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Mobile Robot Position Controlling System Based On IoT Through Raspberry Pi[1]

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Abstract

In IoT communication technologies, interconnected computing devices, mechanical and digital machines, objects, animals or unique identifiers (UIDs) can transmit data over a network without the need for people or networks. Increasingly, organizations in various industries use IoT technology to work more efficiently, provide better customer service, improve decision-making, and increase business value. In this study, an HTML based control panel was created and IoT based mobile robot position control was performed via Raspberry Pi via this control panel. The control of this mobile robot is entirely IoT-based and can be controlled from anywhere with Internet access via the control panel on the relevant web page. The aim of this study is to prove how a real-time platform can be controlled over Internet via a widely used microcontroller today such as Raspberry Pi and to explain how the communication between the microcontroller and Web takes place simply and understandably in the background.

Keywords: IoT, Raspberry Pi, Position Control.

Raspberry Pi Kullanılarak IoT Tabanlı Mobil Robot Konum Konrol Sistemi Tasarımı

Öz

IoT haberleşme teknolojilerinde birbirleriyle ilişkili bilgi işlem cihazları, mekanik ve dijital makineler, nesneler, hayvanlar veya benzersiz tanımlayıcılar (UID'ler) bir ağ üzerinden insanlara veya ağlara ihtiyaç duymadan veri aktarabilir. Giderek artan bir şekilde, çeşitli endüstrilerdeki kuruluşlar daha verimli çalışmak, daha iyi müşteri hizmeti sağlamak, karar vermeyi geliştirmek ve iş değerini arttırmak için IoT teknolojisini kullanmaktadır. Yapılan bu çalışmada HTML tabanlı bir kontrol paneli oluşturulmuş, bu kontrol paneli aracılığı ile Raspberry Pi üzerinden IoT tabanlı mobil robot konum kontrolü yapılmıştır. Bu mobil robotun kontrolü tamamen IoT tabanlı olup, robot Internet erişimi olan her yerden ilgili web sayfası üzerinde yer alan kontrol paneli aracılığıyla kontrol edilebilmektedir. Yapılan bu çalışmanın amacı günümüzde yaygın olarak kullanılan bir mikrodenetleyici olan Raspberry Pi aracılığıyla gerçek zamanlı bir platformun Internet üzerinden nasıl kontrol edilebileceğini ve mikrodenetleyici ile Web arasındaki haberleşmenin arka planda basit ve anlaşılabilir bir şekilde nasıl gerçekleştiğini açıklamaktır.

Anahtar Kelimeler: IoT, Raspberry Pi, Konum Kontrolü.

1. Introduction

The connection of physical objects to the Internet makes it possible to access remote sensor data and control the physical world remotely. The merging of captured data with other sources, such as data on the Internet, results in new synergistic services that go beyond the services that can be provided by an embedded system. This spread of the Internet has led to the emergence of new paradigms, and in this context, one of the new paradigms, IoT based communication is one of the hottest and most curious issues in information and communication technologies.According to Cisco, 2.5 billion new people will step into the online world and 50 billion new devices will be connected to each other by 2020. The interaction of these devices and sensors,

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which are found in such an excessively high number, is one of the most important research topics and studies in this field that have an important place in the world of technology. Internet, which enables devices and sensors to communicate with each other, is a great importance and solves the problems arising from the communication necessity of these devices (Altınpulluk, 2018).

Vanitha, Selvalakshmi, Selvarasu presented a mobile robot which is monitored and controlled via Internet through Raspberry Pi board (Vanitha et al., 2016).

Marroquin, Gomez, Paz presented a low-cost alternative for a mobile explorer robot that has camera and a temperature / air humidity sensor and uses open hardware and software, whose design is intented to be able to inspect its environment in addition to being controlled remotely using the Internet technologies of the Things through a graphical user interface (web application) (Marroquin et al., 2017).

Srividhya, Kumar, Manivannan, Rihfath, Ragunathan presented an IoT based robot system which is used for vigilante purposes. This robot can be moved in all directions and gets a live stream on android platform using Raspberry Pi. The signals generated from Android app are sent to Raspberry Pi. These received signals are processed by the commands and the robot is directed with used directive (Srividhya et al., 2018).

Park, Choi, Choi J. presented an IoT based context-aware system that gathers sensor data from the natural environment, which is converted to sensory data and abstracted as situational data to provide robot services (Park et al.,2016).

Wang, Zhao, Hao presented an IoT based indoor mobile robot, which is used for the housekeeping service and called as smart housekeeper. People can operate the robot remotely by another smart mobile phone at any time. It can realize remote video searching, home appliance control, and indoor security (Wang et al.,2015).

2. Material and Method

In this project, firstly, the control panel of the mobile robot system (HTML-based web page) was created. This control panel has directional buttons to be used for guiding the robot and has an interface that determines the robot will be moved at the respective position along the respective distance.

In the second stage, the control data which were retrieved from user via the control panel is obtained through the Raspberry Pi and this data is sent to the Arduino microcontroller, which operates simultaneously with Raspberry Pi, a separate interface where the robot system is installed.

In the third stage, the position control of the mobile robot is performed according to these control data on Arduino.

Within the scope of this project, Raspberry Pi, which retrieves the control data from database and Arduino, which is the controller of the mobile robot system, works simultaneously on this IoT system.

2.1. Mobile Robot System

The mobile robot consists of Arduino UNO Microcontroller, two wheels integrated with DC motors, L293D Motor Drive Shield for controlling motors, the Rotary Encoder Module and the HC-06 Bluetooth Module for communication with Raspberry Pi. The wheels on the mobile robot enable the movement of the robot by means of DC Motors.

2.2. Mechanical Design of the Robot

Firstly, there is a need for DC motors, batteries for the power supply of the motors, wheels, power supply encoder module, and a platform where the Arduino will stand together. Therefore, in the design of the mobile robot, a frame (chassis) is needed in which these equipment will be kept together. Figure 1 shows the image of the skeleton used in the design of the robot.

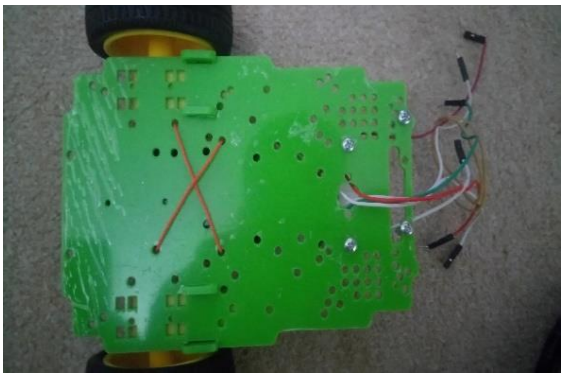

Figure 1. The Image of the Frame

After providing the frame of the mobile robot, DC motors are integrated into the spaces reserved for the two motors on the right and left sides of the bottom of this frame by screwing the DC motors. Figure 2 and Figure 3 shows the DC motors integrated into the right and left sides of the frame, respectively.

Figure 2. Image of the Right DC Motor and Wheel Integration to the Frame

Figure 3. Image of the Left DC Motor and Wheel Integration to the Frame

After the wheels have been placed, a drunken wheel is integrated in the front-lower part of the chassis, which works in harmony with the other two rear wheels. The purpose of the use of the drunken wheel is to ensure that the movable platform is easily guided and can rotate freely in any direction. Figure 4 shows the image of the drunk wheel integrated into the frame.

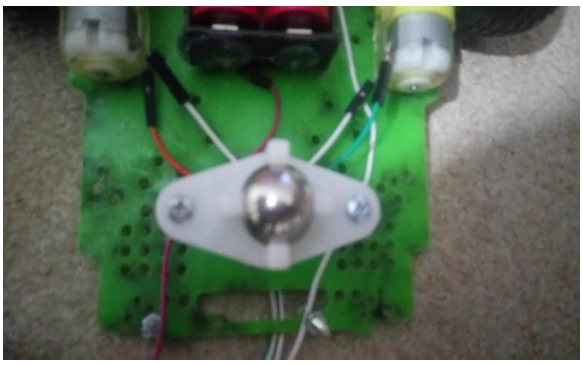

Figure 4. Image of the Drunken Wheel Integration to the Frame

Finally, the batteries required for the Arduino to be integrated on the frame and the L293D Motor Drive Shield on the Arduino is located on the bottom of the frame. Figure 5 shows the batteries installed in the system.

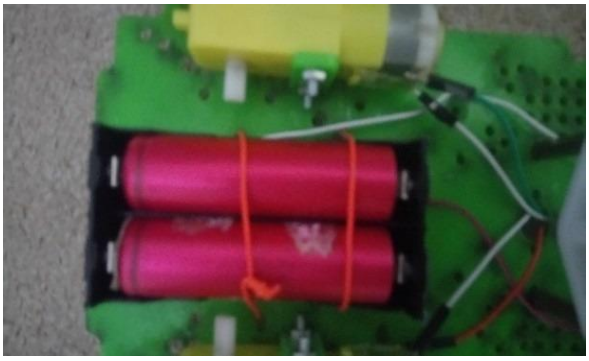

Figure 5. Image of the Batteries Integrated to the Frame

In the mechanical axis, the basic structure of the mobile robot system has been formed by providing the physical harmony of the skeleton and wheels with each other, and then the L293D Motor Driver Shield and HC-06 Bluetooth Module and Arduino have been added.

2.3. Hardware Design of the Robot

Arduino serves the most fundamental task in the system that controls the mobile robot system. Together with the L293D Motor Drive Shield, it does not perform the basic function of robot movement. Figure 6 shows the Arduino UNO model image integrated on L293D Motor Driver Shield.

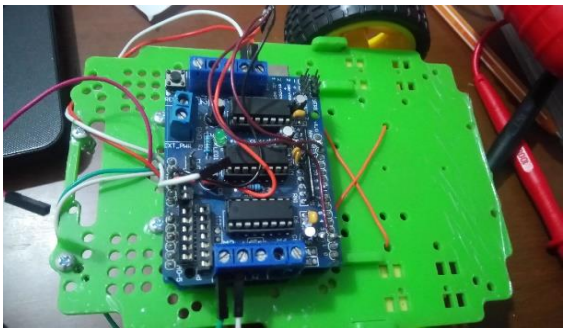

Figure 6. Image of the Integration of L293D Motor Driver Shield and Arduino UNO to the Frame

2.4. Raspberry Pi (Model 3B+)

Raspberry Pi is a credit card sized single card computer developed by the Raspberry Pi Foundation in the UK to teach computer science in schools.

Figure 7 shows the image of Raspberry Pi (Model 3B+) which has been used in this project and it features Quad Core 64-Bit 1.4 GHz ARM Cortex A53 based processor, 1GB LPDDR2 SDRAM, Dual Band 2.4 + 5GHz 802.11.b / g /n / ac Wireless Communication Module, 300Mpbs Gigabit PoE Line Compatible Ethernet Module, 4.2 Low Energy Bluetooth Module, 40 Pin Inputs, including power input pins, Micro SD Memory Card Input, Video Input with HDMI Interface, Display Port, Camera Port, 4 Pole 3.5mm Audio Output, 4 USB 2.0 Input MicroUSB 5V / 2.5A.

In this project, the 3B+ model of Raspberry Pi series was used to retrieve the data which were saved from the control panel to the database via HTML page on the Internet, and then transfer the relevant data to the platform where the mobile robot system operates. The Wireless Communication Module on the card is connected to the Internet and the Internal Bluetooth Module is used to transmit data to mobile robot system.

Figure 7. Image of Raspberry Pi (Model 3B+)

2.5. Arduino UNO

Arduino UNO is an Arduino board with ATMega328 microcontroller.

Figure 8 shows the image of Arduino UNO which has been used in this project and it features 14 digital input / output pins. 6 of them are used as PWM outputs, 6 analog inputs, one 16 MHz crystal oscillator, USB connection, 2.1mm power jack, ICSP header and RESET button. Arduino UNO contains all the necessary components to support a microcontroller. Arduino UNO can be powered by connecting it to a computer with a USB cable or supplying it from an external power source.

In this project, Arduino UNO was used as the main micrcontroller of the mobile robot system.

Figure 8. Image of Arduino UNO

2.6. L293D Motor Driver Module

L293D Motor Driver Module is a control board which was used in this project for controlling the DC motors on the wheels of mobile robot.

Figure 9 shows the image of L293D Motor Driver Module which has been used in this project and it features two L293D Motor Driver Controller and a 74HC595 Shift Register. Shift Register increases the number of pins from 3 to 8 to control the motor direction and two L293D Motor Driver provides the main functionality of controlling the motors.

Figure 9. Image of the L293D Motor Driver Module

2.7. Rotary Encoder Module

Figure 10 shows the image of Rotary Encoder Module which has been used in this project and it is an electromechanical encoder that generates an electrical signal based on the movement of the shaft on which it is located.

In this project, Rotary Encoder Module is integrated into the motors to monitor the motor position for the allowing the robot to move along the specified distance.

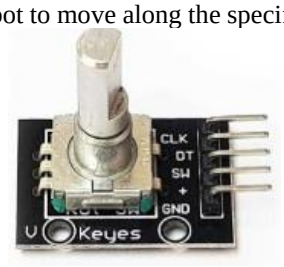

Figure 10. Image of Rotary Encoder Module

2.8. HC-06 Bluetooth Module

Figıre 11 shows the image of HC-06 Bluetooth Module which has been used in this project and it features high-speed data transfer that enables wireless serial communication in an open area of 10 to 100m radius.

In this project, HC-06 Bluetooth Module was used for providing the communication between Raspberry Pi and Arduino.

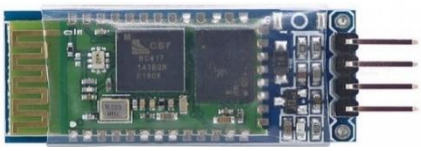

Figure 11. Image of HC-06 Bluetooth Module

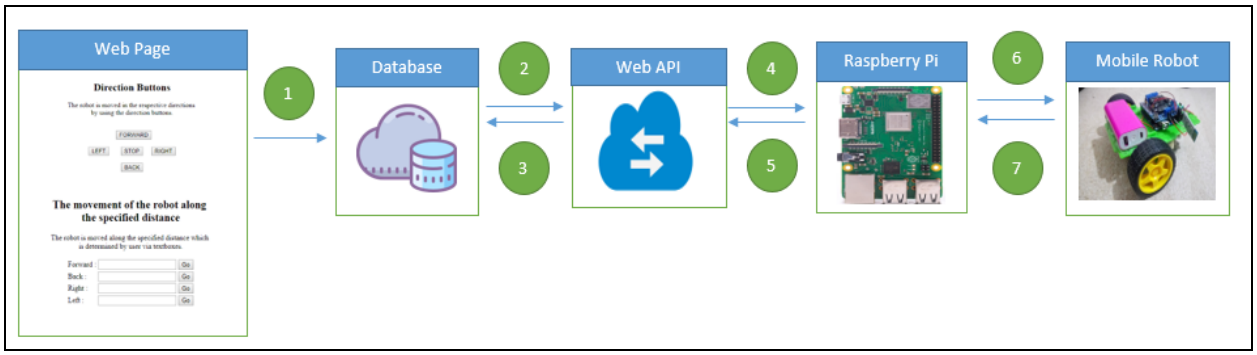

Figure 12. The Flowchart of the Proposed Architecture of the System.

2.9. System Architecture

In the first step, a HTML-based web page which has the control interface was created for the interaction with the user. By using this HTML page, the user can move robot using the direction buttons to the relative directions and also can move the robot along the specified distances (cm) using the textbox areas on the control panel.

After the user interaction, the relative data are stored on the database. This data retrieval operation on the control panel from user is performed by a POST method which is one of the main HTTP requests and these data are saved to a database on the web which was created using MySQL database management system.

Figure 12 illustrates an example PHP script of data retrieval operation using POST method of HTTP request. In this script code, "Forward" instruction which is submitted clicking the related directional button is saved to the related area on the database.

```php
if(isset($_POST['Forward']) && !empty($_POST['Forward']))
{
    session_start();
    $data ="forward";
    $sql = "INSERT INTO data(data) VALUES ('$data')";
    mysqli_query($db,$sql);
}
```

Figure 12. Basic PHP Script Code of the usage of POST Method.

In the second step, Web API is one of the latest methods for establishing communication between devices which have Internet connection. It works as a framework for creating services that can communicate over HTTP protocol, which can be handled by a large number of different clients (smartphones, web browsers, tablets, computers, etc.) (Trichkova, 2015). According to this determination, the database and Raspberry Pi must be connected each other for transferring data through a Web API .So in this project, a Web API is needed for fetching the control data from the database for sending them to Raspberry Pi.

In the third and fourth steps, Raspberry Pi makes a connection to Web API using HTTP protocol to request data from the database. Then, Web API connects to the database and shows these data to Raspberry Pi in a specific data format. Figure 13 illustrates an example PHP script of database connection and encoding of the data.

```php
<?php

$db = mysqli_connect("hostname","id","password","database");
$sql = "SELECT data FROM data";
$result = mysqli_query($db,$sql);
$data = array();


    while($row = mysqli_fetch_array($result))
    {
        $data["data"] = $row["data"];
    }

echo json_encode($data);
mysqli_close($db);
?>
```

Figure 13. Example of Basic PHP Script Code of Database Connection and JSON Encoding.

In the fifth step, The specified data format used which was used and referred on the previous paragraph is JSON.

JSON (JavaScript Object Notation) is a structurally lightweight and flexible data exchange format that is easy to read and write, which can be easily used in applications, and its main purpose is to exchange data in smaller sizes during the data transferring operation.

Web API shows the data in JSON format and Raspberry Pi parses JSON data. Figure 14 illustrates an example Python script of making a connection to Web API and parsing JSON data to extract the requested control data.

```python
#!usr/bin/env python

import urllib
import json

while 1:
    response = urllib.urlopen("http://vipreteam.com/json.php")
    json_data = json.loads(response.read())
```

Figure 14. Basic Python Script Code of Reading JSON Formatted Data From the Requested URL.

In the sixth and seventh steps, Raspberry Pi makes a Bluetooth communication to Arduino by its Internal Bluetooth Module to send the control data retrieved from Web API. Figure 15 illustrates an example Python

script of establishing serial Bluetooth Communication and sending the parsed JSON data to this serial port.

Finally, Arduino makes connection to this port by its HC-06 Bluetooth Module and retrieves the extracted control data and controls the mobile robot system according to these data.

```
#!usr/bin/env python

import serial

port = serial.Serial('/dev/serial0',baudrate=9600,
                     parity = serial.PARITY_NONE,
                     stopbits = serial.STOPBITS_ONE,
                     bytesize = serial.EIGHTBITS,
                     timeout = 1)

while 1:
    port.write(json_data['related_data_index_name'].encode('utf-8'))
```

Figure 15. Basic Python Script Code of Establishing Serial Port and Sending Parsed JSON Data to this Port.

3. Conclusions

After the hardware and mechanical parts of the mobile robot were created, the web page of the control panel was created and uploaded to the server on Internet.

In the control panel of Figure 16, there is an interface consisting of direction buttons that determine the direction in which the mobile robot will move and a separate interface which receives distance data (cm) from user that the robot will be moved along the relevant distance. For example, the Forward button on the first interface is submitted by user, the corresponding command saved to the database. Then, Raspberry Pi connects to the Web API, receives the control data and sends these data to the mobile robot system. Likewise, the control of the mobile robot has been accomplished by using the corresponding interface on the control panel succesfully.

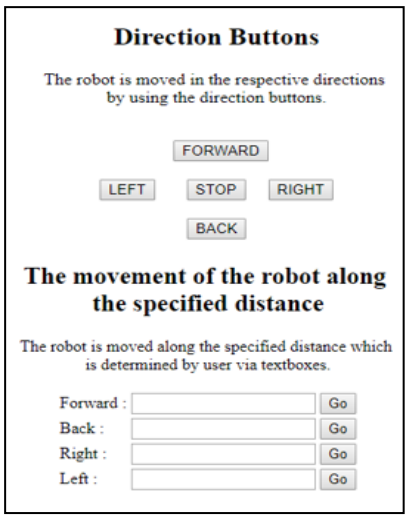

Figure 16. Control Panel on the Web Page.

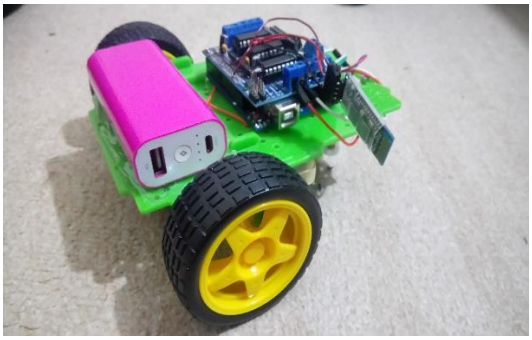

Figure 17. Image of the Mobile Robot

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