

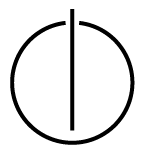
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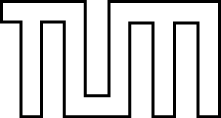
Der Technischen Universität München

Bachelorarbeit in Wirtschaftsinformatik

**Implementation of a Bluetooth touchpad based on Android OS**

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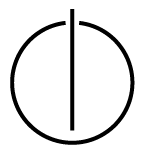
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**Implementierung eines Bluetooth Touchpads**

**auf Basis von Android OS**

**Implementation of a Bluetooth touchpad based on Android OS**

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Ich versichere, dass ich diese Bachelorarbeit selbstständig verfasst und nur die angegebenen Quellen und Hilfsmittel verwendet habe.

München, den 15. Oktober 2011 Nikolay Kostadinov

I assure the single handed composition of this bachelor thesis only supported by declared resources.

München, den 15. Oktober 2011 Nikolay Kostadinov

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Abstract (English)

Smart phones are gaining popularity both in the corporate and the entertainment sectors. They are gradually becoming a universal device, able to complete a variety of different tasks and fit into various use case scenarios. This work concentrates on realizing a single scenario and presents a completely new way of using a mobile phone for remote control of notebooks, computers and other Bluetooth-enabled devices.

The aim of this work was to develop a touchpad by using the Android OS as a platform. The touchpad application running on Android phone is able to connect to other systems over the Bluetooth radio technology. By using a set of standard supported drivers, the application provides an input service for the user that is not less powerful than the capabilities of ordinary input devices such as mouse and keyboard. The project not only fulfils this goal, but also introduces an extensible framework, which is extremely easy to implement by developers willing to unleash the power of the Bluetooth communication in combination with the widely supported drivers for input devices.   
 The open source Android operating system has established its place as the most popular operating system, designed to power smart phones and other mobile devices. Devices running this freely distributed OS are less expensive, than other devices with similar hardware specifics. For its openness, user-friendly concepts and developer-friendly software development tools, it became the platform of choice for this project.

Abstract (Deutsch)

Smartphones werden immer populärer sowohl in der Unternehmens- als auch in der Unterhaltungsbranche. Sie werden allmählich zu einem universellen Gerät, das in der Lage ist, zahlreiche Aufgaben zu erfühlen. Deswegen findet es auch in vielen Anwendungfälle einen Platz. Diese Arbeit konzentriert sich auf die Realisierung von so einen Anwendungfall und präsentiert eine völlig neue Art und Weise, wie die Fernsteuerung von Notebooks, Rechnern und anderen Bluetooth-fähigen Geräten, mit Hilfe eines Mobiltelefons betrieben werden könnte.

Das ursprüngliche Ziel dieser Arbeit war es, ein Touchpad auf Basis von Android OS zu entwickeln. Die Touchpad-Anwendung, die aufs Android-Handy läuft kann sich mit anderen Systeme mit Hilfe der Bluetooth-Technologie verbinden. Durch die Verwendung von einer Reihe von Standard-unterstützten Treiber bietet die Anwendung den Nutzer zahlreiche Eingabemöglichkeiten, die nicht weniger mächtig sind als diese, die von üblichen Geräten wie Maus und Tastatur angeboten sind. Allerdings, erfühlt das Projekt nicht nur dieses Ziel. Es wird ein Framework vorgestellt, welche von den Entwicklern sehr einfach zu implementieren ist. Damit können sie Applikationen entwickeln, die sowohl die Vorteile der Bluetooth-Kommunikation, als auch der breit unterstützten Treiber für Eingabegeräte ausnutzen.

Die Open-Source-Betriebssystem Android hat sich in der letzten Jahren als die meistgenutzte Betriebsystem etabliert, die speziell für mobile Geräte entwickelt ist. Geräte, auf die dieses freies OS läuft, sind meistens billiger als andere Geräte mit vergleichbaren Hardware-Spezifikationen. Android ist offen und bietet benutzerfreundliche Konzepte, sowie entwicklerfreundliche  Software-Entwicklungstools. Deswegen ist Android die natürliche Wahl für diesen Projekt.

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3. Introduction

As Android becomes more and more popular, third-party developers are producing an increasing number of Android applications. The applications are small and useful programs utilizing different combinations of hardware features. Although, most of the mobile devices running Android are supporting Bluetooth communications, very little is done for realizing the vision that a mobile phone could be used as an universal remote control, that could connect to virtually any notebook, computer or other type of device supporting the Bluetooth technology and a standard set of drivers for input services, such as the HID drivers.

The main problem is the missing support for these drivers. The developer would have to dive deep into the lower levels of the operating system’s architecture and write programs interacting directly with the Bluetooth stack as part of the operating system’s core. The input service that would be provided by the application must be described according to the HID protocol. Information on how to do this is also spare. Then the resulting service description has to be inserted in the registry of an existing SDP module, which is responsible for making it publicly available, so the computer could find it and read it. Since the computer and respectively the user are aware of the service, a communication channel over Bluetooth must be established, so the service would be utilized.  Although, Bluetooth communication is generally supported by APIs that are part of the Android framework, developers are not provided with access to the lower level communication protocols, such as L2CAP. However, if communication on the higher levels is possible, there must be a way of accessing the protocols beneath.

The Bluetooth touchpad project is presenting a solution for each of these problems. A service description for a Bluetooth mouse and keyboard is defined and passed to the SDP server of the Android operating system. On the other hand, the resulting application is able of establishing communication by using the required protocols, although this feature is not officially supported. The solutions are packed in an extensible framework, which could be easily implemented by developers and used in other projects. The Bluetooth touchpad app, implemented on top of the framework is abstracting from the mouse and keyboard input specifics and thus provides a number of totally different input capabilities by using the phone’s motion sensors, the phone’s display and even the voice recognition API.

In this work, first the Bluetooth technology and also some specifics of common Bluetooth input devices are presented. The SDP is also explained, since it is playing an important role in the Bluetooth stack. Afterwards, the Android platform and the development phone used in the project are briefly introduced. After building up this foundation of knowledge, the implementation of the framework is reviewed in detail. In the last chapter results of quality tests are provided and the application’s performance is measured.

1. Bluetooth technology

In order to implement a Bluetooth touchpad based on the Android OS, one must first understand what Bluetooth is and how it works. In this chapter, first some common Bluetooth devices are introduced and then the communication technology behind them is reviewed in detail. Understanding both the hardware specifics of the devices and the architectural model behind Bluetooth is crucial in order to implement a new Bluetooth device from scratch.

2.1 Common Bluetooth devices

The task of realizing a Bluetooth touchpad on a mobile phone, running Android OS, could be moreover approached as simulating the behavior of a wireless Bluetooth mouse and keyboard. Subsequently, in order to complete this task, the functionality of both, as well as their physical capabilities and structure must be considered. In the following section the hardware specifics of regular corded mouse and keyboard, as well as a graphics pad device are successively discussed. Then the hardware capabilities of such wireless devices and the underlying Bluetooth technology are further reviewed. Finally, the process of physical connection and identification of Bluetooth devices, as well as some communication security concerns are briefly looked through.

2.1.1 Mouse

The main goal of the modern mouse is to translate the motion of your hand into signals that the computer can use as an input method. A simple, standard featured mouse consists of two buttons (left and right) and a scroll wheel, which could also act as a third button. Furthermore, the mouse motions on a flat surface are translated into the motion of a cursor on the computer’s display.



Figure : Mouse functionality

As shown on the figure 1 above, the mouse functional capabilities could be shortly described as the following three basic user interactions:

1) Pressing left/right button

2) Scrolling the wheel up/down

3) Mouse motion on surface

A mouse consists of several sensors that could handle and translate the user interaction into specifically formatted data, which is then sent to the computer for further processing.

* + 1. Keyboard

The modern computer keyboard originates its design from the mechanical, non-electric typewriters invented in the 19th century. Today, it is used to type text and numbers into computer programs, where the interpretation of key presses is left to the underlying software programs. Keyboards often have different or additional keys depending on the manufacturer or the operating system they are designed for. However, the different keyboard’s keys have similar size and shape. Furthermore, they are placed in a similar pattern, no matter what language is represented. The user interaction consists of pressing a single or a combination of keys at the same time. The keyboard reports all key presses to the operating system by sending them as specifically encoded data.

2.1.3 Graphics pad

A graphics pad, (also called drawing tablet) is modern computer input device that enables the user to hand-draw graphics, similar to the way a person can draw images with a pencil on paper or with fingers and paint on canvas. The ability to detect some or all of the pressure of the stylus and representing them on the computer display is considered to offer a natural way to create computer graphics. Figure 2 below is showing the concept of the device.



Figure : Graphics pad concept

Similarly to the mouse, the pad is able to capture the movement of the stylus or the user’s finger on its surface and translate it into the motion of a cursor. Since the behavior of this device is similar to the behavior of the mouse, the functionality of this device is also included in the Bluetooth touchpad implementation.

2.1.4 Bluetooth devices

Other than a regular mouse or keyboard, a wireless device is not using a cable connection for sending the data, but radio frequency technology. Radio frequency devices consist of two components: transmitter and receiver. The transmitter is placed in the device and is able of sending radio signal that encodes information about the user’s actions. In addition, the receiver is connected to the computer and is respectively accepting, decoding and passing the information to the computer’s operating system. Bluetooth is one of the most popular radio frequency technologies that wireless mice and keyboards use. Bluetooth is shortly described on the main page of its vendor- the Bluetooth Special Interest Group[1] as “short-range communications technology that is simple, secure, and everywhere. You can find it in billions of devices ranging from mobile phones and computers to medical devices and home entertainment products. It is intended to replace the cables connecting devices, while maintaining high levels of security.” (Bluetooth Basics [2]) Indeed, the fact that Bluetooth receivers can accommodate multiple Bluetooth peripherals at the same time is one of the main reasons why the technology has established its status as one of the most popular wireless standards ever.

2.1.5 Bluetooth radio

Almost all of the electronic devices today utilize radio frequencies (RF) to communicate with other devices. In order to avoid conflicts during communication, different devices use different frequencies. One of the benefits of the radio frequency technology is that it does not need a clear line of sight between the transmitter and the receiver. Unlike the infrared based communication technology, used for example in TV remote controls, the wireless signal can pass through barriers such as furniture or walls. What is more, the RF technology provides variety of other advantages for the wireless devices - the RF transmitters and receivers are very inexpensive, tiny and light weight. Furthermore they require low power and can therefore run on batteries.

Bluetooth is one the most widely used RF technologies. It allows a large number of different devices to connect to each other such as: phones, printers, notebooks, tablets etc. Bluetooth devices usually have a range of 5 to 10 meters and operate in the 2.4 GHz range by using RF. One Hertz (Hz) indicates thousand cycles per second or thousand electromagnetic waves per second. Subsequently one Megahertz is one million and one Gigahertz (GHz) is one billion cycles per second. [3]

In order for two Bluetooth devices to establish communication channel and transmit data, they must be “paired”. Pairing indicates the process of determining a common frequency and also a common communication code, resulting in a communication channel. Consequently pairing makes it possible to filter out interference from other RF devices. There are several methods of pairing, depending of the type of device and its manufacturer. If both devices have display, which is the case when pairing an android phone and a Bluetooth capable computer, the “Numeric Comparison” is usually used. A 6-digit numeric code is shown on each display and the user is asked to compare the numbers to ensure they are identical. Once the comparison is successful, one could confirm the pairing and data transfer between both devices may start. If the user has confirmed on both devices and performed the comparison properly, this method provides significant protection from one of the most common attacks - “man in the middle”. [4]

On the other hand, devices with limited input capabilities, such as Bluetooth mice and keyboards either require the user to enter a pin, which is predefined and usually easy to guess (“0000” or “1234”) or they do not require any user interaction at all. Obviously, this type of pairing does not provide protection against “man in the middle” attacks. As a consequence, a Bluetooth touchpad realized on an Android phone provides better protection then an ordinary Bluetooth mouse and keyboard, since it provides possibility for numeric comparison as part of the Android operations system.

In addition, Bluetooth devices use encryption schemes to encrypt data in unreadable format, as well the frequency-hopping method. This method causes the two Bluetooth devices to automatically change frequencies. Frequency-hopping “divides the band into 79 channels (each 1 MHz wide) and changes channels up to 1600 times per second”. (Bluetooth security mechanisms [3]) Every Bluetooth device has a physical clock responsible for this frequency change. Therefore, in order to establish a communication channel the devices needs to synchronize their clock and their frequency hopping pattern, a piconet is created. The concept of frequency hopping pattern is shown on figure 3 below. [3]



Figure : Frequency hopping pattern [3]

A piconet consists of master and between one and seven slaves. The master is responsible for setting the clock time and also the hopping pattern. Slaves, on the other hand, accept the master’s settings. Moreover, a Bluetooth device could be master in only one piconet, but a slave across multiple piconets. Generally, this frequency hopping technology strengthens the security on the Bluetooth protocol, because “any device not belonging to the piconet is unable to participate in communications by sending or listening to the data exchanged because it does not have access to the frequency hopping sequence. “(Bluetooth security mechanisms [3])