LEGO Mindstorms robot controlled by Android smartphone

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Abstract

Smartphones are becoming more common issue and has long not been used exclusively for calling and texting. To this type of mobile devices were added also tablets and notepad and various hybrid of these devices. The most commonly used operating system these devices is Android [1]. Main advantage of Android operating system is that Android is open source system and there are millions of applications placed on Google Market.

One of the new areas in which mobile devices are used is remote control or in function of user interface to various devices. This document shows a possibility of such remote control of mobile robot. This article describes LEGO Mindstorms kit and description of developed application that is able to control robots basic movement, follow line and scan surface.

1. LEGO Mindstorms

LEGO Mindstorms is building kit created by LEGO. Mindstorms is the name that LEGO gives to their range of robotic toys. The LEGO Mindstorms platform uses the basic concepts of LEGO to build mechanical models. Due to the intrinsic features exhibited by the LEGO Mindstorms platform, such as reusability, modularity, flexibility, and cost-effectiveness, the authors argue that the introduction of that platform in some Engineering curricula is useful, for example to improve the learning of several areas of knowledge, such as mobile robotics, computer programming, artificial intelligence, distributed systems and electronics.

Example of LEGO Mindstorms already used in this paper is shown on figure Fig. 1

NXT consists of three main parts the NXT brick, motors and sensors

Main part of the robot is NXT brick, unit that manages sensors and motors. NXT has three output ports labeled A, B and C, three input ports labeled from 1 up to 4. It allows user attach three motors and four sensors. NXT has also USB port that can be used to connect NXT to computer and download programs from computer to NXT, or send data from NXT to computer. This can be done also by using Bluetooth. NXT has also loudspeaker, four buttons (Enter, Back, Right and Left) and display. NXT brick is shown on figure Fig. 2.

LEGO Mindstorms comes with different types of sensors. Color, touch, ultrasonic, light and sound sensors are basic ones, but universality of NTX
allows users to use even more sensors and even using sensors created by users.

2. Android

Android is an open source project developed by the Open Handset Alliance and held by Google Inc. It is often wrongly attributed to the operating system based on Linux kernel alone, but in fact it contains a middleware and a variety of additional applications. For these reasons it is more fair to say that Android is a software stack for mobile devices.

Users can easily download new applications (also called apps) directly from their mobile devices, or by using the Android Market official web site (over 200,000 apps are available there). Both paths provide a very seamless experience and require only a little user interaction. The system takes care of the whole installation process in the background including finding a path for the new application. Users are only asked if they agree on the application’s permissions which basically means a set of actions that the new app will be permitted to perform (like accessing resources or device’s sensors).

When designing a new Android application, one has to take under consideration not only a variety of platform versions but also a target device’s specification. The most important feature is probably the screen resolution. Oppositely to Apple’s iPhone, Android is not limited to a single device and Google does not manufacture its own phones. As it was mentioned beforehand, Android is a software stack and thus it can be installed on practically any device that satisfy a minimal set of requirements and it was meant to support a variety of resolutions or even screen orientations [4].

3. Android application tasks

The main tasks of the developed application are:

- Connect to NXT brick via Bluetooth
- Enable user to control robot movements various ways
- Run line follower program
- Online distance measurement
- Scan surface using ultrasonic sensor

Ways to control robot movements: normal, progressive and via gyroscope.

Normal control – control by pressing a buttons. User controls movement direction only, he doesn’t control movement speed.

Progressive control – user controls robot movement by sliding the arrows. He controls direction and movement speed.

Gyroscope – user controls robot movement via gyroscope sensor when rotating android device. User is able to control robot direction and robot movement speed.

Line follower program enable robot to follow contrast line on floor. Android application just executes a line follower program which is already loaded in NXT brick.

Distance measurement shows real-time distance from nearest object in ultrasonic sensor scope.

Scan surface reads data from ultrasonic sensor and generate graph from scanned side surface.

4. NXT controller

Developed android application’s name is NXT controller. After successfully connecting the NXT brick via Bluetooth user can choose one of the program function. Application menu is shown on figure Fig. 3 Application menu. From the menu is user able to choose one of the NXT controller function.

On figure Fig.4 is shown screen of normal control. User controls just a direction of the robot by pressing finger on the buttons. For the robot movement medium speed is chosen.

On figure Fig.5 is shown screen of progressive control. User controls speed and direction of the robot by sliding finger over the arrows.
On figure Fig.6 is shown screen of gyroscope control. User controls speed and direction of the robot by rotating a device. User has to activate this type of control first. Other vise will robot move immediately even of unintentional rotation when changing control mode.

On figure Fig.7 is shown screen of distance measurement. The range of ultrasonic sensor is approximately 5 - 255 cm where accuracy is ± 3 cm. Distance measure mode shows distance of the nearest object in ultrasonic sensor range. Actual value of the distance is shown on the screen.

On figure Fig.8 is shown screen for surface scan mode. Robot is moving straight and ultrasonic sensor is turned on a side. Actual robot does not have motor for moving ultrasonic sensor so it has to be done manually. On the screen is shown actual measured distance and actual travelled distance. Scan surface progressing until user abort or after 250 cm of travelled distance.

After successful surface scan application saves the scan on the memory card and offers the user to send scanned surface to specified email. Outputs of surface scan process are two jpg pictures: original and adapted graph. Differences of original and adapted graph is shown on figure Fig.9

On the left side of the figure Fig.9 is placed original surface scan graph. Due to measurement errors may occur in the measured data also isolated extremes that are unreal. Adapting process finds these isolated extremes end eliminates them.

**Conclusion**

Today, a smartphone or a tablet might integrate a MEMS microphone, an image sensor, a 3-axis accelerometer, a gyroscope, an atmosphere pressure sensor, a digital compass, an optical proximity sensor, an ambient light sensor, a humidity sensor and touch sensors, GPS antenna, RFID module etc. Mobil devices may support communication via infra port, Bluetooth, Wifi, mobile network, SMS, voice call etc. These properties make mobile devices (smartphones, notepads, tablets etc.) well equipped also for remote control function.

In this article was shown a possibility to control LEGO Mindstorms robot. Versatility of both smartphones and LEGO Mindstorms building kits allows creating almost unlimited number of different functions. By adding other sensors and rebuilding
robot user is limited only by set of available sensors and user's own creativity.

Acknowledgements
The paper has been prepared under support of Slovak grant project KEGA No. 005TUKE-4/2012.

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