# ABSTRACT

The present study aims to monitor an indoor space using an autonomous moving robotic platform. Gives the ability to its user to inspect the environment in which the robot moves despite being at a distance from this space. This is accomplished by controlling and detecting either autonomously or manually from a distance, the entrance but also the movement inside the room of a human or animal by notifying the operator.

To achieve the above, research will be held in order to select the appropriate sensors for motion detection, distance counting but also the appropriate means (materials) that meets the conditions of the closed space. Furthermore, the necessary software will be written. In order to develop a robotic platform based on low construction costs and functionality.

The robot will be controlled during manual mode by an android smartphone with software 5.0.0 or later. Accordingly the appropriate android application will be developed that aims at wireless communication between operator and robot.

Considering the system requirements for the operation of the robot during the automatic and manual control, will be used as hardware components of the system the microcontrollers Arduino Yun and Arduino Uno, the motion and distance detection sensors AM 312 and HC-SR04 respectively. For the movement of the robotic vehicle, four dc motors will be used with one wheel attached to each one respectively, an IP camera for live video transmission by the robot itself. As well as a pack of batteries to power the system. All hardware components of the system are mounted on a robotic platform the ''4WD SMART ROBOT CHASSIS CAR'' [1].

For the proper function of the system, the smartphone, Arduino Yun and Arduino Uno microcontrollers must be in constant communication. Therefore, software has been developed for each one separately in order to achieve its main goals and exchange information with each other. An Android application for the smartphone has been developed using the Android Studio 3.5 program, in order to establish the communication between smartphone and Arduino Yun for sending commands - data. The Arduino Yun and Uno microcontrollers have been programmed with the use of Arduino IDE 1.8.5 software. Yun takes over the wireless connection and communication with the smartphone, the "driving" of the motors as well as the detection of a man or an animal in the area. The Arduino Uno microcontroller ensures the independent movement of the robot by detecting the distance of obstacles that needs to overcome.

For the synthesis of the robotic platform, a research was conducted to select the appropriate components and methods at a theoretical as well as at practical level. During the hardware and software testing period, it was found that there were time delays in the exchange of Yun-smartphone data, in motion detection and video streaming. So depending on the selection of sensors, IP cameras or of an alternative communication method the system would be improved.

Finally, there is the possibility of improvement - expansion of the system by adding more parts and different methods. In order to control the robot and its space more efficiently from anywhere in the world.


# KEYWORDS

Autonomous robotic platform, microcontrollers, sensors, Arduino Yun, Arduino Uno, indoor control, Space supervision, Wi-Fi, Android application, IP camera, video stream


# INTRODUCTION

The main purpose of this project is the research in order to design and create an autonomous robotic vehicle. Its function will be to move within a specified area and detecting the entry or movement of any person or animal. The control of the robot and its space is divided in two parts: in auto and manual mode. In auto mode the robot moves within the controlled area autonomously and alerts user when human or animal detected. On the other side in manual mode, the operator with the use of a smartphone controls the movement of the robot and inspects the area by receiving a video stream of the space.

Consequently the construction of this project creates the need of acquisition the appropriate information on designing and developing robotic vehicles. More specifically, in this investigation all the appropriate knowledge should be found and collected about:

- Programming robots with the use of microcontrollers.
- The achievement of robot's autonomous movement but also the access and the manual control of them from a distance.
- What types of sensors gives the ability to robots, detecting human or animals.
- What possibilities robot needs to have in order to move autonomously, detecting and avoiding obstacles.
- The building of an android application which aims to control the robot.

Finally the result of this investigation, considering the needs of this project, should constitute an appropriate selection of components and methods that will compose a functional system based on open sources and technologies that will provide a cost effective solution.

# METHODOLOGY

To achieve the objectives of this project a survey will be conducted in 3 basic parts. Firstly to obtain the appropriate theoretical background, an investigation will be carried out in bibliography of technological content in the sectors of robotics, programming, mechatronics and communications protocols. Guided by the results of the theoretical survey, the design of the robotic vehicle begins. At this stage, considering the needs of the system, an exploration of the existing technology will be carried out in order to find and choose the suitable means

such as the hardware and software parts, which can be harmoniously combined in order to compose a robotic vehicle. The next step after the selection of robot's parts is the synthesis of them. At this time is parallel conducted the development of robot's software and the connection of the parts, in order to test and observe the efficiency of all methods and parts that are used. According to the results of the observations some actions will be taken in order to improve the system or counteracting any unwanted effects. So that the final design and construction of the robotic vehicle will take place [2] [3] [4].

More specifically the material elements that will be sought in the market are microcontrollers that are accessible wirelessly, possessing a numerous of ports to connect the needed parts and they and are compatible with common sensors and programming languages. The next step after the selection of microcontroller is to figure out what types of sensors have the ability to detect people. The exploration will be among PIR, pyroelectric, microwave (MW) sensors and cameras with the ability of objects recognition.

As for the independent movement of the robot, firstly we need to find a moving robotic platform that meets the conditions of space. And the next step is the selection of a sensor that detects obstacles so as the robot avoids them when it moves. The types of sensors that will be examined are those that use Laser, ultrasonic and infrared irradiation.

After the selection of all the hardware parts, the construction of them and the robot's software development will take place. During this time a survey conducted in bibliography to obtain the needed knowledge in programming microcontrollers and smartphones. During the development of the Android app, some tutorials were attended to expand our knowledge in Java and in the architecture of Android Studio programming environment. Regarding the wireless communication between smartphone and microcontroller, an exploration was carried out about the technology but also the comunication protocols that will be used. The choice of methods and technologies will be based on their reliability and swiftness. The comunication technologies that will be investigated are Wi-Fi and Bluetooth. Then according to the selection of the comunication technology the next step is to find the method of data transaction between smartphone and microcontroller. The methods that will be investigated are the «Socket» and «Rest Calls».

During the procedure of construction of the robot, tests and observations conducted in order to improve the system and meet any new needs that arise. A malfunction observed in the process of detecting human and obstacles, there were some problems with the power supply that our microcontroller couldn't provide it. Also during the development of the android application, observed that not all the Ip cameras are compatible to the system. Therefore some actions took place both in software and hardware parts such as adjustments, testing of different methods or parts in order to solve any problems.

# HARDWARE

The design and manufacturing process of the material components contains the selection of all suitable materials and their testing for the construction of the robotic vehicle. There will be a selection of components and accessories such as microcontrollers, robotic platforms,

sensors, motors, power supplies and the developing of any additional electronic circuitry required for the system's proper function.

## Selection of microcontroller

First component searched was a microcontroller that would control the robot and its functions. The request was to have the ability of wireless comunication, the needed number of sockets and the compatibility with other parts, for connecting all the required components. Taking a close look at the Arduino and Raspberry Pi microcontrollers that both complete the above requirements. We decided to choose Arduino Yun microcontroller that provides 20 digital input-output pins, 12 of them can be used as analog inputs and 7 as PWM outputs. It also has a built-in Wi-Fi module, allowing it to connect to a wireless router or act as an access point. Moreover it has two processors the 32U4 processor and Atheros AR9331. The 32U4 processor is programmed with the help of Arduino IDE software, and the Atheros AR9331 runs a distribution of Linux for embedded systems named OpenWrt-Yun, based on OpenWrt [2] [3] [5] [6] [7].

## Detection of human or animal

The main purpose of this project is to detect humans or animals. Consequently an investigation took part in order to discover types of sensors that respond in these basic needs. Types of sensors that will be investigated are PIR, pyroelectric, microwave (MW) sensors and cameras with the ability of objects recognition. As a consequence of this survey the PIR AM 312 sensor selected. Since the sensor's characteristic meet all the needs of the robot and its space, but is also a reliable detector for the temperatures of its working area, without a high percentage of error triggering and its dimensions and weight are acceptable. Sensor's detection ability provides a range of almost 100° cone angle at distances of about 6 m and the triggering time is ≈3.2sec. In addition the ''ld-bzeg-1203'' buzzer and an IP camera were selected and added to the robot to notify the user when human or animals are detected [4] [8] [9] [8] [10] [11] [12].

## Selection of the robotic platform

One of the basic actions of the robot is movement. Considering the conditions of the inspected space, as it is an indoor place and the floor is almost flat without any holes. A construction with 4 wheels and electric motors was selected. Specifically, we selected the ''4WD Smart Robot Chassis Car'' which is a robotic platform consisting of 4 wheels with their dc motors and a pack of batteries installed between two acrylic surfaces. These two surfaces have many notches and sockets to settle all the necessary accessories [1].

## Movement of the robotic platform

For driving the dc motors of the vehicle and avoiding the overload of Arduino Yun, it was necessary to create an electronic circuit that would intervene between Yun and the dc motors and it's function would be to receive a digital signal from the Arduino and amplify this signal, then depending if it is «low» or «high», it will activate or deactivate the desired engine pair and finally steering the vehicle. After market research we selected the L293D integrated circuit. This is because it has the ability to «drive» two dc motors, plus it has a fairly small volume, weight and cost [13].

## Detection of obstacles

The detection of obstacles is specially needed for the autonomous movement of the robot in order to detect and avoid them. The category of sensors that have this ability is the proximity sensors. From this category, types of sensors that are mainly used in robotic applications and will be investigated in this project are those that use ultrasonic, infrared light (IR) and laser. Analyzing the characteristics of the above types of sensors we ended up to the choice of an ultrasonic sensor the HC-SR04. As they are commonly used in similar applications and their ranging distances that cover are acceptable for our project, with 2cm to 400cm minimum and maximum distances respectively, the detection angle is conical about 15° and its dimensions and weight are acceptable for the project [4] [14] [15] [16].

## TABLE OF MATERIALS

| ITEMS | PROPERTY | NAME |
|---|---|---|
| 1 | MICROCONTROLLER | ARDUINO YUN |
| 1 | MICROCONTROLLER | ARDUINO UNO |
| 1 | MOVEMENT DETECTION SENOR | AM 312 |
| 1 | DISTANCE DETECTION SENOR | HC-SR04 |
| 1 | BUZZER | LD-BZEG-1203 BUZZER |
| 1 | VOLTAGE REGULATOR | L78S05CV |
| 1 | INTERGRATED CIRCUIT | L293D |
| 1 | POWERBANK | 5V |

| | | |
|---|---|---|
| 1 | BATTERY PACK | 4 X AA |
| 4 | BATTERY | 1.2 VOLT AA |
| 1 | BATTERY | 9 volt Ni-MH |
| 1 | ROBOTIC PLATFORM | ‘’4WD SMART ROBOT CHASSIS CAR’’ [1] |
| 4 | WHEELS [1] | |
| 4 | DC MOTORS [1] | |
| 1 | SWITCH | SWITCH ON – OFF |
| 1 | CIRCUIT BOARD | |
| 1 | IP CAMERA | |

## Selection of a secondary microcontroller

During hardware testing, noticed that Arduino Yun couldn’t power up both AM 312 and HC-SR04 sensors simultaneously. So we decided to add a second microcontroller in order to perform the distance detection function. The microcontroller that added was the Arduino Uno in which connected the HC-SR04 sensor. The comunication between Uno and Yun is made via “Software Serial” connection.

## Power supply of the vehicle

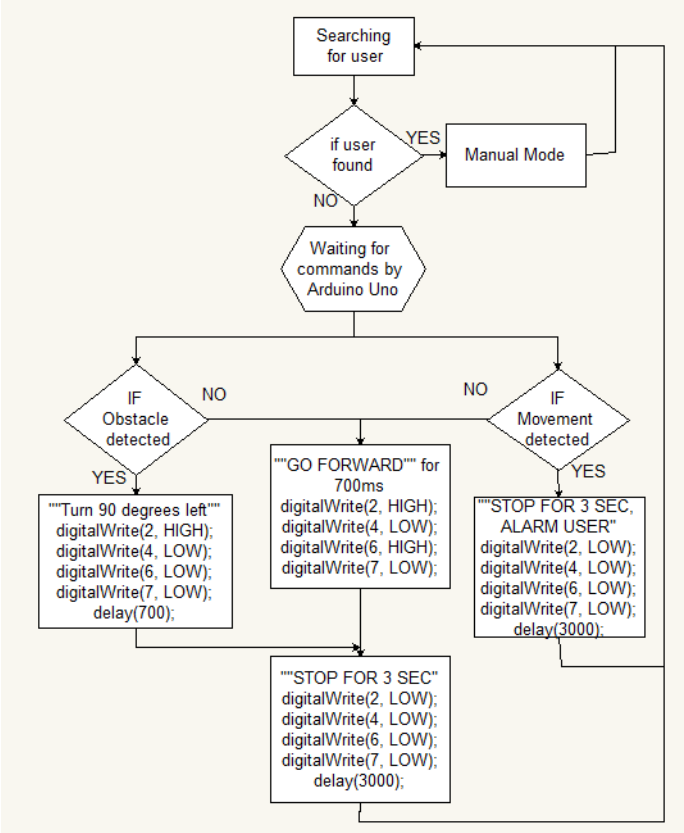
This robotic platform consists of many components that consume energy and every of them have its own needs. Due to that except of the battery power, we have to create the appropriate electronic circuit to power up some parts. Therefore, the "L7805CV" voltage regulator is used, which regulates its output voltage to 5 volts. There is a 9 volt battery that amplifies the L293D and then the motors. This battery is also connected to the circuit of the voltage regulator ‘’L7805CV’’. Afterwards the ‘’L7805CV’’ supplies 5 volts to the sensors, Arduino Uno and the IP camera. Finally there is also a powerbank to power up Arduino Yun, and a pack of 4 ‘’AA 1.2’’ batteries for the dc motors [17].

# SOFTWARE

The software part of this project is the one that «connects» and plans the operation of each individual component in order to frame the robotic platform. The software's development took place in parallel with the process of designing and manufacturing the material part. It consists of two main parts and its subcategories. The first part is the code that Arduinos execute during the manual or auto mode. The second part is the code that composes the android application.

## Arduino's code

This robotic system uses two microcontrollers. Its common target is the comunication between them and the smartphone. Arduino Yun's individual goal is the automatic and manual «driving» of the robot, the notification of the user when human or animal is detected and the exchange of data with smartphone. Arduino Uno is responsible to detect the distance of obstacles and sending this information to Yun via "Software Serial" connection [3] [5] [18] [19] [20].

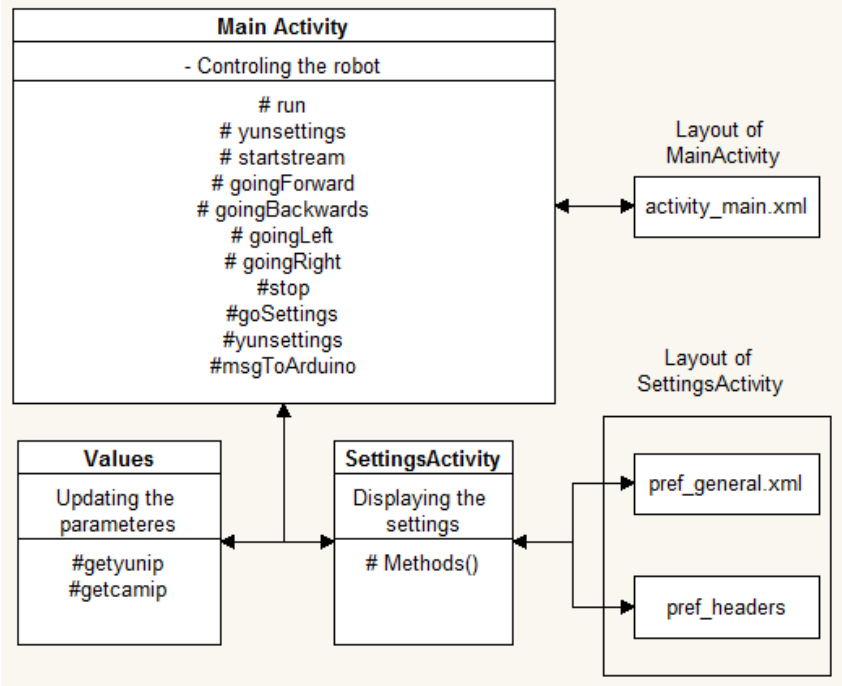



**Εικόνα 1 Arduino Yun block diagram**

## Android application

An android application has been developed in order to control the robot and inspect its space with the use of a smartphone. The application will provide a graphical interface to the

user for the control and the settings of the robot. To accomplish this, the code of this app tries to establish a comunication with Arduino Yun and gain access to the IP camera's video stream. The connection of those devices is made via Arduino Yun's Wi-Fi signal and the method used for data exchange between Yun and smartphone is the method of «Sockets» [21]. The application is divided in 4 basic classes: "MainActivity" class contains all the methods and its graphical interface "activity_main" with which the user controls the robot and has access to the video stream. "Values" is a helper class that provides useful parameters to "MainActivity". ''SettingsActivity'' and ''AppCompatPreferenceActivity'' are given classes with their own graphical interface ''pref_general.xml'' that have been modified to our needs so as the user configures the system's parameters [21] [22] [23] [24] [25] [26] [27] [28].




Εικόνα 2 Android's application block diagram

# RESULTS

During the design and construction process of the robotic platform a theoretical research carried out in relative surveys and bibliography to collect all the required information. As a result of this research, equipment acquisition and practical testing of hardware and software are performed.The selected components are the Arduino Yun and Arduino Uno microcontrollers, the HC-SR04 and HC-SR501 sensors for distance measuring and movement detection respectively. During the connection and testing of the components some deviations from the initial design observed. So we proceeded with the corresponding actions to solve these problems. Such as the replacement of the initial movement sensor with the AM 312 that seems to have a better response to the robot's needs. In addition each sensor that tested individually worked properly, but when attempted the connecting of all these sensors to the Arduino Yun, it was noticed that the HC-SR04 sensor couldn't be activated,

due to Yun's lack of power. For this reason Arduino Uno added and settled to use the HC-SR04 and sends the distance measurement to Yun, with the use of "Software Serial" connection.

# CONCLUSIONS

After the complete of this project, it was found that the space inspection with the use of a robotic platform can be completed efficiently while maintaining the protection of user. As the inspection of the room and the control of the robot can be done remotely via the topic Wi-Fi LAN that Arduino Yun provides. Although the user must be within the range of the Wi-Fi signal. A solution to this problem could be to add a router that would provide a DDNS address to Yun, in this way user will be able to control and inspect the robot and its space, from all over the world.

The selection of these methods and parts are not the only solution. For example an Arduino Uno microcontroller with a Wi-Fi Shield could be a cheaper solution. In addition this robotic platform has the potential for future improvements. The main limitation of this project that could be overcome is the power supply. A suggestion for resolving this issue could be to develop a scenario of an automatic approach to a recharging station. Also an improvement could be the combination of more types of detection sensors that work together and help each other.

# BIBLIOGRAPHY


[1] Arduino Tech, "DIY 4WD Smart Robot Car Chassis Kits With Magneto Speed Encoder For Arduino 51 – Arduino Tech," 19 2 2019. [Online]. Available: https://www.arduino-tech.com/diy-4wd-smart-robot-car-chassis-kits-with-magneto-speed-encoder-for-arduino-51/. [Accessed 6 8 2019].

[2] tmomas, "Open Wrt Project: Arduino Yun," 9 9 2018. [Online]. Available: https://openwrt.org/toh/arduino.cc/yun. [Accessed 24 5 2019].

[3] Arduino, Arduino, 15 1 2015. [Online]. Available: https://www.arduino.cc/en/uploads/Main/YUN-V04(20150114).pdf. [Accessed 24 5 2019].

[4] Σ. ΜΙΧΑΛΗΣ, "Αισθητήρια ρομποτικής," ΣΦΑΚΙΩΤΑΚΗΣ ΜΙΧΑΛΗΣ, Κρήτη, 2009.

[5] SM, "Arduino - Arduino Yun," Arduino, 2 10 2018. [Online]. Available: https://www.arduino.cc/en/Guide/ArduinoYun. [Accessed 24 5 2019].

[6] Techopedia, "What is Bluetooth? - Definition from Techopedia," 2019. [Online]. Available: https://www.techopedia.com/definition/26198/bluetooth. [Accessed 30 5

2019].

[7] Techopedia, "What is Wi-Fi (Wireless Fidelity)? - Definition from Techopedia," Techopedia, 2019. [Online]. Available: https://www.techopedia.com/definition/10035/wireless-fidelity-wi-fi. [Accessed 30 5 2019].

[8] EIE distributed by MANTECH, "AM312 Datasheet," MANTECH www.mantech.co.za, 2019.

[9] Brandon Lighting, "Best Motion sensor for LED lighting products from China supplier," Brandon Lighting, 10 4 2018. [Online]. Available: https://brandon-lighting.com/motion-sensor-microwave-sensor/. [Accessed 19 6 2019].

[10] Green Lighting, "Microwave vs PIR Sensors: Which do you need? - Green Lighting," Green Lighting, 22 3 2019. [Online]. Available: https://greenlighting.co.uk/pir-vs-microwave-sensors-need/. [Accessed 19 6 2019].

[11] N. K. Ichiro Shibasaki, "Pyroelectric Sensor - an overview | ScienceDirect Topics," Science Direct, 2018. [Online]. Available: https://www.sciencedirect.com/topics/engineering/pyroelectric-sensor. [Accessed 14 6 2019].

[12] ioarvanit, "Παθητικοί αισθητήρες υπέρυθρων - PIR Sensors -," ioarvanit, 31 12 2018. [Online]. Available: https://ioarvanit.gr/archives/3058. [Accessed 20 6 2019].

[13] Texas Instruments Incorporated, "L293D Datasheet," Texas Instruments Incorporated, Dallas, 2019.

[14] "HC-SR04 Ultrasonic Sensor: Working, Pin Diagram, Description & Datasheet," 18 9 2017. [Online]. Available: https://components101.com/ultrasonic-sensor-working-pinout-datasheet. [Accessed 15 6 2019].

[15] Electronics Hub, "Electronics Hub," Electronics Hub, 24 12 2017. [Online]. Available: https://www.electronicshub.org/ir-sensor/. [Accessed 15 6 2019].

[16] ioarvanit, "Μετρώντας την απόσταση με τον ήχο -," ioarvanit, 29 12 2018. [Online]. Available: https://ioarvanit.gr/archives/2992. [Accessed 20 6 2019].

[17] browaygroup, "Component7 LM7805, 5 Volt Voltage Regulator -3Pc – Broway Group," 14 3 2019. [Online]. Available: http://browaygroup.com/product/component7-lm7805-5-volt-voltage-regulator-3pc/. [Accessed 23 7 2019].

[18] SSH.COM, "SSH (Secure Shell) Home Page," 2019. [Online]. Available: https://www.ssh.com/ssh/?utm_source=s&utm_medium=nav&utm_campaign=head#sec-The-SSH-protocol. [Accessed 18 6 2019].

[19] M. Rouse, "What is Secure Shell (SSH)? - Definition from WhatIs.com," 16 3 2016. [Online]. Available: https://searchsecurity.techtarget.com/definition/Secure-Shell. [Accessed 19 6 2019].

[20] K. Chandrakant, "REST vs WebSockets | Baeldung," 10 4 2019. [Online]. Available: https://www.baeldung.com/rest-vs-websockets. [Accessed 28 5 2019].

[21] "Java Socket Programming (Java Networking Tutorial) - javatpoint," 2019. [Online]. Available: https://www.javatpoint.com/socket-programming. [Accessed 28 5 2019].

[22] S. K. A. S. A. G. P. L. T. Ambroise Dhenain, "Wi-Fi Controlled Car," Aarhus, 2013.

[23] Vadorequest/AAD1, 12 12 2013. [Online]. Available: https://github.com/Vadorequest/AAD1. [Accessed 22 8 2019].

[24] Developer Android, "Settings | Android Developers," Android Developers, 13 6 2019. [Online]. Available: http://developer.android.com/guide/topics/ui/settings.html. [Accessed 25 9 2019].

[25] developer android, "Settings | Android Developers," Android Developers, 13 6 2019. [Online]. Available: http://developer.android.com/design/patterns/settings.html. [Accessed 25 9 2019].

[26] "Java - Networking - Tutorialspoint," 17 1 2019. [Online]. Available: https://www.tutorialspoint.com/java/java_networking . [Accessed 28 5 2019].

[27] "Lesson: All About Sockets (The Java™ Tutorials > Custom Networking)," Oracle, 2019. [Online]. Available: https://docs.oracle.com/javase/tutorial/networking/sockets/. [Accessed 28 5 2019].

[28] Tutorialspoint, "Android - Activities - Tutorialspoint," 2019. [Online]. Available: https://www.tutorialspoint.com/android/android_acitivities.htm. [Accessed 15 6 2019].