App Controlled Patient Assistance Robot with Home Automation

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***Abstract*— With the advent of technology, everything is available in a single touch. This paper introduces a system for bedridden and elderly patients which aid to fulfil their need for independent living. The proposed system is a voice-controlled robot that acquires commands via smart phone and converts it to corresponding text. Text is transmitted serially over Bluetooth. On recognizing the command, it moves towards the set location and procures the object. The movements are guided along a predefined path. Ultrasonic sensors in front of the system detect any obstacles. Home automation feature is also incorporated, that allows the user to control home appliances by voice input. Further the project also incorporates voice calling to the saved contacts, in case of emergency.**

Keywords—Android; Bluetooth; Home automation system; Microcontroller; Robotic arm; Smart phone; Appliances

I. INTRODUCTION

Prevalence of nuclear family system, replacing the joint family system has created social issues of looking after the elderly or the bedridden. Those who are committed to take care, have to make perfect balance of time for their professional and family life. In the case of unforeseen event of parents or grandparents being bedridden, proper management of time will be naturally on stake.

Being confined to bed is tough for both the patient and the caretaker, whether it be a case of long term illness, short-term bed rest, and post-surgery recovery. A patient with restricted mobility needs to get things done as and when required, but this would be tiresome and inconvenient for their caretakers. Hence arises the need for a system which can fulfil the requirements of mobility restricted patients, which make them live independently. Patient assistance robot is an idea that evolved from this need of living an independent life. Home automation feature is also incorporated along with the intended system, for the ease of control of appliances.

The patient assistance robot is equipped in such a way that, it carries out necessary ADL (activities of daily life), like getting water and medicines. A robotic arm with five dof (Degrees of Freedom) is responsible in grabbing things that patient request for. The robot responds to the patient voice and brings the specified item. The robot moves in a predefined path from patient to the table where these are kept and vice versa. The movement is made possible with the help of two motorized wheels. Ultrasonic sensor of the robot senses any obstacles. The robot also gives indication of low battery, to prevent power drain. The voice of patient acts as command for robotic actions. Hence it is necessary to recognize the voice, decode the message and to respond accordingly. This is met with the help of an android app which recognises the user command and converts this speech to text, which is serially transmitted to the microcontroller to perform the task. The user can also make necessary calls to saved contacts with the app provided.

II. RELATED WORKS

The patient assistance robot offers an ideal solution for the bedridden and elderly patients [1].The accelerating medical advancements also necessitate the need for patient assistance. The increasing requirements of the patients and relatives for the best options have put a great dilemma in the minds of the healthcare providers in offering the same. Modern technological world requires the systems to be simple, flexible and easy to use. Robotics is now an emerging field in medical science [4].

The reliability and tolerance of this field ensures a great deal of relief and comfort to their users all over the world. Getting things done in a speck of time is the motto nowadays. The fastest systems survive. Features added supporting these are of importance and to be handled with care. The complete system comes with a feedback response. Home automation is a novice feature and is a budding environment for the patient care domain. The services offered could enable any bedridden patients to enjoy a well relaxed and a peaceful period of rest, with the least assistance [5].

The patient assistance robot can be done in various methods. In a paper robotic car uses Speech recognition technique to recognize voice commands. The voice commands includes direction Move forward, Move backward, Turn left and so on. System involves a microphone, which picks up the voice signals, which converts them to digital form using ADCs (Analog to digital converters). The required features are extracted from the speech using windows of specified duration, say 20 to 30 milliseconds. The data is compared with a preformed sequence and then analysed [6].

In another paper the Automation system combines the wireless communication and speaker recognition using MATLAB code, which makes it applicable for home appliances as well as in industry. The speech commands are stored in data base of MATLAB and are matched with the voice command of speaker using Mel Frequency Cepstral Coefficient (MFCC) algorithm which recognizes the speech of speaker and extracts the features of speech. Human voice is converted into digital, producing digital data representing signal at every discrete time step. The digitized speech samples are then processed using MFCC to produce voice features. Low-power RF (Radio Frequency) ZigBee transceiver wireless communication modules are made use of. The automation system controls lights, fans and other electrical appliances in a home or office using speech commands wirelessly [7].

III. SYSTEM DESIGN

A. Block Diagram

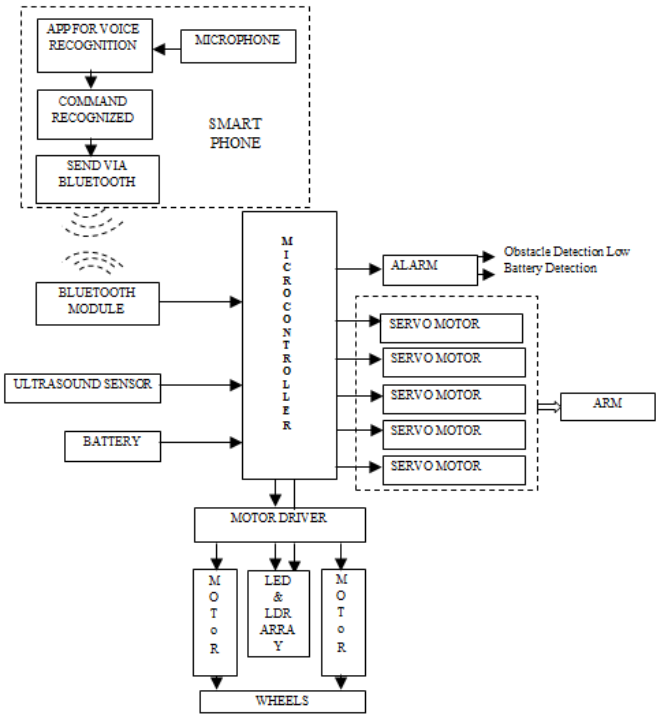

Fig. 1. Block diagram of the system

The overall structure of the hardware design is illustrated in the Fig. 1.

1) Microcontroller ATmega328:
The microcontroller is the heart of the system. It is chosen based on the processing power and the speed of the system. ATmega 328 is chosen considering its high performance and sustainability making it highly reliable in this sensitive project.

2) LED and LDR Array:
The robot motion is track recorded. A series of combination of LED (Light Emitting Diode) LDR (Light Dependent Resistor) array is used in achieving the desired operation.

3) Ultrasonic Transmitter Receiver Module:
The module is used facilitating the detection of obstructions in path that could hinder the motion of the robot.

4) Motor Driver
The robotic unit is equipped with five Servo Motors, in demand for five dof (degrees of freedom), each controlled by Motor driver.

5) Bluetooth Module
The wireless communication systems have gained a wide popularity in the medical domain. It enables a safe and secure transmission of the data with less complexity.

6) Home Automation Module
The module has another microcontroller ATmega328 and a set of relay drivers and relays to control light and fan in the room. The Fig. 2 shows the block diagram of home automation system.

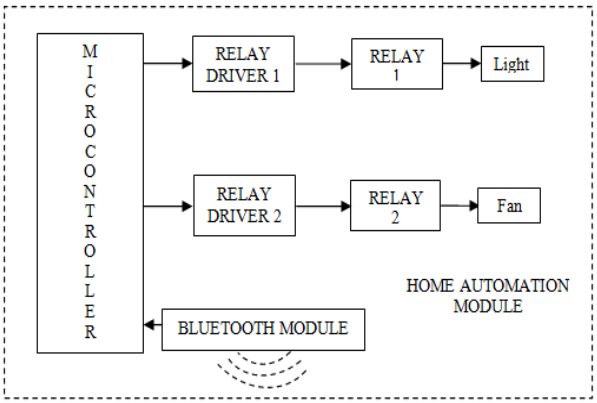

Fig. 2.Block Diagram of Home Automation system

B. Methodology

As patient assistance robot is intended to assist the user with restricted mobility, it has been designed to fetch the necessities based on the user's voice commands. For this a microphone is used which would essentially pick up the different commands like 'water' and 'medicine'. It is necessary to recognize the voice, decode the command and to respond accordingly in order for the reliable operation of the system. This command is recognised using Android App (Application) and through Bluetooth module it is transferred to the microcontroller for performing the commands.

Once the system recognises the command it responds to it by moving towards the set location of specified item and bringing it to the patient. The movements are through a predefined path, the arrangement with LED's and LDR's checks any deviation from set path. An ultrasonic sensor in front of the system detects the

obstacles and in case of obstacles, which would be a rare condition while considering a disabled user's room, PAR (Patient Assistance Robot) indicates the relatives or caretaker through an alarm, to remove the obstacle. Once the robot reaches the set location it picks the requested item and returns to the patient. For completing this action the system is equipped with an arm of five dof and wheels for moving around. The movements, avoiding obstacles, picking up item, alarm for low battery and obstacle detection are done using C programming in Arduino IDE (integrated development environment).

C. Software design

a) Voice recognition

The voice recognition is done with the help of an app developed for the same, using Android studio. The app has facility to record the voice input if in proper format they are converted to corresponding text output, which is send to the main microcontroller via Bluetooth, where it decodes the input into appropriate commands. These include commands to get reach of necessities, or to make phone call in case of emergency, or to control various home appliances. The Android App block is shown in Fig. 3.

Based on the Java programming language, a built-in Bluetooth module, and a series of useful sensors already integrated and having permanent Internet connectivity, almost any Android device is categorized as a perfect tool for remote robotics control over Bluetooth.

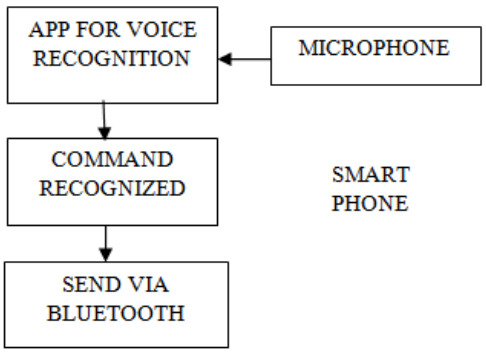

Fig. 3. Android App Block

b) Line controlled movement

In this ATmega based line follower robot IR (infrared) Transmitters and IR receivers also called photodiodes is used. They are used for sending and receiving light. IR transmits infrared lights. When infrared rays fall on white surface, it's reflected back and caught by photodiodes which generates some voltage changes. When IR light falls on a black surface, light is absorbed by the black surface and no rays are reflected back, thus photodiode does not receive any light or rays.

Here in this line follower robot when sensor senses white surface then ATmega gets one as input and when senses black line ATmega gets zero as input.

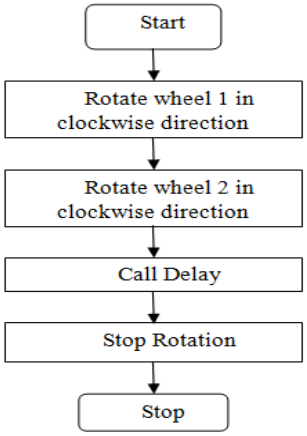

Fig. 4. Flowchart for forward movement

The forward, right and left direction movements are made possible with their respective functions. The Fig. 4, Fig. 5, and Fig. 6 show the flowchart of the movements. Different directions for movement is obtained by rotating the motors, hence the wheels at either sides, in clockwise or in anti-clockwise direction corresponding to the direction to be achieved. In case of forward movement both motors has to rotate in clockwise direction, but for right and left direction one wheel rotates in clockwise while other wheel in anti-clockwise direction.

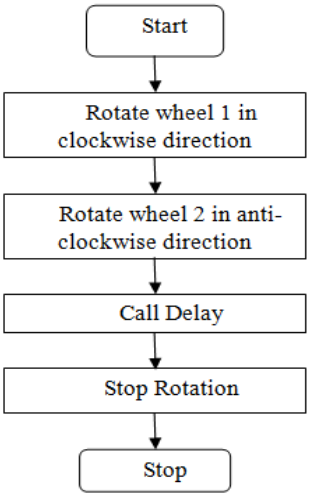

Fig. 5. Flowchart for Left direction

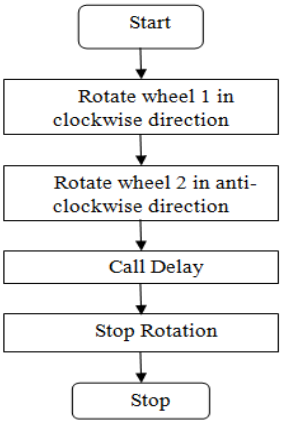

Fig. 6. Flowchart for right direction

Table I. Line Controlled Movement

Robot Current Position	Motor 1	Motor 2	Direction to be moved
On black line	High, Low	High, Low	Forward
Towards right of line	Low, High	High, Low	Left
Towards left of line	High, Low	Low, High	Right
At the end of line	Low, Low	Low, Low	Stop

The line controlled movement is given in table I. The ADC values from LDR is read by the microcontroller and with respect to the values of each ADC pins that corresponds to LDR values, the motor driver is given signals to rotate the motor either in anti-clockwise or in clockwise direction. Thus the direction of movement is determined by the ADC values from each pin, according to the values decision is made to move in any one of the direction.

The program identifies the position of the sensor module by comparing the sensor readings with the reference point. If the reading of a particular sensor is greater than the reference level the program can assume that the particular sensor is above black. If the reading of a particular sensor is less than reference level then it is assumed that the particular sensor is above white. If both sensor readings are less than reference level then it means both sensors are on white. If both sensor readings are above reference level it is assumed that both sensors are above black (the same thing happens if lifts the robot off the track). Based on the above four conditions, the program appropriately switch the left and right motors to keep the robot following the black line. The entire flow chart for Line controlled movement is given in Fig. 7.

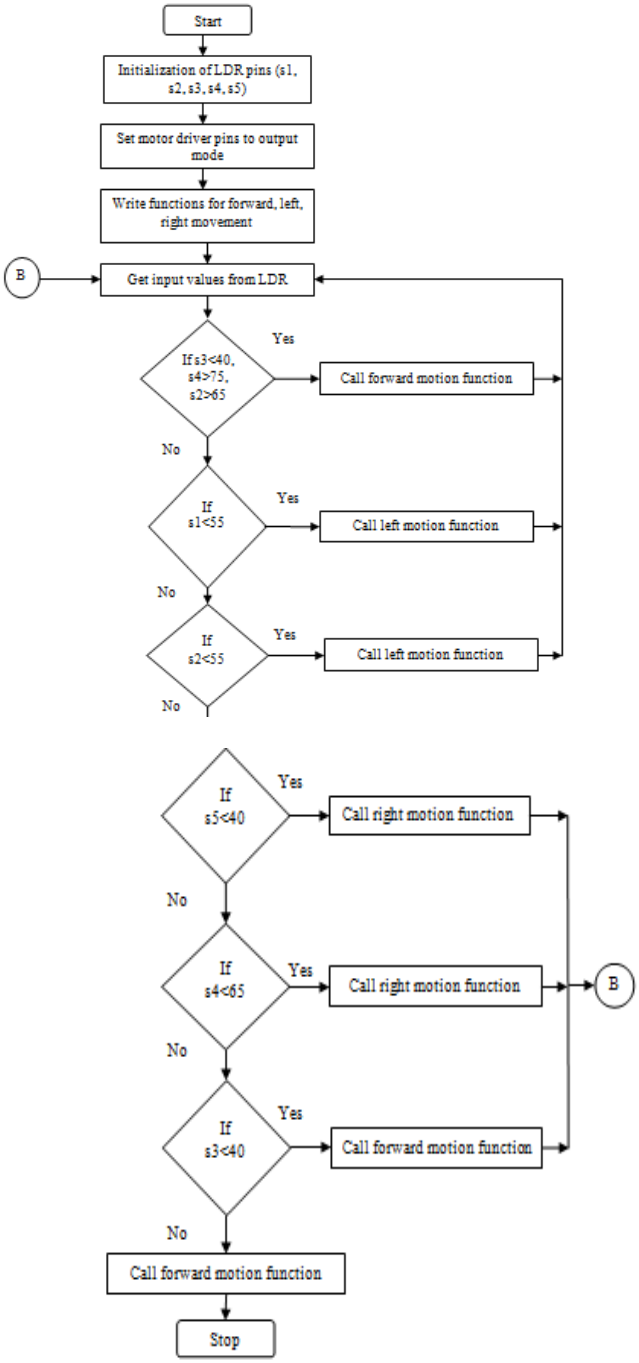

Fig. 7. Flowchart of Line controlled movement

c) Obstacle detection

The obstacle in the predefined path of the robot can cause undesirable effects to the robot action and its movement. Hence any kind of obstacle has to be detected on the path. The ultrasound sensor is used for this purpose which transmits

ultrasound first, and waits for any reflected echo ultrasound at the receiver.

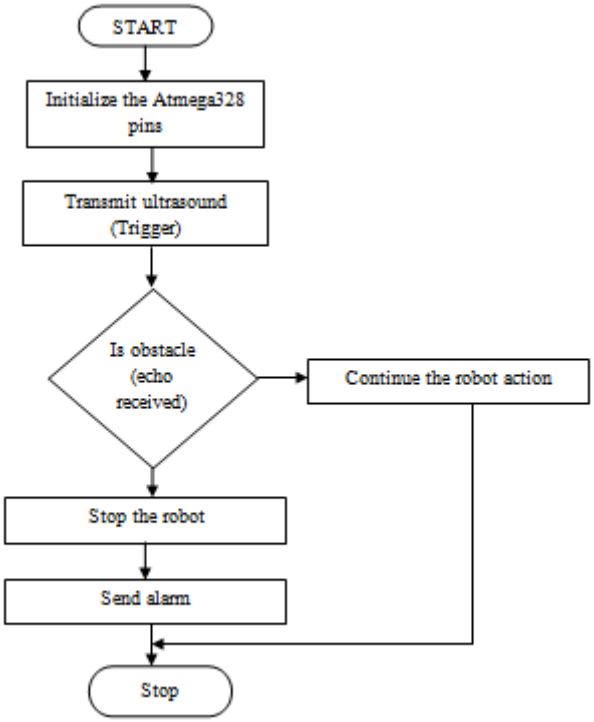

Fig. 8. Flowchart of obstacle detection

If any echo is obtained at the receiver end it is considered to have detected an obstacle on its path. If an obstacle detected in the path of robot it has to be stopped and the obstacle has to be removed. This is performed with the help of alarm system. If no reflected echo is obtained it is considered to have no obstacles in the path and robot is free to continue in its path. The Fig. 8 shows the flowchart for the detection of obstacle using ultrasound sensor and gives alarm.

IV. RESULTS AND DISCUSSION

The line follower part using LED and LDR array for robotic movement was done initially. A pair of five LEDs and LDRs was fixed along with the motorised wheels. The robot followed the set black path without deviating from the path. The Fig. 10 shows LED-LDR array with motorised wheel arrangement for line detection for robotic movements. The LEDs and LDRs are soldered to dot board which is connected to ATmega microcontroller and this in turn controls the wheels to rotate any of the specified direction depending upon the values of LDR.

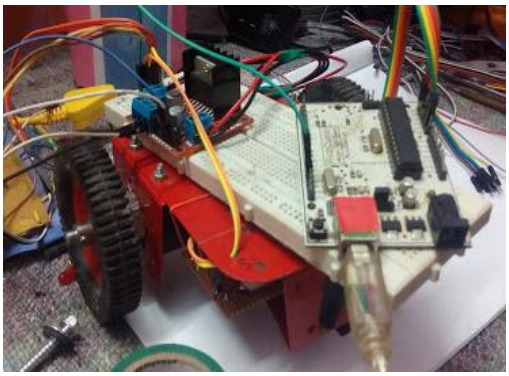

Fig. 10.LED- LDRand wheel Arrangement for line detection

The robotic arm which is equipped to grab the requested necessity was assembled and programmed to pick and place. The grabbing action of robotic arm is shown in Fig. 11 and Fig. 12.

Fig. 11. Robotic Arm holding Medicine

Fig. 12. Robotic Arm held closed

Ultrasonic sensor was embedded in front of the robot to avoid collision and notify the caretaker if the distance to obstacle is

less than a predetermined limit. Bluetooth based app was developed and installed within the project which can reduce the patient constraints.

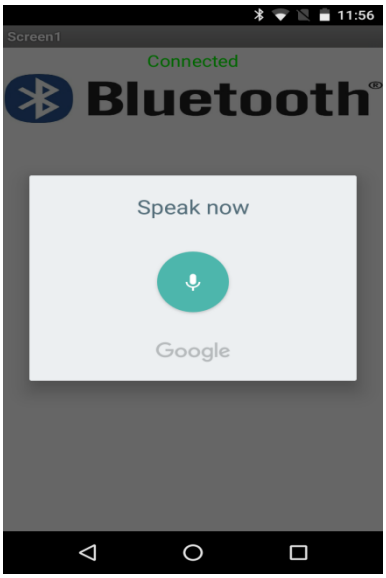

Fig. 13. App for voice recognition and text transmission via Bluetooth

Fig. 13 shows the app for voice recognition and Fig. 14 displays the text which is converted from the voice. The Android App receives voice input and converts into text which is later on transmitted over Bluetooth. The App was developed in Android Studio using Java and xml programming for App layout. App has features including voice to text conversion, make phone calls and bluetooth connectivity. In order to perform home automation separate unit with Bluetooth connectivity was integrated to the appliance control that according to commands switches them.

Fig. 14. App displaying the text recognised from the voice

V. CONCLUSION

The app controlled patient assistance robot with home automation uses voice inputs of the patient to perform the required action. This make patient to have done their necessities they come across in daily life when restricted within the room. The app installed within the smart phone makes the system compact and effortless method to access the system. The text corresponding to each voice input is transmitted over Bluetooth to robot and further performs handy ventures. The robot moves around to accomplish the task of giving water and medicine. The home automation allows patient to control electrical appliances within the room. Thus we were successful in our effort of designing and developing a cost effective patient assistance system.

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REFERENCES

[1] Kunimatsu Hashimoto et al., " A Field Study of the Human Support Robot in the Home Environment", IEEE *Workshop on Adv. Robot. and its Soc. Impacts (ARSO)*, Shibaura Institute of Technology, Tokyo, Japan, Nov. 7-9, 2013.

[2] Nirmal T M, "Multipurpose Robot for Patients and Military Applications: A Robotrover for Multiple Disabled Persons, Patients and Military Applications ", *Int. J. of Electron. Commun. and Comput. Technol. (IJECCT)*, Vol. 4, Iss. 4, Jul. 2014.

[3] Chauhan, Gaurav, and Prasad Chaudhari. "Robotic Control using Speech Recognition and Android", *Int. J. of Eng. Research and General Sci*., Vol. 03, Iss. 01, Jan. - Feb. 2015.

[4] Matthew Gombolay et al., "Robotic Assistance in Coordination of Patient Care", *Proc. of Robot.: Sci. and Syst.*, Jun. 2016.

[5] Dhawade Pooja, J., Y. V. Lathkar, and B. Date Purushottam. "Smart Home Using Andriod Application", *IJRET: Int. J. of Research in Eng. and Technol.*, Vol. 03, Iss. 04, pp. 365-367, Jul. 2014.

[6] Pratik Chopra et al., "Voice Controlled Robot", B.E. project, Department of Electronics, K. J. Somaiya College Of Engineering, Vidyavihar, Mumbai, Apr. 2007.

[7] S. R. Suralkar et al.," Speech Recognized Automation System Using Speaker Identification through Wireless Communication", *IOSR J.of Electron. and Commun. Eng. (IOSR-JECE*), Vol. 6, Iss.1, pp. 11-18, May. - Jun. 2013.

[8] Sharon Panth et al., "Home Automation System (HAS) using Android for Mobile Phone", *Int. J. of Electron. and Comput. Sci. Eng.*, Vol. 03, No. 01.

[9] Akihiko Hanafusa et al., "Self-Aided Manipulator System for Bed-Ridden Patients - Evaluation of Psychological Influence for the Generated

Approach Motion ", *IEEE 11th Int. Conf. on Rehabil. Robot. Kyoto Int. Conf. Center*, Japan, Jun. 23-26, 2009.

[10] Mark W. Spong et al., "Control in Robotics", *The Impact of Control Technol. rep.*, IEEECSS, 2011.

[11] ATmega328/P [Online] http://www.atmel.com/images/atmel-42735-8-bit-avr-microcontroller-atmega328-328p_datasheet.pdf

[12] H.F. Machiel Van der Loos et al., "Rehabilitation and Health Care Robot", *Field and Service Robot.*, chap. 53, pp. 1223-1251.

[13] Bilal Orun, Carlos RDM Roesler ,and Daniel Martins "Review of assistive technologies for bedridden persons", 2015.

[14] Naoto Suzuki et al., " System Assisting Walking and Carrying Daily Necessities with an Overhead Robot Arm for In-home Elderlies", *Proc. of the 22nd Annu. EMBS Int. Conf.*, Jul. 23-28, 2000, Chicago.

[15] Ultrasonic Ranging Module HC-SR04 [Online] http://www.micropik. com /PDF/HCSR04.pdf

[16] Android Studio [Online] http://developer.android.com/sdk/index.html

[17] Dual Full Bridge Driver [Online]http://www.st.com/content/ccc/resource /technical/document/datasheet/82/cc/3f/39/0a/29/4d/f0/CD00000240.pdf/files/CD00000240.pdf/jcr:content/translations/en.CD00000240.pdf