Using smart-phones for adding convenience and safety to life in the home and car

Literature Review

Luke Bell
University of Cape Town
lukekingsleybell@gmail.com

ABSTRACT

Through the rapid development of smart-phones in recent years, many users have old devices, equipped with useful technology,s that are no longer in use. This project aims at harnessing the power of these unused devices to improve users' lives, either by making every-day tasks in the home easier, or by improving road safety while driving. Research has been conducted that looks at various ways in which smart-phones, along with other technologies, have been used to improve life in the home and car. This research will then be critically analysed and synthesised in order to assess what areas, if any, have been left open for development of unused Android devices in the areas of car safety or home convenience. Focus will be given to applications of Android devices that have minimal requirements on other technologies, with only the device itslef required for whatever solution is presented to be possible. This research is important to the communit of Android users, or those users with old, unused Android devices, as it gives them an option to use these devices in such a way that, with minimal effort, their lives are improved. Either through a higher level of road safety while driving, or through added convenience in the home.

It has been found that road accident detection is the ideal problem for this project, with solutions that most closely meet its aims. Minimal to no requirements on technology other than an Android device, and maximal impact on users' and society's life as a whole.

1. INTRODUCTION

Many Android devices, after users have upgraded to a newer smart-phones, are left at home, unused. This is a waste of processing power as well as useful sensor hardware. This project aims at harnessing the power of these unused resources in such a way as to improve home care or security, or road safety. The author studies numerous applications of smart-phones in the home and car and how they relate to the project's aim.

This paper summarises research done on how smart-phones, particularly Android smart-phones, have been used to improve home care, automation or security, or road safety. Android was chosen as the target operating system, rather than IOS, because of the availability of lower-end phones, as well as the open-source software packages that are available on the platform.

The author will first look at how Android devices have been used to improve home care and security. Dealing with home *care* , *automation*, and *security*. Following this, applications designed for use within users' cars were looked at. The author will discuss *Traffic monitoring* , *Driving detection* , *Pothole detection* and *Accident detection*.

The main body of this paper, section 2, visits the various ways in which Android devices have been used to improve users' lives. Section 2.1 summarises and compares applications aimed towards life in the home, broken up into subsections *Home care*, *Home automation* and *Home security*. Then section 2.2 breaks down various applications for improving road safety, with subsections *Traffic monitoring*, *Driving detection*, followed by *pothole detection*, and finally *Accident detection*.

ACM ISBN 978-1-4503-2138-9.
DOI: 10.1145/1235

2. ANDROID DEVICES TO IMPROVE USERS' LIVES

Research done was separated into two sections: what applications of Android devices have been developed for the home, and for driving. Through these sections, the author will study and compare various ideas and how they have been carried out. This will helps in best understanding the strengths and weaknesses related to using Android smart-phones for various applications across these respective areas, and hence make it as clear as possible for the project to move in the best direction regarding the aim of using Android devices to improve users' lives.

2.1 Applications for the Home

Smart-phones to improve life at home has been a popular topic in research over the past years, as smart-phone technology has progressed so fast and their systems so regularly updated. These devices are reasonably cheap and easy tools for adding automation to the home.

2.1.1 Home care

There is a growing need for home care with increased strain on hospitals due to ageing populations, as well as lack of access to hospitals in developing countries [11].

Sidén et al. [**?**] suggest the use of Near Field Communication (NFC) tags paired with NFC equipped Android smart-phones in order to record medical information that is then posted to a web server for further interrogation by medical experts if necessary. The technology aims at using general resistive sensors, with require very low or no power to take readings, improving energy efficiency and life span of the sensors. Through NFC, some sensors can be powered through the smart-phone device that connects to the sensor. Sensors available for home care NFC include thermometers, blood detection for bandaged wounds, and urine content in diapers [?]. This technology may prove extremely helpful in the home medical field, lowering strain on hospitals and helping the elderly to take care of themselves where previously they wouldn't be able. But NFC technology Is not found in most smart-phones on the market today, especially in old phones that users are no longer using, so it will be a while before this becomes a viable option for the majority of smart-phone users.

Another group of researchers looked at using Android devices, along with the Android Accessory Development Kit (ADK) for home automation, specifically aimed at elderly people to help them care for themselves [?]. The ADK is an Arduino-like chip with built-in sensors, wireless and USB technology. An Android smart-phone or tablet can be connected through USB or wireless technology to the ADK to provide a user interface for the system of sensors and controls implemented by the ADK. Examples for application of the system include security sensors like smoke detection and surveillance cameras, light control to improve energy efficiency and add convenience to the home, and intercom systems for communication throughout the home [?]. Though this system is relatively inexpensive, and uses an Android device to improve life at home, it requires the external technology of the ADK, which most users do not have. On top of that extra cost, there is a level of difficulty in setting up and maintaining the ADK chip and interconnected system throughout the home.

2.1.2 Home automation

With rapidly developing smart-phone technology, often not being utilised to its full potential, a large space for development in home automation has opened up, where users don't have to spend vasts amounts of money on a home automation system. Instead, using their smart-phones paired with other low cost sensors to provide a working system for their homes.

Android applications paired with Arduino micro-controllers have been implemented in homes to allow users to control various appliances, lighting, heating and power throughout the home [?]. This is all done through an interface on users' phones, which connects to the Arduino through the internet, thus allowing the user to connect to his or her home remotely from anywhere in the world. Voice activation within the app give the user the option to turn things on or off through speech, this is done through the Google Speech Recognition engine. The application is equipped with user authentication, preventing any unauthorised users from controlling some home that isn't theirs.

2.1.3 Home security

As with Home automation, the cost of installing home security systems can be made drastically lower by using smart-phone technology. This makes home security more accessible to those who can't afford large-scale, costly home security systems.

Das et al [?] developed a system called HASec (Home Automation and Security System), which pairs a smart-phone with a server in the cloud to control various devices within the home. The client-server architecture model used removes any computational requirements on the users' smart-phones, which means that the system could easily be extended to lower-end smart-phones and feature phones. Motion sensors, when triggered, cause cameras to record video for a period of time around the triggering event of the motion sensor. The system also includes home automation features such as controlling brightness of lights.

2.2 Applications for road safety

Researchers have looked at various ways in which to integrate smart-phone technology into users' cars in order to improve road safety, add convenience to the process of driving and provide knowledge about traffic situations in users' surrounding areas. Research has also been done on improving technology within cars, or building external infrastructure, to be part of the transportation system with the aim of improving road safety [2, 3, 6, 9]. Getting most cars on the road to have improved technology or building added infrastructure into road and other transportation systems, however, will take considerably longer, and cost considerably more, than developing mobile applications that users can download onto their smart-phones and use immediately in their cars. It is important to note that users should not be using their devices while driving, as this has proven to cause a lack in focus on driving and decreases overall road safety [8]. Thus, applications developed for the project's purposes must run in the background, without the requirement of user input during driving. Distracting audio or visual outputs must be avoided for the same reason.

2.2.1 Traffic monitoring

An Android application, DriveAssist [5] was developed to provide a user interface for data collected from Vehicle-to-X (V2X) services that come built in with many modern cars. This service, comprising of Vehicle-to-vehicle and Vehicle-to-Infrastructure systems, gathers information from all cars connected through the wireless network to provide traffic knowledge to users relevant to their current area. Users are able to – in real time – view incidents on the road that are near them, such as to avoid danger, as well as find alternate routes where and when necessary for arriving at their destinations with less delay [5]. This application is an inefficient solution to the problem faced in the project because it relies on technology outside of the user's smart-phone. The V2X framework is only found in a small proportion of cars that are on the road, only introduced in 2012, and first implemented in 2013.

2.2.2 Driving detection

One way in which smart-phones can aid in improving road safety is to protect users from the smart-phones themselves. Through driving detection, a device can be locked, essentially preventing the driver from using their phone in a way that impairs their driving ability.

Chu et al [4] developed a Driver Detection System (DDS) which uses smart-phone sensors to detect when a user is driving a car. The system is able to, with a success rate of over 80%, recognise when a user is inside a moving vehicle, as well as detect when a user is the actual driver of the vehicle. This is done through the processing of various micro patterns that separate passengers from driver. For example, a driver will regularly move their right foot the manoeuvre the driving pedals. The intended application of the system is to prevent drivers from receiving notifications on their phones while driving, for increased road safety. Another application of the system is driving analytics for insurance companies, who would be able to track their customers driving habits and adjust premiums and such accordingly. Though the DDS system can be implemented in any car, with the only requirement being that the user has a smart-phone, the system does not achieve the projects aim in significantly increasing users' road safety, or make the activity of driving any more convenient for users.

2.2.3 Pothole detection

Mednis et al. [10] explored the concept of using smartphones to automatically detect potholes while driving. They proposed a system in which road authorities would have access to automatically generated statistical data related to damaged areas on the road, allowing the fixing of damaged areas to happen in a more efficient and organised manner. Four different detection algorithms were tested, all using the accelerometer sensor found on most Android devices. A success rate of over 90% was achieved on a test track over multiple runs, showing the effectiveness of the algorithms tested as well as the developed software. This application of Android devices in cars does not require any other technology, making it widely available to all car and smart-phone owners. But this system is a solution for road maintenance, and does not *significantly* improve users' lives while they are driving.

2.2.4 Accident detection

Accident detection can be vital with regard to preventing as much harm as possible to those involved in accidents. Often, the biggest problem in preventing permanent injuries is the time taken for emergency services to be notified about an accident, fetch whoever was injured and deliver them to the nearest hospital. Through accident detection systems, this time can be reduced considerably, which could result in far less permanent injuries and deaths on the road. Another application for accident detection is for insurance purposes. Being able to track where and when customers were involved in road accidents will be very useful to insurance companies.

Lahn et al [7] used Android smart-phones and their sensors to detect car crashes using a software application that makes use of a pipeline architecture to filter and combine sensor data in order to recognise crashes. Their application was very good at recognising crashes, with 100% of test data crashes recognised. But they had a problem with false negatives, where the application would detect a crash where there hadn't been one. This solution to car crash detection is very relevant to the project and will be closely studied with the intention of improving on their application and algorithm.

WreckWatch is an Android application developed in 2011 by White et al [13] which proved to be very successful in the detection of car accidents. It was developed as a means of increasing road safety, with the driving idea behind it being that a decrease in emergency services response time to accidents and an increase in the situational awareness related to an accident would decrease road injuries and deaths [12]. The application makes use of a well-tested algorithm, with inputs from multiple sensors on a users smart-phone, which determines if a given circumstance is indeed a car accident or not. When a users phone detects an accident, it automatically sends data related to the accident to emergency services, including geographic location and user medical information, who then are dispatched to the scene of the accident. WreckWatch also allows for bystanders of accidents to report on an incident. Witnesses to an accident can provide additional information to emergency services, or notifying them of the accident in the case where the drivers phone has been destroyed, or the driver doesn't have the application installed on their device. Through information sent to emergency services via victims' and bystanders' devices, a higher situational awareness is given to the emergency services dispatched to the scene of the accident. This higher situational awareness allows for more efficiency in dealing with the problems associated with the accident [1]. The application runs on a client-server architecture model, with user information stored and various computations done on the server, and each user's smart-phone device acting as a client, sending requests to the server. This solution to accident detection is ow cost to users, who only need a smart-phone to take full advantage of the application's features.

Zaldivar et al [14] developed a similar system to WreckWatch, the key difference being that instead of relying on Android sensors to detect accidents, an On Board Diagnostics II (OBD II) interface is used, a system built into the vehicle with various sensors to detect faults and accidents. The OBD interface then communicates through wireless technology with a user's smart-phone that then alerts emergency services of an accident. Although ODB technology has been required in all cars manufactured since 2001, it is not found in older cars, making this solution not applicable to as wide an audience as that which WreckWatch is applicable to, with the ony requirement being that a user has a smart-phone.

3. CRITICAL ANALYSIS

In this section, the various applications of smart-phones in the hoe and car previously visited, will be revisited in order to compare them with each other, as well as way up their strengths and weakness with respect to this project's aim.

Home care solutions [**?**, **?**], although dealing with a very important problem, with far too few solutions currently available, require a significant amount of technology other than users' smart-phones in order to perform their tasks and fulfil their purposes. Solutions looked at by the author required either Near Field Communication (NFC) technology, which is not available on most smart-phones on the market today, or an Android Accessory Development Kit (ADK).

Solutions for *Home automation* [**?**] were of valuable use to users, making every day tasks within the home far easier, and generally improving users' living convenience. But micro-controllers connected to various devices or areas throughout the home were required for an android application to control whatever components of the home the user wanted to control.

The solution developed by Das et al [**?**] to handle home security proved very effective and could be used on both high and low-end devices with the same level of effectiveness. However, the system relied on some kind of CCTV or other camera or sensor system with the user's device acting merely as a controller for the system.

Although solutions for the home show to have high and valuable impact on users' lives, they all require technology other than users' smart-phones in order to perform the various services they are designed to perform. Even though the proposed solutions were, in general, far cheaper than traditional, existing solutions that are available in the market, they do not meet this projects aim of proposing a solution with only a smart-phone as a user requirement.

In general, solutions to road safety problems held less requirements than those related to the home.

DriveAssist [5], an application developed for *Traffic detection* incorporated Vehicle-to-X (V2X) technology to gather information from a network of users to deduce traffic situations in specific geographic areas. This solution dealt with a problem that has been dealt with many times before. Traffic detection and analysis is an area where users have the option of using multiple products, both free and paid for, that all work efficiently and accurately in delivering the user valuable, relevant traffic information related to their current location. This solution also relies on extra outside technology, making it an non-viable solution to a problem with enough attention already.

The Driving Detection System (DDS) developed by Chu et al [4] prevents users from access certain smart-phone features while driving, moving their attention towards the roads and away from their phones while driving. The solution, although theoretically very useful and impactful, proved to have slight accuracy problems. Differentiating between passengers and the driver in the car was a problem faced, but various algorithms were employed to aid in this differentiation. Other than the accuracy difficulties, the application fulfils the aim of this project and can be improved upon to further meet those aims.

The solution to *Pothole detection* proposed by Mednis et al [10] was simplistic in its aim.It efficiently and accurately performed the desired function and didn't require anything other than a smart-phone in order to be used. This problem, however, is not in any way major in most users' lives, and hence the solution doesn't make a noteworthy improvement to users' lives.

Accident detection proved to be the most interesting problem area with regard to this project's aim. The problem is a significant one for society in general, with road accidents being one of the leading causes of death in countries across the world. Solutions found by the author dealt with with problem in a variety of different ways [7, 13, 14]. Among these solutions were applications that were efficient in detecting accidents and sending accident information to the relevant places, as well as holding only the requirement of a smart-phone.

4. CONCLUSIONS

The author has visited numerous fields inside which users' lives can be improved through Android devices and applications. Weighing up the various strengths and weaknesses of each field and application with regards to the projects aim.

Through the critical analysis detailed above, it has been concluded that the *Accident detection problem* will be this projects main focus, with application solutions that significantly improve road safety, and hence users' lives, as well as requiring only smart-phones. The project will move forward with this problem, and look to improve upon those solutions discussed above. Specifically, with the aim of improving the accuracy at which accidents can be detected.

5. REFERENCES

[1] A. Blandford and B. W. Wong. Situation awareness in emergency medical dispatch. *International journal of human-computer studies*, 61(4):421–452, 2004.

[2] L. Bouraoui, S. Petti, A. Laouiti, T. Fraichard, and M. Parent. Cybercar cooperation for safe intersections. In *Intelligent Transportation Systems Conference, 2006. ITSC'06. IEEE*, pages 456–461. IEEE, 2006.

[3] M. Celidonio, D. Di Zenobio, E. Fionda, G. G. Panea, S. Grazzini, B. Niemann, L. Pulcini, S. Scalise, E. Sergio, and S. Titomanlio. Safetrip: a bi-directional communication system operating in s-band for road safety and incident prevention. In *Vehicular Technology Conference (VTC Spring), 2012 IEEE 75th*, pages 1–6. IEEE, 2012.

[4] H. Chu, V. Raman, J. Shen, A. Kansal, V. Bahl, and R. R. Choudhury. I am a smartphone and i know my user is driving. In *Communication Systems and Networks (COMSNETS), 2014 Sixth International Conference on*, pages 1–8. IEEE, 2014.

[5] S. Diewald, A. Möller, L. Roalter, and M. Kranz. Driveassist-a v2x-based driver assistance system for android. In *Mensch & Computer Workshopband*, pages 373–380, 2012.

[6] S. Kamijo, Y. Matsushita, K. Ikeuchi, and M. Sakauchi. Traffic monitoring and accident detection at intersections. *Intelligent Transportation Systems, IEEE Transactions on*, 1(2):108–118, 2000.

[7] J. Lahn, H. Peter, and P. Braun. Car crash detection on smartphones. In *Proceedings of the 2nd international Workshop on Sensor-based Activity Recognition and Interaction*, page 12. ACM, 2015.

[8] D. Lamble, T. Kauranen, M. Laakso, and H. Summala. Cognitive load and detection thresholds in car following situations: safety implications for using mobile (cellular) telephones while driving. *Accident Analysis & Prevention*, 31(6):617–623, 1999.

[9] F. J. Martinez, C.-K. Toh, J.-C. Cano, C. T. Calafate, and P. Manzoni. Emergency services in future intelligent transportation systems based on vehicular communication networks. *Intelligent Transportation Systems Magazine, IEEE*, 2(2):6–20, 2010.

[10] A. Mednis, G. Strazdins, R. Zviedris, G. Kanonirs, and L. Selavo. Real time pothole detection using android smartphones with accelerometers. In *Distributed Computing in Sensor Systems and Workshops (DCOSS), 2011 International Conference on*, pages 1–6. IEEE, 2011.

[11] C. Sepúlveda, A. Marlin, T. Yoshida, and A. Ullrich. Palliative care: the world health organization's global perspective. *Journal of pain and symptom management*, 24(2):91–96, 2002.

[12] C. Thompson, J. White, B. Dougherty, A. Albright, and D. C. Schmidt. Using smartphones and wireless mobile sensor networks to detect car accidents and provide situational awareness to emergency responders. In *ICST Conf., June*, 2010.

[13] J. White, C. Thompson, H. Turner, B. Dougherty, and D. C. Schmidt. Wreckwatch: Automatic traffic accident detection and notification with smartphones. *Mobile Networks and Applications*, 16(3):285–303, 2011.

[14] J. Zaldivar, C. T. Calafate, J. C. Cano, and P. Manzoni. Providing accident detection in vehicular networks through obd-ii devices and android-based smartphones. In *Local Computer Networks (LCN), 2011 IEEE 36th Conference on*, pages 813–819. IEEE, 2011.