatic external defibrillator giving the user the best chance of helping someone having a heart attack. *Emergency info* (right) gives details of blood group, medical conditions and who to contact in the event of an accident or health incident.



Figure 4: Screenshots of Apps Relating to Emergency Information

Personal Communications

Communication without speech is required either as a result of a neurological condition such as Parkinson's Disease, or as a result of a language disorder such as aphasia, or as a result of a head injury or stroke. People with learning disabilities might also have difficulties in finding or speaking the right word. Sophisticated speech synthesisers can be used but similar functionality can be achieved using apps such as *ProLoQuo2Go*, which allows the user to touch big colourful icons on the smart phone screen to generate spoken sentences. A screenshot is shown on the left of Figure 5.

Stuttering Control is a sophisticated voice monitoring system that evaluates and scores speech behaviour taught during therapy. When clients use the device during in the real world, fluency scores for each utterance are displayed on the screen, enabling the user to build up their confidence and personal technique as shown in Figure 5. When 3G services are available, the smart phone's camera can become the basis of face-to-face teleconsultation opportunities, including low-cost signage applications for deaf people. To overcome bandwidth and power limitations, algorithms that have been downloaded to the smart phone identify hand motions and focus on transmitting those at the expense of the rest of what's on the screen as shown towards the right of Figure 5. For people wanting to learn sign language, *sign 4 me* (shown on the right of Figure 5) gives instructions in 3D.



Figure 5: Overcoming Communication Problems Using Smart Phones

Support for People with Diabetes

Diabetes is one of the most common chronic diseases. Prevalence has risen over the last few decades reaching a prevalence of over 6% in adults with the majority suffering from the Type 2 form which is strongly associated with obesity and lack of physical activity. Intensive lifestyle intervention may be the most effective means of management in order to reduce the risk of cardiovascular disease and other circulatory problems that can lead to future amputations. This involves reducing bodyweight, improving fitness levels and maintaining glycaemic control and requires adherence to behavioural changes that are difficult to endure over an extended period of time. Support for each of the three components described above may be crucial, and there are many relevant applications now available for smart phones.

Exercise and Calorie Counter (see left of Figure 6) measures the number of steps taken, the speed of walking/running and, from these, the number of calories consumed over a period of time. It also provides a history of exercise enabling an individual to develop their profile and adjust their performance or length of exercising as required by their personal support programme. The Merck program, **Vree for Diabetes**, allows people with type 2 diabetes to track their blood sugar level, their activity level, nutrition intake and medication compliance (as shown in the middle screen of Figure 6). It can also help people with a weight loss programme by offering lessons on advanced nutrition and exercise strategies. Other apps, such as **GoMeals** (shown on the right of Figure 6), are aimed more specifically at nutritional inputs and calories consumed. They can offer a more complete analysis of food and advice on where suitable meals could be obtained.



Figure 6: Screenshots from Apps to Support Diabetics

Mental Health and Well-being

There are many mental health disorders that have an adverse effect on well-being. Depression is one of the long term conditions that can be most devastating with over 3 million people in the UK having suffered symptoms at some stage of their lives. Effects can be compounded in older people by social isolation and loneliness, especially when their close relatives and friends live far away from them. Stress, anxiety, bipolar disorder and Schizophrenia can have a similarly destructive effect on Quality of Life. Treatment options are limited but the role of cognitive behavioural therapy (CBT) is gaining in importance as the evidence for its success emerges. A number of apps can help individuals with a range of interventions from exercise through to mood analysis.

eCBT Mood helps people who are feeling down or depressed to feel better by using CBT both as an adjunct to traditional psychotherapy (involving a therapist and patient), and as a stand-alone intervention to help people address their problems. It aims to help people learn how to first identify and then to challenge the distorted thinking that fuels some forms of depression (recognising that, in some cases, people may be genuinely distressed as a result of their current circumstances rather than due to distorted thinking). By systematically tracking daily and weekly depression severity, it is possible to track progress over time, and also share those results with loved ones or professional caregivers as shown in the screen-shot on the left of Figure 7. The **Depression & Stress Therapists** app is similar and provides multiple depression relief options including relaxation exercises, nurturing activities, physical fitness activities and thought modification. In addition, it logs and tracks efforts as shown in the centre of Figure 7. Similarly, the **Moodifi** app (see right of Figure 7) helps the user to track daily mood and ability to function. It tracks dozens of symptoms in three different clusters: depression, mania, and anxiety, encouraging the user to produce a self-rating in each cluster before writing a diary page to describe how they are feeling at the time.



Figure 7: Screenshots from Mood Improvement and Tracking Apps

Other apps are focused on practical opportunities for improving mood and reducing stress. **Pure Sleep Premium** (see left of Figure 8) and **Lightning Bug** create background sounds to help people relax and to enjoy a higher quality of sleep. They include white noise, and rain and waves soundtracks. The **Live Happy** app helps to cultivate optimism and shake away negative thoughts by engaging in simple activities (see Centre of Figure 8) that have been scientifically proven to improve psychological well-being. The app is fully integrated with FACEBOOK and TWITTER. Inspired by yoga, **Pranayama** (see right of Figure 8) is an app that offers an easy way of improving health and reducing stress. Using music and animated visuals to encourage slower deeper breathing, it can result in the user having more energy, stamina, and focus.



Figure 8: Screenshots of Apps Used to Improve Well-being through Practical Approaches

Limitations of Smart Phone Use

The Smart Phone is a new class of mobile phone which should operate using the best communications technology available. Unfortunately, mobile coverage in the UK remains patchy; whilst 97% of the population can receive a 2G service from at least one operator, this falls to 87% in Scotland where no signal is possible in large areas of the highlands. The situation with 3G services is considerably worse - the UK figure is 76% of the population, but is only 66% in the South West of England, and as low as 40% in Northern Ireland. It follows that many of the applications that require large bandwidth e.g. video, cannot be offered universally across the country.

However, once an app has been downloaded and installed, it will not necessarily require constant communication to operate successfully. Consequently, standalone apps can be employed independently of location and the availability of a mobile signal. Indeed, many more apps require communication only in the event of an emergency, and the alarm message can be sent satisfactorily using the 2G network. Furthermore, many rural communities are developing wi-max services that can be used to give them Internet access without the need for fixed line broadband nor 3G communications.

As more and more apps are employed, often running simultaneously and making use of the smart phone's sensors and radio receivers, they will consume increasing amounts of power from the battery. Good battery management will therefore be essential if the device is to be available and operating over extended periods of time. Whilst wireless charging options, and power scavenging may be possible in the future, in the short term users may need to employ dedicated docking stations and to have them recharged close to their beds overnight, especially if they are to be used for continuous monitoring purposes. In the same way, users will need to become accustomed to keeping their smart phones with them at all times, including when they go out. Waterproof covers and holsters or lanyards may be employed to allow them to be used in the shower, for example, while devices such as the Zomm, which can be used to provide reminders. The Zomm is attached to a keyring whilst keeping in contact with the smart phone using Bluetooth; it offers a range of useful functions including the raising of an alarm if the Zomm is separated from the phone by more than the set distance (which can be set between 5 and 20 metres). The day that the smart phone will be used for opening the front door lock, for paying bills, and for replacing a number of other household gadgets from TV remote controller through to the music centre and message reminder has already arrived. The opportunities within Assistive Technology are enormous.

Conclusions

Smart Phone Applications (SPAs) are capable of transforming a high performance mobile phone into a number of different assistive devices that can improve the lives of millions of people with and without disability. Due to the falling prices of smart phones, and the relatively low cost of downloadable applications, SPAs are capable of make a number of standalone devices either redundant or uncompetitive. By combining several applications into one small portable device, the acceptance and increased use of assistive technologies is likely to quickly increase. Whilst SPAs will be a major source of improvement for people with disabilities generally, groups such as people with learning disabilities who tend to face many of the challenges described above will benefit most. They should therefore be the focus of future service developments, and new service models need to reflect the decreased significance of issues such as installation, maintenance and replacement. Alongside this, there should be increased attention to training, issues of insurance, data integrity, security and back-up in the event of accidental loss or theft. Unless robust procedures are put into place then there will be a potential for abuse.

The role of SPAs to extend telecare/health into the world outside the home will need to be considered by existing telecare/health service providers especially as they take on the challenges of personalisation and an increased use of a retail model for community equipment. The technology has matured quickly and with a greater emphasis on individuals making their own service arrangements for everything from domiciliary care to meals provision, telecare/health service providers must be agile in embracing the opportunities to make technology more popular.

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