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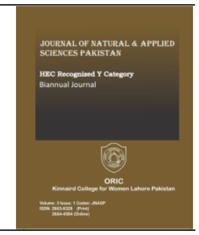

INTERNET-ENABLED WIRELESS MONITORING AND DEVICE CONTROL SYSTEM

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Abstract

Abstract: In this study, we focused on controlling various electronic devices wirelessly. Many systems based on wireless technology are available on the market, with ranges varying from meters to a few kilometers. However, when it comes to controlling devices from one area to another—across different cities, states, or even countries—conventional controlling devices are not feasible. Controlling devices through the internet has made this task possible, as the internet is accessible worldwide. The user is crucial to the operation of this project; it is not dependent on automated control, such as navigating between two GPS positions or an automated line-following system. The user receives all visual information from the onboard camera and uses it to send commands to control the robot. This type of control requires a controller, which can be a PC, laptop, or smartphone. The object to be controlled must have an internet connection and a device capable of accessing internet data. Additionally, software plays a crucial role, requiring web design languages along with some scripting languages. The majority of the robot's performance was as anticipated. It worked flawlessly in the open areas where we tested it. Because there was little lag thanks to the integrated video server, video streaming operated well. Despite some issues with the camera rotation button, the control interface functioned flawlessly. Other features, such going forward, reversing, turning right, and turning left, all operated without any issues, suggesting that the onboard motor may have been the source of this difficulty. By making the environment more dynamic and user-friendly, this project offers a fun user experience and is very helpful in a variety of situations.

1. Introduction

Conventionally, even in this modern world where everything is advancing, we still use traditional methods, such as switches, to regulate various devices at home and elsewhere (C. Chaudhary *et al.,* 2021). The physical method of switching devices is not convenient, especially for elderly and disabled individuals; therefore, we need to find a solution. We have now entered the era of technology, where we aim to design a system that eliminates all traditional methods of controlling devices (Ayub, U *et al.,* 2021). This study will put light on an advanced control system that will enable people to monitor their devices like fan, light, refrigerator, air-conditioner, automobiles etc. via internet. Such controlled devices are known as "smart devices". This automation system is getting more popular and a common practice as well (A. K. Panigrahi *et al.,* 2021). A smart device can be consider as an integration system which would use the range of techniques like computers, network communication and wireless technology that would connect all indoor subsystems that are attached to household electrical devices (Wangemann *et al.,* 2022). The proposed system is cost effective solution that will control electrical devices remotely and hence guarantee security in the absence of owner (McAndrew & Alasdair, 2015). This study demonstrate an advanced system of home and specially automobile automation that will utilize the controlling via internet, connected with wireless network to enable wireless control over electrical devices in automobile as well as in home (M.A. Abu Radia *et al.,* 2023). This controlled system would be operated from any place around the globe. This proposed system will utilize the use of networking that is controlling the various devices and automobile from internet (Sirin Kumari *et al.,* 2024). Hence, the proposed system would be highly beneficial as it is cost-effective, prevents electricity loss, and has a vast range, allowing devices to be controlled from any location (L. Akter *et al.,* 2024).

1.1 Problem Statement

We are interested in designing a smart device which removes all the manual methods that require human effort to turn On/Off the devices through mechanical switches. This system utilizes the use of automobile through internet that will allow the users to make control over their home appliances and automobile wirelessly so controlling can be done from effortlessly (Dawid Witczak & Sabina, 2024). The capacity to remotely monitor and operate objects via the internet has become a crucial component of modern life and industrial operations in the quickly expanding sector of the Internet of Things (IoT) (Reimers *et al.,* 16). However, the range, security, dependability, and scalability of current wireless communication systems are frequently severely limited. Many existing systems fail to offer safe or scalable solutions, and devices in many of them experience connectivity problems in bigger areas or complex contexts (Mukherjee *et al.,* 2017). In industries where efficient, long-distance communication is essential, these obstacles impede the broad adoption of IoT solutions (Piriya *et al.,* 2017). The purpose of this article is to examine the possibilities for creating a broad wireless monitoring and control system that tackles these issues, guaranteeing increased security, scalability, and dependability while enhancing user experience;

(Marieke E.Klijn & Jurgen Hubbch, 2021). The idea in which we are interested is that we would design a same controlled automation system that would be able to give a chance to user to control their devices wirelessly from any place (M. Islam & M. Chowdhury, 2020). This is the study which will provide the users with the control of devices and the visual feedback of environment remotely (M. Alhelaly, 2019). This study is about the controlling of various devices over the internet wirelessly (H. Taneja *et al.*, 2019). Idea of controlling the devices using internet connection gives this study the agility to be controlled globally (O. Kennedy *et al.*, 2017). The aim of the study is to work in the area which is not feasible for the human observer and also designed for the users who wants to remotely monitor his/her premises (A. Barthwal & K. Sharma, 2017). The main feature of our study is to implement a cost-effective and reliable smart system that replaces complicated circuits and devices while also saving time (R. Kjeiiby, *et al.*, 2019). This study involves knowledge of programming, web design, and networking, with the Linux (Debian) operating system also being utilized. By implementing this idea, users can easily control their devices via the internet.

1.2 Purpose and Objective

The main purpose of choosing this idea is to implement a smart system. A smart system can be considered analogous to an automobile, where no human effort is required to control devices through a switch; instead, all devices will be controlled automatically. To achieve this, a controlled system will be developed, operating via internet communication on our laptops. This internet-controlled system will enable the smart system to control devices remotely from any location to the desired area.

The main objectives of our idea are as follows:

- Design an analog and digital electronic acquisition system for the microcontroller.
- Utilize interface techniques to connect the microcontroller.
- Replace hardware circuits by developing equivalent program code.
- Implement a cost-effective and reliable smart automation system capable of remotely controlling devices.

2. Materials and Methods

Figure 1 shows the block diagram of the system, illustrating the data flow and effectively explaining its working principle. Since the project is not based on automated control—such as maneuvering between two GPS coordinates or an automated line-following system—the user plays a central role in its operation. All visual data captured by the onboard camera is transmitted to the user, who then sends commands to control the robot. A webpage serves as the communication platform between the user and the BeagleBone Board. The user’s commands are transmitted via this webpage over a Wide Area Network (WAN) and then through a Local Area Network (LAN), where they are received by the board. The board processes these commands and executes the required actions accordingly; *Ayub, U* et al. [2]. WAN enables the user to control the robot over long distances and is also referred to as a public network. On the other hand, LAN refers to the network to which the robot is connected, which can be as small as a Wi-Fi network within a room or building or as large as a network provided by services like EVO. The BeagleBone Board serves as the central processing unit of the system. It is powerful enough to handle user requests while also acting as a server; McAndrew and Alasdair [5]. The webpage interface that the user interacts with is hosted on this unit, allowing it to control all connected electronic components through Python programming. The board runs on Linux (Debian) as its operating system, ensuring stability and efficient processing.

2.1 Designing of Hardware Structure

For any project to function as specified, it is essential to have a reliable power supply, especially when dealing with electronic circuits. The power supply circuit is one of the main components of the onboard system. Since our circuit includes a BeagleBone Board, we opted not to use a separate power source for it. Instead, we designed a power supply circuit incorporating two voltage regulators. One regulator supplies 5V, with capacitors in place to eliminate any ripples present in the input or output. This 5V supply is specifically used to power the BeagleBone Board. Additionally, another regulator in the circuit provides a 9V supply, also using capacitors to remove any voltage fluctuations. This 9V power source is responsible for driving the motors and other onboard equipment, including the buzzer, LEDs, and three different motors.

Figure 1: Block diagram of the system.

To control the buzzer and LEDs, we used a simple transistor circuit. The output from the BeagleBone Board is connected to the base of the transistor, which acts as a switch to turn the buzzer on and off based on the input from the board. A 1kΩ resistor is placed at the base of the transistor, serving as the input point for the command from the BeagleBone Board. This resistor limits the amount of current flowing from the base to the emitter, ensuring the protection of the BeagleBone Board. Additionally, another resistor is connected to the collector of the transistor to safeguard the buzzer and LEDs from excessive current flow. This circuit is based on integrated circuits (ICs) and is primarily designed to drive the motors in the car. An H-Bridge IC is used for this purpose, allowing the motors to operate in two different directions based on user input. Additionally, these ICs are suitable for low-voltage applications, making them ideal for this system. The onboard setup includes three motors, each serving a specific function: one for driving the car forward and backward, another for making turns, and the third for rotating the onboard camera. This part of the project primarily relies on the L293D H-Bridge IC, which is specifically designed for motor control.

Table 1: Hardware Summary

SR. No.	Hardware Summary	Specification	References
1	Power Source	9V, 2A and 5V, 1A	[5, 8-11]
2	Processing Unit	Beagle Bone Board	[3, 8, 15]
3	Motor Driver IC	L293D H bridge Analogue+Digital IC	[15]
4	Motors	M1 & M2 for driving M3 for rotting Camera	[13]
5	Control Circuit Components	Transistor BC547, 1K Resistor	[2, 9, 14]
6	Output Components	Buzzer, LEDs	[4, 11-14]
7	Input Component	Camera	[17]

2.2 Software and Programming

Software for this remotely controlled drone using IoT for technology comprises of three main components.

1. On board server
2. Client accessible Web based UI
3. Hardware control using I/Os

1. The onboard server is essentially an API of the Apache server, used to host the website directly from the onboard system. The primary reason for utilizing an onboard server instead of a separate server is to ensure faster transmission of commands between the user and the device. Additionally, an onboard API for the camera server was installed to enable live streaming from the onboard camera.

2. Figure 2 illustrates the command flow for the user-accessible website's UI. When the user accesses the webpage and logs in, they are presented with a set of control buttons and a live streaming window. The user can issue various commands to the device, including Forward, Reverse, Turn Left/Right, Camera Turn Left/Right, Light ON/OFF, and Horn. Whenever a button is pressed, it triggers the associated PHP code. There are four separate PHP files handling different sets of commands: the first file manages Forward, Reverse, and Turn Left/Right; the second controls Light ON/OFF; the third handles Camera Turn Left/Right; and the fourth is responsible for the Horn. The UI remains active until the user decides to close it by pressing the close button.

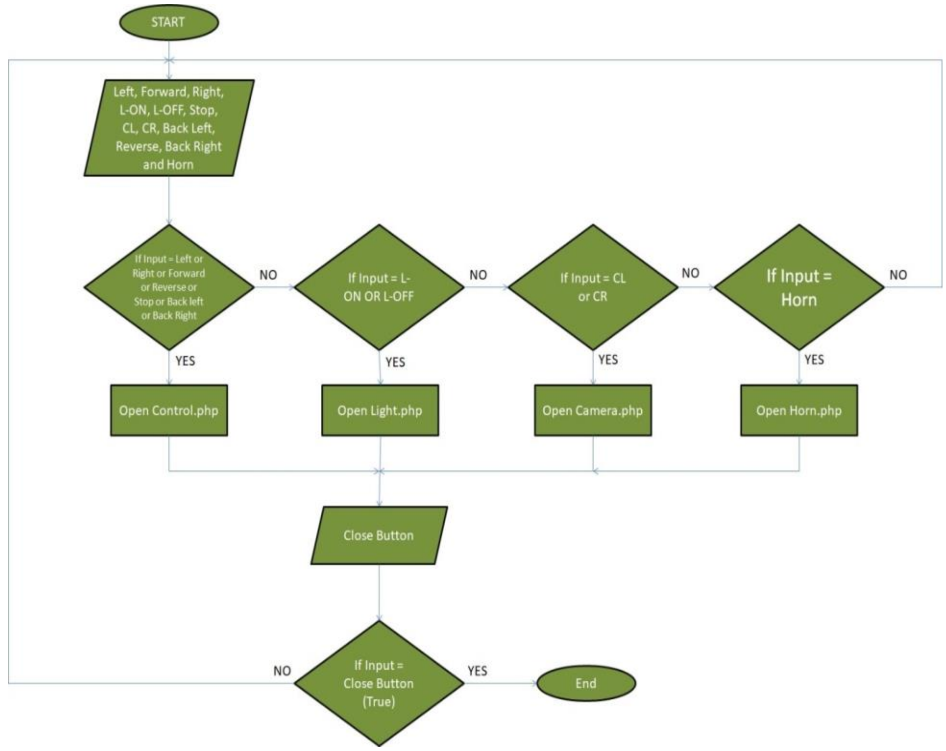

Figure 2: Website UI flow chart.

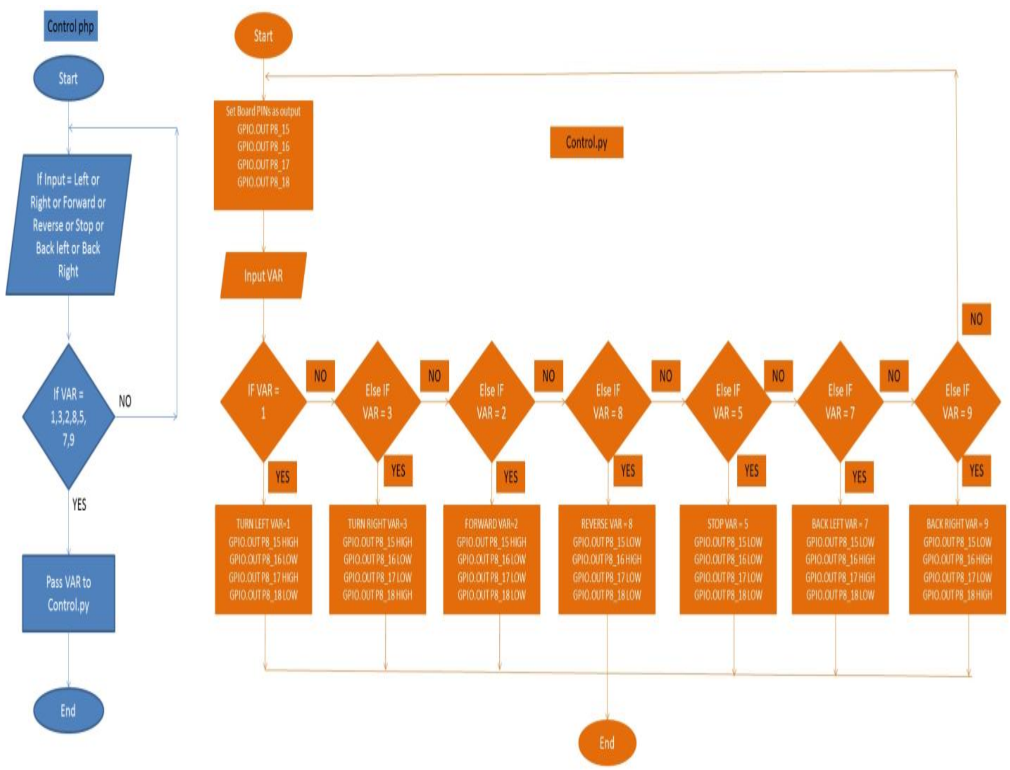

Figure 3: Blue control.php and orange control.py

3. Flow chart in (Figure 3) shows two flow charts one in blue is of Control.php and another one in orange is of control.py, whenever user presses a button a certain variable related to that button is passed on to the PHP code from UI this code could also be called as a button identifier for that particular PHP file, this PHP file which is Control.php in our case then passes on this variable to designated Python file which is Control.py in our case which has the basic purpose of invoking board's GPIOs defined for controlling motors, once the variable is passed from PHP file to this Python code it then has certain sets of conditions to determine which particular GPIOs should remain High and which should remain LOW so in order to make the user command being implemented as can be seen there are 7 conditions for this particular set of commands, same is the case for other PHP and Python files.

3. Results and Discussion

The challenges associated with the project were primarily related to internet availability in the required environment. To address this issue, we decided to use an onboard internet dongle. Web design played a crucial role in the project, as it served as the interface connecting the user with the BeagleBone Board. Therefore, it was essential to develop functional and reliable code to ensure the system operated correctly under the required conditions. In addition to web design, we used Python and PHP as the primary programming languages for writing the control and communication scripts. For successful communication between the BeagleBone Board and the user, a stable network connection was essential. We used Apache server software on the BeagleBone, which made it easy to access the required webpage within a local network. However, the real challenge arose when we needed to connect the BeagleBone Board to **a** public network. To resolve this, we had to study port forwarding on the router. Another major issue was the dynamic IP address, which created difficulties in maintaining a stable connection between the board and the user. Since the public IP address of the board kept changing, the user needed a way to determine the current IP. This problem was solved by registering a domain name through a web service, allowing the BeagleBone Board to be accessed via a fixed domain instead of a changing IP address. Video transmission was another challenge during the project. We addressed this by using a script by Derek Molloy, which provided a video server for the BeagleBone. This solution enabled the onboard camera to function as an IP camera, streaming real-time video through a designated port. The robot performed as expected in most aspects. We successfully tested it in open fields, where it functioned smoothly. Video streaming worked efficiently, as the onboard video server ensured minimal lag. The control interface operated well, though we encountered some glitches in the camera rotation button. This issue might have been caused by the onboard motor, as other functions—such as moving forward, reverse, turning right, and turning left—worked without any problems. The internet speed of the onboard dongle was sufficient to ensure smooth operation. The inclusion of the L293D motor driver was highly effective, as it prevented the BeagleBone Board's GPIOs from directly handling the motor's load. Additionally, the domain name registration provided stable connectivity, eliminating issues caused by dynamic IP changes. Overall, the robot's performance met expectations, with only minor improvements needed in the camera control system.

4. Applications

This project enhances security by enabling users to detect unauthorized individuals in their yard, serving as a remote monitoring unit. Additionally, it can function as a land surveillance vehicle for searching and locating objects from a safe distance. Its compact design, combined with a motorized camera, provides a 270-degree field of view, ensuring extensive visual coverage. This allows for discreet surveillance, as the device can be positioned in a corner without attracting attention due to minimal wheel movement noise. Beyond security applications, this project holds significant value in research. It can be deployed in environments that are hazardous or unsuitable for human presence, such as regions with extreme temperatures. Furthermore, in remote areas with abundant sunlight, integrating a solar panel could make the system self-sustaining, eliminating the need for frequent manual recharging. Lastly, the project can be utilized in workplaces for employee monitoring, allowing employers to oversee operations remotely from their air-conditioned offices, thereby conserving energy and improving overall efficiency.

5. Conclusions

This project is highly useful in various scenarios and provides an enjoyable user experience by creating a more interactive and user-friendly environment. However, despite its advantages, it also has some drawbacks. A poor network connection may lead to disconnection from the device, causing delays in response. Unlike online gaming, where minor delays may be insignificant, in this practical application, such delays can severely impact decision-making and potentially result in damage to the project. One of the key advantages of this project is its affordability. It utilizes low-cost components, such as simple DC motors and a low-resolution camera, which is used primarily for monitoring rather than high-resolution photography. The only expensive component in its assembly is the BeagleBone Black. The project relies on an internet connection as its communication medium, enabling worldwide remote control. As long as the system remains connected to the internet, users can operate it from anywhere in the world.

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