SMART TRAFFIC LIGHT WITH IOT

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ABSTRACT

Traffic lights are signalling devices position at road intersections to control flows of traffic. Due to the Penang is very small, and there is a lot of road with junction, traffic light become the most important devices to control the traffic flows. The existing traffic light system is the pre-set period, inflexibility of the traffic light has sometimes caused the traffic to be jammed. It causes a lot of troubles to the drivers and it greatly affects those emergency especially for ambulance. This paper presented a model of smart traffic light system was built by using sensors to detect the traffic flow and response accordingly. The system is able to arrange the logic to prioritize the directions with more traffics. With this smart traffic light algorithm, it will make the traffic light more efficient and reduce the traffic jam. A mobile application was created together with the system which able to send interrupt to the traffic light system by using Internet of Thing. The traffic light will change to green for the direction where the emergency rescue team come from. This can help to make emergency rescue team to pass through the traffic light with minimum delay. The proposed model expected to provide a significant improvement to the traffic system in Penang.

Keywords: smart traffic light, internet of things

1. Introduction

Traffic lights are signaling devices position at road intersections to control flows of traffic. Traffic lights display a standard alternate colour (red, yellow and green) to give way to users. Green light allows traffic to proceed in the direction denoted, Yellow light warns that the signal is about to change to red, while the red colour prohibits any traffic from proceeding.

In Malaysia, traffic light is the system used to control the traffic for a junction since long time ago. Normally, a traffic light will be set up at the junction with the traffic of average 800 to 5500 vehicles [1]. Traffic light normally has two types of preset timing, which is

peak and off-peak. Peak hours are normally referring to the early morning and the evening which that time a lot of people using their vehicles to work or off-work.

Penang an island of Malaysia which having a 293km^2 of land area with the populations of 1.767million. Due to no well establish public transport, most of the residents stay in Penang are using their own vehicle for daily transportation usage. Unlike the capital of Malaysia, Kuala Lumpur, Penang do not have a lot of highway, but is mostly state road. Traffic light become the most important devices to control the traffic in Penang.

The main problem of the existing traffic light system is the pre-set period of the traffic light, which the system called "Preset Cycle Time (PCT) Controller" [2]. The setting for this kind of traffic lights is almost be done based on prior traffic counts, and mostly the setting can be manually changed, the disadvantage of this method that if there is a congestion in any roadway, the green light will not be extended, and the next phase will continue on time without considering the traffic density in any other. Although this problem doesn't seem to be very significant where it doesn't cause a lot of troubles to the drivers, it may be greatly affects those emergencies especially for ambulance. This is always can be notice that Ambulance is always trapped in the traffic on Penang. Therefore, the implementation of a Smart Traffic Light System which with Internet of Things (IoT) is very important. With the IoT Technology, the ambulance can control the traffic light at the junction during the emergency. Besides, the smart traffic light system able to detect and compare the number of cars at each side of the junction, and automatically to set the timing accordingly.

2. Tools

2.1. Internet of Things

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items which embedded with electronics, software, sensors, actuators, and connectivity. IoT devices employ a broad array of networking protocols, applications and network domains.

The Internet of Things is making the physical world and information world together. Sensors play a very important role to bridge the gap between the physical world and information world. Sensors collect data from their environment, generating information raising awareness about context. The change of the environment can be monitored and the corresponding things can make some responses if needed [3]. IoT will make the impact of the Internet even more pervasive, personal and intimate in daily life [4]. Figure. 1 shows the graphical of Internet of Things. IoT estimated will consist of 50 billion devices connected to the Internet by 2020.

Figure 1. Internet of Things

2.2. Arduino

Arduino Mega 2560 is a single board microcontroller based on the ATmega2560 and used as the main controller for this project. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analogue inputs, 4 universal asynchronous receiver-transmitters (UARTs), a 16 MHz crystal oscillator, a USB connection, a power jack, an In Circuit Serial Programming (ICSP) header and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Arduino Mega 2560 can be programmed with the Arduino Software (IDE).

The Arduino integrated development environment (IDE) is a cross-platform application for Windows, Mac OS and Linux that is written in the programming language Java. It is used to write and upload programs to the Arduino board. The Arduino IDE is incredibly minimalistic, yet it provides a near-complete environment for most Arduino-based projects. The top menu bar has the standard options, including "File" (new, load save, etc.), "Edit" (font, copy, paste, etc.), "Sketch" (for compiling and programming), "Tools" (useful options for testing projects), and "Help". The middle section of the IDE is a simple text editor that where you can enter the program code. The bottom section of the IDE is dedicated to an output window that is used to see the status of the compilation, how much memory has been used, any errors that were found in the program, and various other useful messages.

2.3. MIT App Inventor 2

MIT App Inventor 2 is use to create the user interface for the project. It is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). App Inventor is written by using Jawa and Kawa Scheme.

This code is designed to be run in Google's App Engine. MIT runs a public instance that all are welcome to use to build App Inventor Applications. It allows newcomers to computer programming to create software applications for the Android operating system (OS).

It uses a graphical interface which allows users to drag-and-drop visual objects to create an application that can run on Android devices. In particular, DSP processor caches are only used for program instructions, not for data. A cache that accommodates data as well as instructions must include a mechanism for updating both the cache and external memory when a data value held in the cache is modified by the program.

The mobile application is created as shown in Figure 2. There is a total of 6 buttons in the Graphic User Interface (GUI). When the machine to machine Wi-Fi is connected, the user need to select one out of the 4 directions, which is North, East, South and West, then follow by the Enable button. The enable button will trigger the info to the traffic light through the IoT device. Once the process done, the screen will show the direction of the emergency which is enable as in Figure 3. The Disable button is used to disable the emergency interrupt.

Figure 2. GUI of mobile application

Figure 3. Emergency enable on mobile application

3. System Program Algorithm

The smart traffic light model using ultrasonic sensor as the sensing device to detect the presence of vehicle. The ultrasonic sensors will then send the reading to the micro-controller, Arduino Mega. The micro-controller will use the data from the sensing device to deduce the logic sequence. The smart traffic light model consists of 4 junctions; each junction consists of 2 ultrasonic sensors as Figure 4.

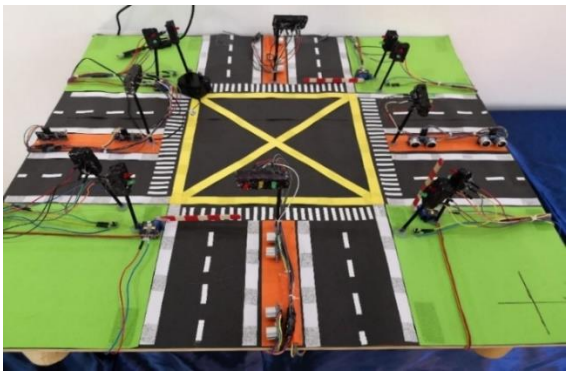

Figure 4. Smart traffic light model with 4 junctions

For the first stage of the smart traffic light system, it is focus on the algorithm set inside the single board microcontroller. The algorithm is function base on the input of the ultrasonic sensor which is used to detect the flow of the traffic.

For the operation, the priority of the smart traffic light system will be given to those sides of the junction which is considered jammed when both of the ultrasonic sensors sensed an object. This condition will be assuming that this junction is consider packed.

The first condition which is one of the 4 junctions (junction A) is packed, while another 3 junctions (junction B, junction C and junction D) do not have a lot of cars which only the first ultrasonic sensor detect car. Junction A will have green light for traffic flow. It will follow by blinking green light and then yellow light before ending with a red light.

The second condition which is two junctions (assume junction A and junction B) are packed, while another two junctions (assume junction C and junction D) do not have a lot of cars. The traffic light will start to show green light junction A and then follow by junction B. This process will repeat again before going to junction C and junction D. The process can be represented by A→B→A→B→C→D.

The third condition which is three junctions with assumption junction A, junction B and junction C are packed, while junction D does not have a lot of cars. The traffic light will start to show green light junction A, follow by junction B and then follow by junction C. This process will repeat again before going to and junction D. The process can be represented by A→B→C→A→B→C→D.

If all the junction does not have is not packed, the traffic light will remain to follow the sequence of A→B→C→D.

Besides, the smart traffic light system is called "smart" for not only its ability to sense the car to arrange the sequence of the junction, but also its ability to decrease the duration of green light. This is very critical as most of the time, the is always traffic light show green at a particular junction while there is not car flow from that direction. This is always the issue cause the traffic light inefficiency and one of the reason cause traffic jam.

When both the IR sensors of the same junction do not detect any vehicle for 5 seconds when it is in the green light stage, the traffic light will immediately decrease its remaining time to become 3 seconds of blinking green light and 2 seconds of yellow light and ending with a red light. The process will follow the next junction which is packed.

The smart traffic light system is also having road block system. The road block system is synchronized with the smart traffic light of the system. When the junction of the smart traffic light is green, the Arduino Mega will send a pulse to the servo motor to control it to turn 90° anticlockwise to open the road block. When the smart traffic is on a red light, the servo motor is controlled to turn back to enable the road block.
The smart traffic light system also has a feature for pedestrian walks. The button will be implemented near the pedestrian traffic lights. When the button is pressed, an interrupt will be sent to the Arduino Mega to light up the pedestrian acknowledgement LED. This is to indicate that the traffic light system has successfully received the wish of pedestrians to enable the pedestrian traffic light. When the traffic light system allows the pedestrian to pass through, all the traffic light will be lighted up red and the road blocks will be closed to stop the cars so that the pedestrians could walk through safely.

The second stage of the traffic light will focus on the IoT part. A mobile application is created for the emergency usages, especially for Ambulance. The mobile application is created by using MIT App Inventor 2. The mobile application will install in an android smartphone. The mobile application is connected to the Arduino Mega by using the Wi-Fi system of the smartphone to the ESP8266 Wi-Fi module.

The mobile application is used to enable the emergency anywhere as long as the smartphone and the traffic light is connected to the Wi-Fi. They are using machine to machine Wi-Fi communication as well as point to point communication. The working mechanism of the system is by choosing the side of the junction where the emergency came from before enabling, and the Arduino Mega will be able to set the particular side

to green light immediately while the others side will be lighted red. This is an interrupt process which will react immediately. The process will only be terminated when the emergency is disabled.

Figure 5 shows the overall system I/O for the smart traffic light system. The inputs of the system are ultrasonic sensors, push button and ESP 8266 Wi-Fi module. The output of the systems are LEDs, servo motors and ESP 8266 Wi-Fi module. Single board microcontroller, Arduino Mega act as the brain of the smart traffic light system.

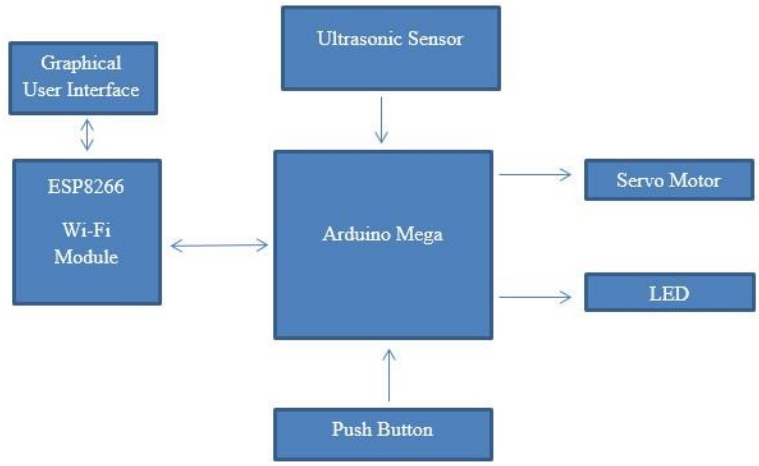

Figure 5. System I/O block diagram

This traffic light system model expect to reduce the traffic jam during the peak hour. The traffic light system able to interact with congestion and thus help passengers, drivers, and products to reach their destinations quickly and safely, which might save time, effort, and, minimize the transportation costs.

4. Discussion

Traffic light is always one of the main points that delay the emergency rescue team like ambulance to reach the rescue location or back to the hospital. Sometime the traffic stuck at the red traffic light and make the emergency rescue team at the back do not able to pass through. With the IoT technology, the mobile application system able to help the emergency rescue team to pass through the traffic light with minimum delay.

By applying model, we able to optimal the traffic lights timing control at the targeted traffic intersections, eliminated conflict between multiple consecutive traffic intersections and eliminated traffic congestion with smooth traffic flow of vehicles

There are few improvements needed. This smart traffic light system should be upgraded by utilise the cloud system. Due to this is the only point to point or machine to machine Wi-Fi connection, no cloud is involved. There are no data collected from the system and store in the cloud for big data analysis that may help for future used. The latency of the system is also an issue but it can be solved by using 5G network. Since the traffic light is one of the critical component in the traffic system, the security of the network that connect between the smart traffic light system and the mobile application must be robust.

5. Conclusion

The smart traffic light system model able to simulate the algorithm of the traffic light process. With the necessary sensor applied, the system is able to detect the presence of the traffics, arranging the logic to prioritize the directions with more traffics. Besides, traffic light is always one of the main points that delay the emergency rescue team to reach the rescue location or back to the hospital. Sometime the traffic stuck at the red traffic light and make the emergency rescue team at the back do not able to pass through. With the IoT technology, the mobile application system able to help the emergency rescue team to pass through the traffic light with minimum delay. With this smart traffic light algorithm, it will make the traffic light in Penang more efficient and reduce the traffic jam.

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