Smartphone Robots

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Abstract. In this chapter we aim to introduce the smartphone robots as a viable research and testing platform. As the smartphone gains on the popularity and market share, the creation of the applications that use artificial intelligence for these devices seems much more important. A smartphone robot is an incremental advancement of the smartphone and uses a smartphone for control functions (aka "the brain") and the chassis with actuators and sensors for moving and acting in an environment (aka "the brawl"). Although these robots have somewhat limited abilities, they offer interesting abilities, nonetheless. The easy development of programs working with sensory data (camera, gyro, accelerometers) or with services available (voice recognition service) means that we can focus on creating the smart applications for these robots.

1 Introduction

In recent years, smartphones have been on the rise. Currently, several major markets in developed countries are near the 50% penetration rate. That means that nearly (and in some countries already) 50% of mobile phones fall to the category "smartphone" [1].

The most recent smartphones can be compared in performance to the low to mid-level computers. They also boast a Wi-Fi or WAN (Wide Area Network in the form of 3G or 4G module) access to the network and an impressive array of sensors (accelerometer, gyroscope, magnetometer, camera and others). Smartphones can connect to other devices with the USB connector or the Bluetooth wireless communication, and the Software Development Kits are available for every major platform (Android, iOS, Windows). All these characteristics make the smartphones interesting for the consumer-oriented robotics.

Professor James Kuffner has used the term "cloud-enabled robots" in the interview robots with their heads in the clouds [2]. The core idea is: if we embrace cloud robotics, we can create "lighter, cheaper and smarter" robots. Cloud robotics is a new concept, the one which makes the idea of the remote brain [3] possible. At the core is the idea of offering the software of the robot as a cloud service. We have covered this topic in paper [4].

But if we combine the possibilities of today's smartphones with the services provided by cloud robotics, we can create a cheap, simple but nonetheless smart robot. There are several commercial projects utilizing the smartphone as a controller

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for a wheeled chassis (Romo [5], SmartBot [6] and others) which can provide entertainment to the users. However, this area of robotics is also interesting for research for several reasons:

Robot-human interaction and how a robot can influence the human behaviour (for example when listening to music [7]).

Simulation of network delay when using the cloud services and testing the infrastructure [8].

Multiple robot control and interaction (especially for cloud robotics).Telepresence systems [9].

Using the smartphone controlled robotic platform to automatically map the area using complementary smartphone sensors [10].

Assistant services [11].

In robotics, smartphones can and are used as a brain of the robot. Actuators can be connected with the use of the micro USB, headphone jack or Bluetooth. The robot can have sensors and feed the data back to the smartphone to complement the smartphone sensors. The smartphone connection modules (Wi-Fi or WAN) provide the connection to the Internet, therefore allowing for remote servers or cloud services to provide required functionality.

This chapter is organized as follows: in section two is a brief description of the Android platform; in section 3 two projects incorporating smartphone and the Lego Mindstorm set are described; in section 4 we outline the future plans for use of the smartphone robots for testing the cloud robotics services; in section 5 we summarize this chapter.

2 Android Platform

Android Operating System is an open-source software stack for mobile devices [12]. It is based on the modified Linux kernel. The source code is released under the Apache License. Applications for Android can be written in a customized version of Java (with the addition of Android SDK) or in native C/C++ code (with the used Native Development Kit – NDK) for specific applications. The architecture of the Android OS is shown in Fig. 1.

Most of the Android smartphones are equipped with at least one camera, accelerometer, light sensor, GPS (Global Positioning System) module, Wi-Fi module, WAN module and Bluetooth module. All of these sensors can be accessed with the Android SDK and the data gained can be used in the application.

The applications are most commonly developed in Java programming language. The lifecycle of the application must be implemented by the developer, as the system postpones the GUI (Graphical User Interface) of the application (called activity) when the application is going to the background to conserve battery. If there is a need to have a longer running process, it is possible to run it as a service in the background process.

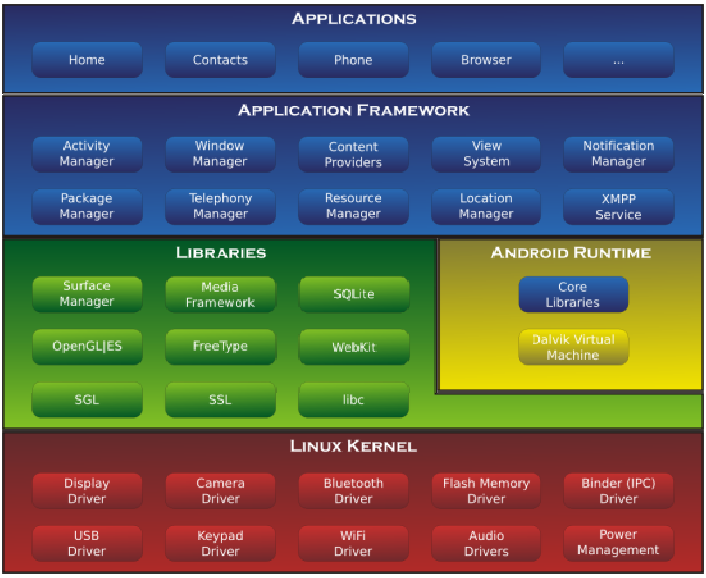

Fig. 1. Android system architecture overview

With the use of Android Application Framework, all developers can have access to the core services. The architecture allows for the easy reuse of components, and, most notably, every application can publish what type of action it can perform. This allows for loosely binding the components together without knowing the exact nature of them. Also, with the use of broadcast receivers, the application can receive and respond the system-wide broadcasts (an example can be the incoming phone call or message) or can respond to specific broadcasts (as a form of communicating between components of the application).

The availability of Software Development Kit, the excessive documentation and training manuals as well as broad and active community of developers backed by the Google Company allow for an easy adoption and learning of the Android applications development. The existence of Google Play Store [13] allows easy distribution of applications and their updates and the monetizing of apps. These features make Android the most used mobile operating system [14]. The problem with Android can be the high number of previous versions still active; therefore, the developers must test the application on these versions. Another problem is the number of different screen sizes and screen densities, so the user interface must be designed for each of them. However, the Android Application Framework offers several tools and methods to mitigate these problems.

3 Smartphone Robot Projects

We have worked on the problem of smartphone robots with two separate projects which will be described in detail in the subsections.

The robot consists of the smartphone and the wheeled chassis built from the Lego Mindstorm set. The robot system is shown in Fig. 2.

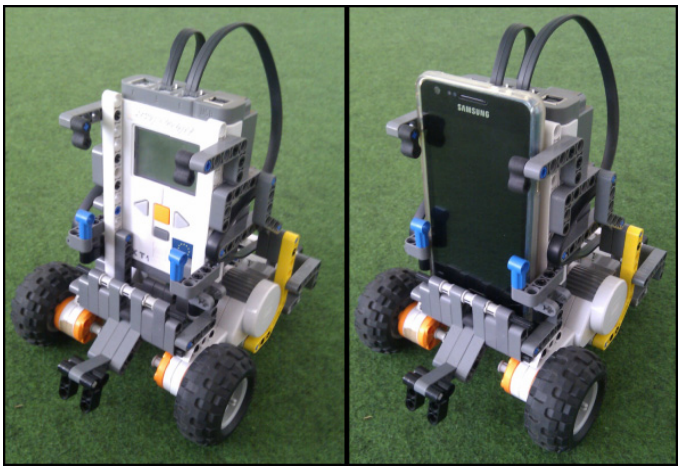

Fig. 2. Chassis built from the Lego Mindstorm set (on the left), complete smartphone robot (on the right)

The robot uses two motors for movement and the differential drive mode (to turn right, the right motor turns backward and the left forward, for the left turn the left motor turns backward and the right forward).

The smartphone controls the Lego NXT brick by sending specific signals via the Bluetooth communication channel. For this, code from the MINDdroid application [15] (available under Apache License) was adapted. Applications create the Bluetooth channel for communication and can send direct instructions for each motor and request the data from sensors. This does not require any sort of interface running on the NXT brick besides the operating system of the brick.

The orientation of smartphone can be reversed in case the smartphone without the front camera is used. Also, the applications can be run on a different chassis if the motors arrangement remains the same. It is possible for the developer of the application to provide the user with the option to specify the arrangement of motors (NXT brick has three output ports for motors).

3.1 Videoconferencing Robot

The task of the videoconferencing robot is to utilize the smartphone and wheeled chassis for communication over the internet. The main goal is to provide an easy setup and affordable system.

Although it is possible to use one of the free alternatives for videoconferencing (Skype, Google Hangouts and others), the possibility of controlling the camera and move with it is a step towards the telepresence applications. Although the use of a

small Lego robotic vehicle is limiting the use of this application, it is a valuable hands-on practice.

The solution is based on the SpyDroid project [16]. It creates a streaming server from the smartphone and allows for accessing the device camera feed from the computer over the Internet. The code needed to control the robot and also the elements on the web interface which allow for controlling the robot movement over the internet were added to the application.

The application provides one-to-one communication and does not support the video streaming from the computer to the robot (due to the lack of support for the technologies used).

More detailed information can be found in [17].

3.2 Voice Controlled Robot

A second application created for the smartphone robot was the voice control. The goal of this application was to utilize existing software tools of the Android framework (Google Speech Recognition) and create an application for the voice control in several languages.

As there is an increasing number of services which provide much needed functionality, the task is to create applications with the use of them and to test their performance.

The application created is a simple control application which was built according to the Android developers guide. It provides the user with the ability to control the Lego robot by voice in several languages (Slovak, English, German, Russian, Spanish and French). The commands were previously specified. The application was tested by several users and also the reaction time was evaluated. The result of speech recognition was trimmed to the first five words and each of them was compared to the specified commands.

The results from the testing show that the use of a cloud based recognition service is viable in the non-critical applications as the robot was able to react in half of a second after the command was spoken. In the noisy environment, the recognition was 50% successful. The success rate of recognition was higher for the native and fluent speakers.

More detailed information can be found in [18].

4 Future Uses of Smartphone Robots

Our main research field is cloud robotics. However, smartphone robots can be very useful as a testing platform. Smartphone itself is a powerful computer with the attached sensors, and we can say it is ready for the cloud. That reduces the time needed to implement the cloud service on the device.

Another important factor is the price of the smartphone compared to the available robotics solutions. This allows for more robotic entities for the same price.

From the research point of view, the smartphone robots can be used as test devices for cloud services, to test the real network delay and the viability of using a cloud service for the robot control.

Besides the testing purposes, we will continue to employ smartphones and smartphone robots for small distinct tasks as human assistants. We will improve the videoconferencing application and allow for smartphone robots to be controlled by voice commands and also increase the level of control with the voice.

Another application will be the use of several smartphone robots as a group towards the common goal.

5 Conclusion

In this chapter, we have provided a brief introduction to the smartphone robots. There are several major operating systems on the market (Android, iOS, Windows), and we have provided an overview of Android OS. Then, we have described two projects we have done with the Android smartphone and the chassis from the Lego Mindstorm set.

The use of smartphone robots can ease the development process for applying the methods of artificial intelligence in real world applications, as many problems are alleviated by the operating system. These range from fast Wi-Fi connection, accurate and easy to obtain sensor and camera data, to the availability of certain services like voice recognition.

Another factor to consider is the affordability of smartphone robots. Not only for research purposes but also for the creation of real world applications. These can be used by general public, as the smartphones are already projected to excess more than 50% of all mobile phones in the developed countries.

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