

# BBM460 Wireless and Mobile Networks Laboratory Final Report Bluetooth RC Car with Wi-Fi Camera



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## Abstract

The main motivation behind this project is to build a remote-controlled car using Bluetooth and having live video surveillance with Wi-Fi technologies to experience these most commonly used two wireless connection types. This RC Car prototype can further be adapted to short-range military applications, daily-life assistant applications, and entertainment fields [1].

With advances in technology over the years, it is possible to remotely monitor areas of importance by using robots in place of humans, and in this context, we developed an RC Car with Bluetooth and Wi-Fi, for controlling and video surveillance purposes, respectively.

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## 1 Introduction

As the final project for our BBM 460 - Wireless and Mobile Networks Laboratory, we decided to develop a remote-controlled car for video surveillance. This car is controlled by an Android phone, and the visual data is viewed on any web browser connected to the same network as the car.

For this purpose, we have used Arduino UNO R3, HC-05 Bluetooth Module, ESP32 Wireless Camera Module, L298N Motor Driver, DC motors, breadboard, car chases, wheels, 9V battery, and jumpers. We have written the Arduino code in Arduino IDE on Linux and prepared the Flutter mobile app in Android Studio on Linux. The design and implementation details will be covered in the next sections.

## 2 Explanation of Technologies

### 2.1 Bluetooth

Bluetooth [2] is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480 GHz, and building personal area networks (PANs).

### 2.2 Wi-Fi

Wi-Fi [3] is a family of wireless network protocols, based on the IEEE 802.11 family of standards that are commonly used for local area networking of devices and Internet access.

## 3 Explanation of Components

### 3.1 Flutter Mobile App

Flutter is a free and open-source mobile UI framework created by Google and released in May 2017. In a few words, it allows you to create a native mobile application with only one codebase. This means that you can use one programming language and one codebase to create two different apps (for iOS and Android).[5]

Utilizing Flutter, The mobile app was created. The bluetooth connection between car and mobile app provided and in this way the forward, back, right, left, and stop commands sends to the car. Using Webview Plugin, the camera interface can be seen in the white space below.

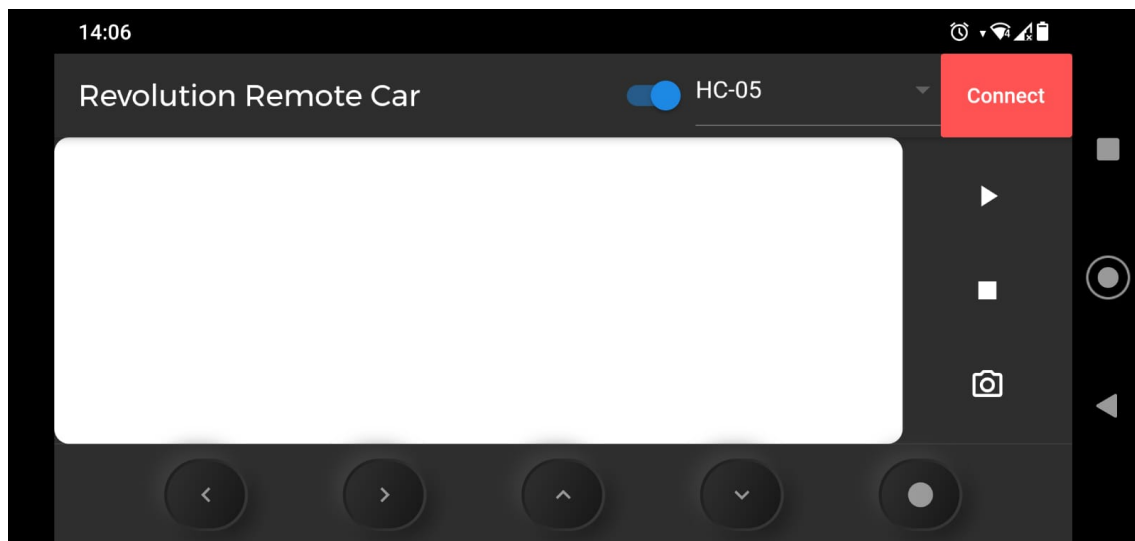


Fig. 1. Mobile App View

### 3.2 HC-05 Bluetooth Module

HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with controller or PC. [6]

- **Type:** Bluetooth Module
- **Purpose:** Provides wireless one way synchronized transmission between a cellphone and Arduino Uno single-board computer
- **Function:** Turn On/Off , Connect
- **Subordinates**
  - Arduino UNO
- **Interfaces**
  - **In:** Analog Signal, Digital Data, Flutter App
  - **Out:** Digital Signal, Digital Data, Arduino UNO

### 3.3 Arduino UNO

Arduino [4] is a microcontroller board based on the ATmega328P. It contains everything needed to support the microcontroller; simply connect it to a computer with a cable or power it with an AC-to-DC adapter or battery to get started. It can be upgraded with several integrations such as Wi-Fi and BT modules, motors, additional hardware.

- **Type:** Mainboard
- **Purpose:** Provides controlling the car remotely and the corresponding data-signal transmission, according to input commands.
- **Function:** Start, Stop, Steer, Gas, Break
- **Subordinates**
  - L298N Motor Driver
- **Interfaces**
  - **In:** Digital signal, Digital data, HC-05 Bluetooth Module
  - **Out:** Digital signal, Digital data, L298N Motor Driver

### 3.4 L298N Motor Driver Module

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A.[12]

- **Type:** Motor Driver Module
- **Purpose:** Interface between the mainboard and the DC motors
- **Function**
  - All wheels turning forward(Forward command)
  - All wheels return(Back command)
  - Right wheels spin forward(Turn Left command)
  - Left wheels spin forward(Turn right command)
- **Subordinates**
  - DC Motors(x4)
- **Interfaces**
  - **In:** Digital Signal, Digital Data, Arduino UNO
  - **Out:** DC current to the DC motors

### 3.5 ESP32 Camera Module

ESP32-CAM is a low cost development board with WiFi camera. It allows creating IP camera projects for video streaming with different resolutions. ESP32-CAM has build in PCB antenna.[8]

- **Type:** Camera Module( with AI Features )
- **Purpose:** For visual surveillance component. Starts web server fixed IP Address.
- **Function**
  - Start Stream
  - Stop Stream
  - Face Recognition
  - Face Enroll
  - Taking Photo

## 4 Software Details

In order for the Flutter application to work properly, the mobile phone SDK range version must be the following:

- minSdkVersion 19
- targetSdkVersion 29

The codes and their explanations are covered in the APPENDICES.

### 4.1 Languages, Frameworks, Plugins and IDE

- Dart(Programming Language for Flutter)
- C/C++(Programming Language for Arduino and Camera code)
- Flutter(Cross-platform framework)
- Android Studio(IDE): is used for writing Dart codes, debug and testing code.
- Arduino IDE: is used for writing C/C++ codes, debug and testing code.
- Genymotion(Cross-platform Android emulator): is used for virtual device and testing codes.
- `webview_flutter`(Plugin): is used for Camera Interface integrating to Flutter App.

#### Requirements

- minSdkVersion 19
- `flutter_bluetooth_serial`(Plugin): is used for Flutter app bluetooth connection with HC-05 Module and sending commands.

#### Requirements

- minSdkVersion 18

## 5 Hardware Details

### 5.1 Arduino UNO Mainboard

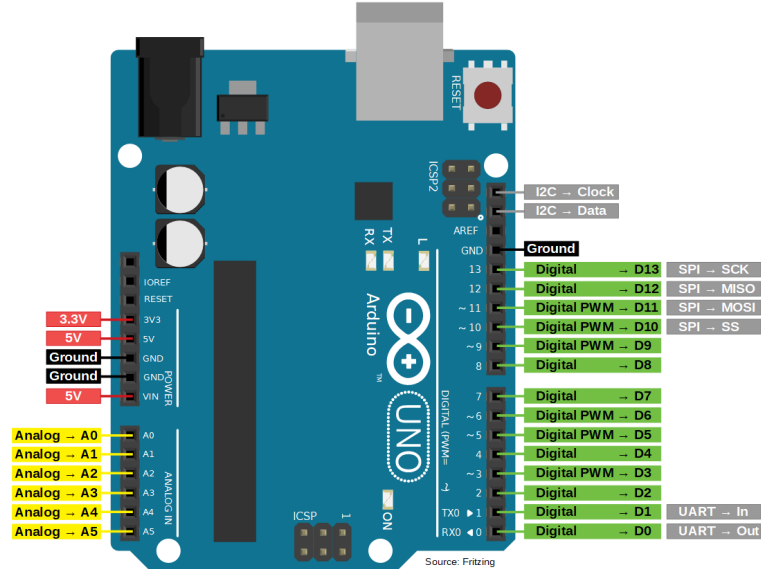


Fig. 2. Arduino UNO Pinout [9]

This mainboard is the main hardware component of the project, since all the other hardware components are connected to each other by it. These connections and the overall circuit diagram will be covered in the following sections. For now, only the pinout scheme of Arduino UNO is shown in Fig. 2.

### 5.2 HC-05 Bluetooth Module

The HC-05 Bluetooth Module provides the Bluetooth (2.0) communication between the Arduino UNO and other Bluetooth devices, as the name suggests. It works on a logic level of 3.3V. So, a 3.3V Regulator is used on the board.

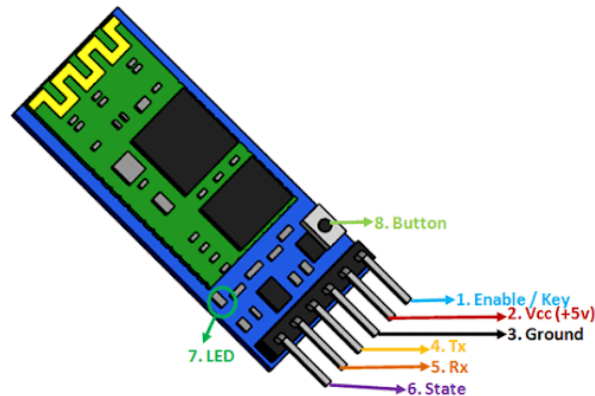


Fig. 3. HC-05 Module Pinout [10]

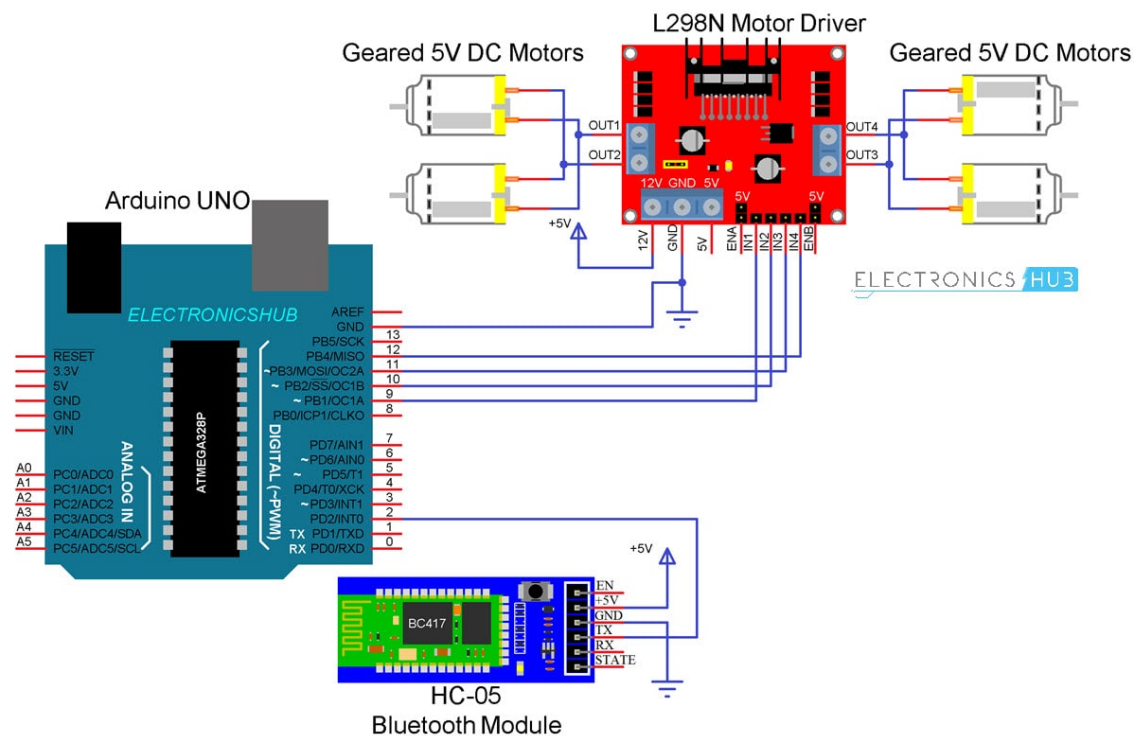
### 5.2.1 Pin Descriptions

- EN: Enable pin. When this pin is connected to 3.3V, the module is enabled. If this pin is connected to GND, the module is disabled.
- +5V: This is the supply pin for connecting +5V, but since the module has a 3.3V regulator, we can safely use 5V power supply.
- GND: Ground pin.
- TX: Transmitter pin of the communication.
- RX: Receive pin of the communication.
- STATE: This is a status indicator pin. This pin goes LOW when the module is not connected to any device. When the module is paired with any device, this pin goes HIGH.

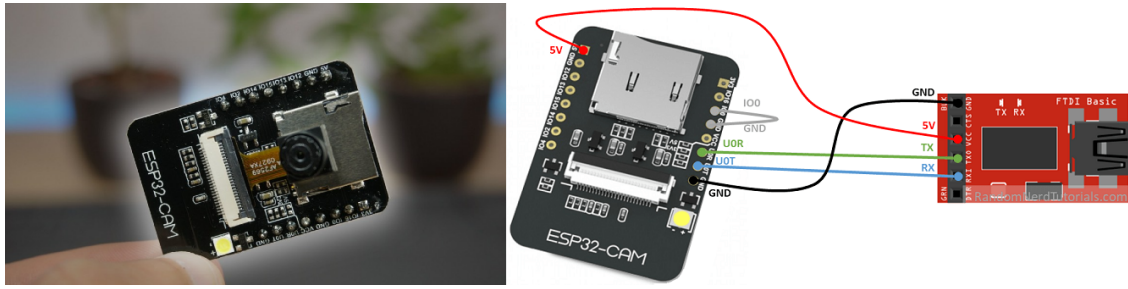
## 5.3 L298N Motor Driver Module

This module provides the required DC current to the motors (4x). The L298N Motor Driver has a dual full driver IC, so it can control upto 2 motors simultaneously. Hence, while controlling our car, we run only two wheels at the same time. For example, to turn right, only the motors at the left-hand side run forward, and vice versa.

The L298N Motor Driver Module will directly take the input data from Arduino's 9-10-11-12 pins. The overall circuit diagram of the car, covering the Bluetooth module, motor driver and wheels is shown in the next figure.



**Fig. 4.** Circuit Diagram of Bluetooth Controlled RC Car [11]



**Fig. 5.** ESP32-CAM and Programmer Diagram [7]

## 5.4 ESP32-CAM Module and Programmer

ESP32-CAM is a very useful component since it contains an embedded Wi-Fi endpoint alongside the camera itself. Also, it does not require any additional connections to the mainboard apart from the 5V and GND connections. After the power connections are done, the camera can start streaming realtime videos to a specific IP address, in the same network. To make the first-time connection and registration, the camera module must be loaded with the FTDI Programmer.

The steps can be summarized as:

1. Installing the ESP32 add-on to Arduino IDE
2. Loading the pre-written code (File/Examples/ESP32/Camera/CameraWebServer)
3. Uploading the code to camera with FTDI Programmer (the pinout is shown in Fig. 5)
4. Obtaining IP Address from Serial Input
5. Opening the IP Address from the URL of the browser

## 6 Conclusion

Via the Android application, forward, backward, right, left and turn on the camera commands, using bluetooth, a signal will be sent to the HC-05 Bluetooth module connected on the Arduino Uno single board computer. Then this module transmits the incoming signals to Arduino Uno. According to the content of the incoming command, signals are directed to the correct inputs of the L298N Engine Module. This engine module directs signals to 4 motors connected to it and the vehicle moves. For camera surveillance, data from the camera is sent to the android application using Wi-Fi technology.

Finally, we have experienced the Bluetooth and Wi-Fi communication technologies and their real life applications on a simple RC car prototype. As a result of this work, we made an inference that the data transfer rate is 3mbps and the maximum range of a Bluetooth device can be 10-20 meters. For wireless communication, the default baud rate is 38400 and other supported baud rates are 9600, 19200, 57600, 115200, 230400 and 460800. The criteria for choosing the baud rate are as follows.

- Data speed (Higher baud rate = faster transmission)
- Connection range (long distance == more distortion / loss == can only support lower baud rate)

## 7 Resources

- [1] <https://www.electronicshub.org/bluetooth-controlled-robot-using-arduino>
- [2] <https://en.wikipedia.org/wiki/Bluetooth>
- [3] <https://en.wikipedia.org/wiki/Wi-Fi>
- [4] <https://store.arduino.cc/usa/arduino-uno-rev3>
- [5] [freecodecamp.org/news/what-is-flutter-and-why-you-should-learn-it-in-2020](https://freecodecamp.org/news/what-is-flutter-and-why-you-should-learn-it-in-2020)
- [6] <https://www.gme.cz/data/attachments/dsh.772-148.1.pdf>
- [7] [randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide](https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide)
- [8] <https://www.olimex.com/Products/LoT/ESP32/ESP32-CAM>
- [9] <https://diyi0t.com/arduino-uno-tutorial>
- [10] <http://blog.ikizoglu.com/2018/05/arduino-hc-05-bluetooth-kullanimi/>
- [11] <https://www.electronicshub.org/bluetooth-controlled-robot-using-arduino/>
- [12] [howtomechatronics.com/tutorials/arduino/arduino-dc-motor-control-tutorial-l298n-pwm-h-bridge](https://howtomechatronics.com/tutorials/arduino/arduino-dc-motor-control-tutorial-l298n-pwm-h-bridge)