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# Improving the Wi-fi Robot's Remote Control System by Adding a Command Storage System

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## Abstract

The industrial robot has many standard or measurable properties that affect the effectiveness of the robot while performing its tasks, among these properties is the ability to repeat the same task more accurately compared to humans in terms of movement with several commands to control the robot's movement remotely and store all movements within the system. Designing a software system to operate and control the Pioneer 3DX mobile robot remotely and repeat the same movements in some applications An error occurs when repeating the restart process in the same session, i.e. before disconnecting and reconnecting to the robot again. So it needs code improvements in the remote control system of the robot using the Wi-Fi mobile phone by adding a command storage and retrieval system By pressing the Replay button, progThread is used to resend all the commands stored in the StrCommands[] array, each of which takes a time period according to the periods stored in the other array TimeCommand[]. The phone is still connected to the robot but the application is in the "off" state.

***key word***: *Index Accelerometer, Android, Robot, Wi-Fi.*

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# تحسين نظام التحكم عن بعد للروبوت باستخدام Wi-Fi عن طريق إضافة نظام تخزين الأوامر

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**الملخص**

يمتلك الروبوت الصناعي العديد من الخصائص القياسية أو القابلة للقياس والتي تؤثر على فعالية الروبوت أثناء أداء مهامه، ومن بين هذه الخصائص القدرة على تكرار نفس المهمة بشكل أكثر دقة مقارنة بالبشر من حيث الحركة مع عدة أوامر للتحكم في حركة الروبوت عن بعد وتخزين جميع الحركات داخل النظام. تصميم نظام برمجي لتشغيل والتحكم في روبوت Pioneer 3DX المتنقل عن بعد ، وتكرار نفس الحركات، وفي بعض التطبيقات يحدث خطأ عند تكرار عملية إعادة التشغيل في نفس الجلسة أي قبل فصل وإعادة الاتصال بالروبوت مرة أخرى، لذا يحتاج الأمر إلى تحسينات في الكود داخل نظام التحكم عن بعد للروبوت باستخدام الهاتف المحمول Wi-Fi وذلك بإضافة نظام تخزين واسترجاع الأوامر بالضغط على زر Replay، يتم استخدام progThread لإعادة إرسال جميع الأوامر المخزنة في المصفوفة StrCommands[]، كل منها يأخذ فترة زمنية وفقًا للفترات المخزنة في المصفوفة الأخرى TimeCommand[]. لا يزال الهاتف متصلًا بالروبوت ولكن التطبيق في حالة "إيقاف التشغيل".

الكلمات المفتاحية: مؤشر التسارع –أندرويد– روبوت– واي فاي.

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## 1- Introduction

The past few decades have witnessed the widespread use of mobile robots and their contribution to increasing productivity in a wide range of fields such as manufacturing, agriculture, military, and education. There is a great interest in developing robot control technology using mobile phones, sensors, touch screens, and Wi-Fi technology to be able to make autonomous decisions and take corrective actions.An application for controlling a spherical robot called Sphero has been developed; it works on iOS and Android. A Bluetooth accelerometer sensor is used accessing the Sphero sensors and controllers, implementing the wall tracking strategy, or detecting corners in a reliable way. [1] Several other similar works include similar features (accelerometer sensor and Wi-Fi technology). The robot is assembled from an RC car, a camera, a control panel, a steering wheel, etc., and is written in Java [2].

A prototype of a flying robot called AR.Drone, produced by Parrot, is presented with a control application that runs on an iPhone and uses Wi-Fi technology to communicate. It uses a dedicated button with the phone's accelerometer to control the AR.Done. [3] In addition to the control approach, exploiting the relationship between the smartphone and the Wi-Fi network, a car that operates based on our voice commands has been proposed in [4]. There is a growing interest in the applications of mobile robots in science, industry, and the military, especially in repetitive, dangerous, or delicate tasks such as monitoring, cleaning, transportation, detection, etc. [5]. This leads to the importance of data storage to query and replay the behavior of robots. In [6,7] the authors explore database techniques to store data from sensors. Without a schema, these tables are stored in Structured Query Language (SQL) databases, e.g., MySQL. [8,9,10].

This paper presents a procedure based on improving the remote control system of a Wi-Fi robot [11] by adding a command storage system and storing and retrieving the robot data, navigating in an environment without the help of routers or central control and is best applied when the environment is static. Using the application and pressing the Replay button, the showDialog(typeBar) method will launch progThread and progThread is used to resend all the commands stored in the StrCommands[] array, each of which takes a period of time according to the periods stored in the TimeCommand[] array.

## 2- Android /Accelerometer controlled Robot, storage, Implementation System

It requires controlling the robot's movement, tracking it in a remote location, and accurately replaying the movements during recording and playback, both spatially (input coordinates) and temporally (event timing). The process of controlling the robot's directional movement is mainly done using the accelerometer sensor on Android smartphones with Wi-Fi as a link. This is done by sending acceleration sensor value changes to the robot via a wireless network. Using a test robot Pioneer P3-DX, the application was implemented at the Center for Innovation and Technology Exploitation (CITE) on the Nottingham Trent University campus, this office area is approximately 16 square meters.

## 2.1-Android/Accelerometer controlled Robot

Robot motion control is developed by controlling the direction of robot movement and storing all movements. This app simply detects accelerometer changes using special sensors built into your Android phone. When any change occurs, the app will send controlled movement commands as wireless signals to the robot using the Wi-Fi calling service that the phone also provides. The app will be written in Java using the Eclipse development environment powered by Android. Table 1 presents the accelerometer values and respective commands. An Orange San Francisco phone is used to run the app, with a 3.2-inch touchscreen with a resolution of 240 x 320 pixels to a massive 3.5-inch AMOLED display with a resolution of 800 x 480 pixels. ] To control the pioneering robot P3-DX: [12] three wheels, a 2.26 GHz dual-core Intel Core CPU, Ethernet and USB ports, built-in audio, 512MB VGA, and other additional hardware.

| x-axis ($m/s^2$) | y-axis ($m/s^2$) | z-axis ($m/s^2$) | Command |
|---|---|---|---|
| **<-4** | - | <-8 | Left |
| **<-4** | - | -6>z>-8 | Left forward1 |
| **<-4** | - | -4>z>-6 | Left forward2 |
| **<-4** | - | 1.5>z>-4 | Left forward3 |
| | | | |
| **>4** | - | 1.5>z>-4 | Right |
| **>4** | - | -4.5>z>-6.5 | Right forward1 |
| **>4** | - | -7>z>-8 | Right forward2 |
| **>4** | - | <-8.9 | Right forward3 |
| | | | |
| **Else** | - | -5.5>z>-7 | Forward1 |
| **Else** | - | -7.5>z>-8.5 | Forward2 |
| **Else** | - | <-9 | Forward3 |
| **Else** | - | 1.5>z>-5 | Stop |
| **Else** | - | >2 | Backward |

Table 1 showing accelerometer values and respective commands

In order to make the connection between the Android phone and the robot over a wireless network, a wireless broadband router will be needed. It is produced by

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CiscoSystems. [13].The router includes a DHCP server that automatically assigns an IP address to any device that will join its network. Figure I present the network used in the project.

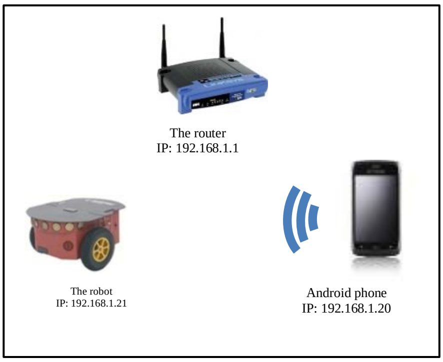


Figure 1: The network used in the project

## 2.2 Storing and Retrieving Robot Movements

It gives the possibility to re-move the robot as in the previous scenario. To recreate a bot's behavior, this requires storing the bot's data and making it difficult for us to query certain behaviors for replay purposes, because the relevant data is in different bag files, which requires writing code and custom logic. This depends on the ability to store a series of events. These events contain the commands and the time it takes for each command to be executed. The storage process takes place before sending the data. There are many ways provided by Android to save app data. There are different solutions depending on the service required. Storage options include: storing data in an internal or external file, an SQLite database, and storing data on a web server. [14]. Robot behaviors are represented and relevant data associated with specific behaviors is stored in an FSM method. It is a very flexible method used to describe the workflow of a task (Schneider 1990), especially to reproduce robot behavior. Figure 2: diagram of implementing robot behavior replay

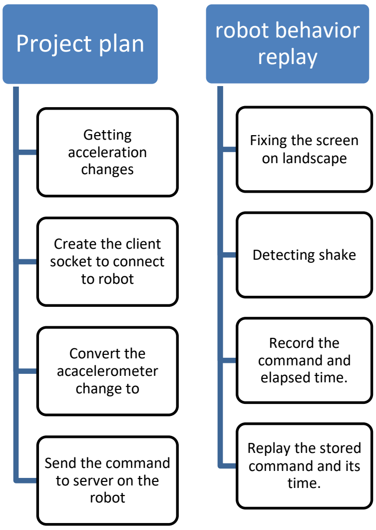


Figure 2: the paper plan

## 2.3. Implementation and Testing

Smart devices provide the feature of automatically changing the screen orientation. It is necessary to fix the screen orientation to one of two positions (portrait or landscape) when you start the application.

The client application requires specifying the direction of rotation of the device to perform control processing. In Android, the Accelerometer class includes a register called SensorEventListener which contains three values to determine the direction of movement of mobile phones in space; These values are shown in Figure 3: [15]. The app can use these values to detect the current orientation of the phone and any immediate changes in orientation.

Vibration can lead to a significant change in the accelerometer value over a specified period. To determine the state of vibration, it is necessary to calculate the difference of changes in the x, y, and z axes between the current time and the previous time, and divide it by the

elapsed time to calculate these changes. In this way, the total speed of changes in the three axes can be found. This total speed is compared to the threshold set for vibration detection. The previous flowchart shows the steps required to create the application described and generally grouped by function:

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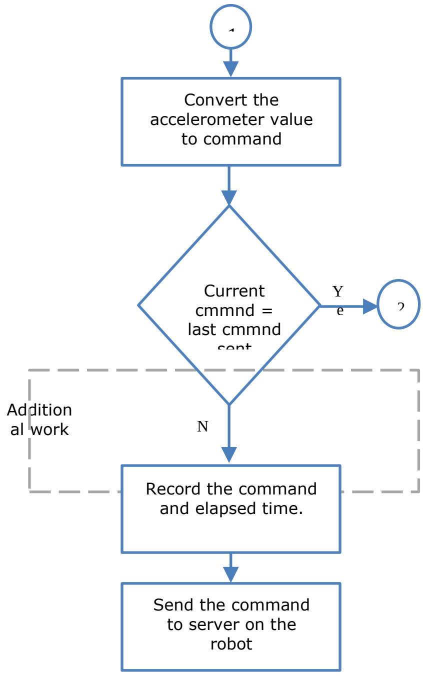


Figure 3 Flowchart of the paper's application

The design strategy and programming aspect involved in developing accelerometer-based features and communicating with the robot are described. According to the application design, the Android development kit allows users to write their own applications using the Java programming language. As shown in Figure 4, it includes the code to sense changes in the accelerometer.
This class also includes a thread to replay the commands stored in the array. The programmed application is connected to the robot via Wi-Fi. Depending on the user interaction.

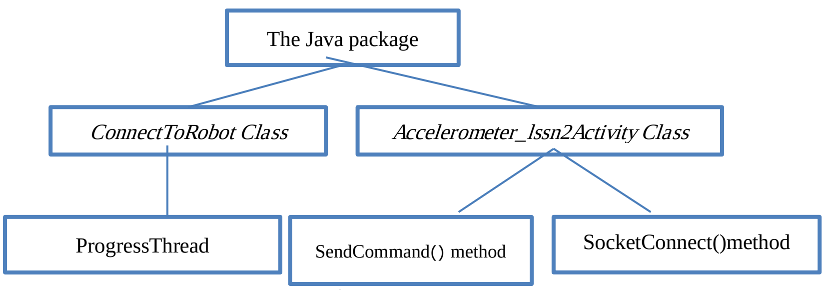


Figure 4 the contents of the Java package in this project

Before launching the implementation of the design, the Android phone should

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join the wireless network manually that includes also the robot. In the connection stage, to create a socket connection between the Android phone and the robot, they should belong to the same network address (subnet). The subnet can be identified using the IP address and its mask.

## 3- Results and Discussion

Based on several experiments conducted, where the omnidirectional robot receives the axis change value on the smartphone sent by the accelerometer sensor, the response time required to make a movement is good enough. During implementing, the results indicated that the application has succeeded to connect and disconnect to the robot over the wireless network. The Android application offers the user interface as in figure 5

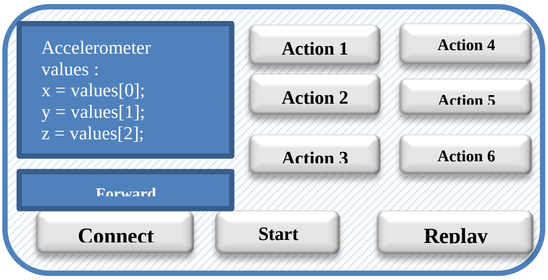


Figure 5: the proposed user interface that contains many the recording buttons

The android application has successfully achieved the required controlling process and the robot moved in all directions according to the directives of the phone without recording a failure or delay in the response of the robot. However, it was clear that the response of the robot in “right” direction is not accurate and it needs to calibrate the acceleration values that are used to represent this direction.

In deals with the replay process of the previous motion of the robot in the first time, the robot re-implemented all previous movements stored in the array without failure or stop. This process was accompanied by the appearance progress dialog window. Nevertheless, it was noted that the progress dialog cannot stop. However, improvements were added to the code that deals with storing and retrieving control commands

## 4- Conclusion

An Android application was designed and developed to benefit from it in directing and controlling the robot’s mobility and storing and retrieving all stored data to restore the robot’s movement automatically without guidance.

The application was based on the accelerometer sensor in the Android phone to guide the mobile robot. Use Wi-Fi to communicate with the robot which has a higher transmission range and speed than Bluetooth.

Moreover, the application recorded and replayed all the previous movements made by the robot, accompanied by the time spent. The application was implemented successfully without any problems that could affect its functionality.

## 5- REFERENCES

[1] Xiaoxuan H. SLAM with the Sphero robot, Master thesis of Automatic Control and Robotics, Universitat Politècnica de Catalunya in 2018.

[2] Suraj Bhattarai. WiFi Robot. Available at: http://iandrobot.net/?p=5 [Accessed: 16 June 2011].

[3] Parrot. Ar.Drone the flying video game, 2011. Available at: http://ardrone.parrot.com/parrot-ar-drone/usa/ [Accessed: 16 June 2011].

[4 ] D. Ruparel , C. Sanghavi, A. Rajde , M. Bhelande Android based Wi-Fi Controlled Robot based on Voice Recognition HBRP Publication Page 1-5 2021, Volume 4 Issue 1.

[5] Ulrich Nehmzow. Mobile Robotics: Research, Applications And Challenges. Available at: ftp://ftp.cs.man.ac.uk/pub/robotics/imeche.pdf.

[6]A.Pascual.ITRAINONLINE MMTKWIRELESS STANDARDS HANDOUT, 2006.Available at: http://www.itrainonline.org/itrainonline/mmtk/wireless_en/02_Wireless_Standards/02_en_mmtk_wireless_standards_handout.pdf [Accessed 14 June 2011].

[7] P. Conlan. Cisco Network Professional's Advanced Internetworking Guide. 1st Edition. Canada: Wiley, 2009

[8] Beetz, M.; Mösenlechner, L.; and Tenorth, M. 2010. CRAM—A Cognitive Robot Abstract Machine for everyday manipulation in human environments. In 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems, 1012–1017. IEEE

[9] Niemueller, T.; Lakemeyer, G.; and Srinivasa, S. S. 2012. A generic robot database and its application in fault analysis and performance evaluation. In 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems, 364–369. IEEE.

[10] Beetz, M.; Tenorth, M.; and Winkler, J. 2015. Open-EASE–a knowledge processing service for robots and robotics/AI researchers. In 2015 IEEE International Conference on Robotics and Automation (ICRA), 1983–1990. IEEE.

[11] Bashir .E 2023 ,Wi-Fi Robot Controlled Remotely Using Android Phone Accelerometer International Conference Image Processing, Computers and Industrial Engineering (ICICIE'2014) , 2014 at Kuala Lumpur (Malaysia)

[12] Pioneer P3-DX,2011 .Available at: http://www.mobilerobots.com/ResearchRobots/PioneerSDK/NavigationSoftware.aspx [Accessed: 15 September 2011].
[13] Linksys WRT54GL WIRELESS ROUTER .Available at: http://home.cisco.com/en-eu/products/routers/WRT54GL [Accessed: 20 September 2011].
[14]Data Storage. Available at: http://developer.Android.com/guide/topics/data/data-storage.html [Accessed: 01 August 2011].
[15] R. Meier. Professional Android 2 Application Development. Wiley, 2010.