Smart Traffic Light System for Arterials (WIP)

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SMART TRAFFIC LIGHT SYSTEM FOR ARTERIALS (WIP)

Abstract

Enhancing student 'Success' by using improved student engagement strategies in high-impact practices, specifically Capstone courses, is akin to university's strategic planning processes. Example-Project titled 'SMART TRAFFIC LIGHT SYSTEM FOR ARTERIALS' represents a Capstone course in which training in Instrumentation has become very necessary and relevant. The Senior Project course, a Design, Build & Test exercise, also often referred to as 'Training in Research and Research Methods', enjoys regular evaluation and redesign, because it is an important exit course that all graduating engineering students must take, and it is a gateway course to the workforce and graduate school opportunities. Unlike most other courses, it is based on Open-Ended Problem-Solving requirements for which skills in specialized Instrumentation selection is required, and so is Training in Research & Research Methods where students learn to Find Information, Analyze these, Plot them, Interpret what they see, Draw Conclusions and Make Decisions to impact the Design Objective. The measured Student successes which form important institutional yardsticks, included high measures of student engagement and positive outcomes that were influenced by measured factors likes self-efficacy, academic achievement, completion, retention, and career preparation. The grading in the course is based on a combination of "objective" and "subjective" evaluations. The objective part involves regular presentations of work in progress (35% of the overall grade) and a paper/Final report and final presentation (25%), each based on work performed and published articles on the subject matter. The more subjective components are 20% of the overall grade and 20% for peer evaluations of participation in small group discussions based mostly on completed work, cited articles and Class-Design Expo Presentations. Traffic congestion is not only a daily nuisance to millions of drivers and pedestrians, but is also a source of fuel loss, pollution, and hazards on the road. Designing, Building and Testing a Smart Traffic Light Controller that is capable of monitoring and adjusting signal operations based on traffic volume and flow patterns at adjoining junctions would significantly and positively impact traffic flows, especially at arterials. The achieved goals of this project were to Design, Build and Test a Prototype Smart Traffic Control System that can adapt to changing traffic flow patterns and meet a wide range of transportation and environmental demands, that can include a reduction in vehicular delays and traffic congestion.

Keywords: *Student Success; Engagement; High-Impact-Practices; Design-Build &Test; Open-Ended-Problem-Solving.*

Introduction

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Enhancing student 'Success' by using improved student engagement strategies in high-impact practices, specifically Capstone courses, contributes to our university's strategic planning processes. The example-Project titled 'SMART TRAFFIC LIGHT SYSTEM FOR ARTERIALS' represents a Capstone course in which training in Instrumentation has become very necessary and relevant. The Senior Project course, a Design, Build & Test (DB&T) exercise, also often referred to as 'Training in Research and Research Methods', enjoys regular evaluation and redesign, because it is an important exit course that all graduating engineering students must take, and it is a gateway course to the workforce and graduate school opportunities. Unlike most other courses, it is based on Open-Ended Problem-Solving requirements for which skills in specialized

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Figure 1. Drone View from HWY120 and HWY

Figure 2. Model of 2 Road Intersections

Current traffic lights in the United States are arbitrary. While systems which sense the presence of automobiles exist, they are based on samples of roads and the greatest traffic through the sensors receives priority. Most sensing roads have a 3 car per lane measurement capacity which means that a 2-lane road intersecting another like road could have 3 cars while the other has 100, though they will receive the fixed amount of time regardless. This can lead to grid lock in high traffic city intersections, increasing travel time of each commuter.
With the current technology available at a low enough cost, the system can be altered to optimize light times.

With the existing infrastructure within most city intersections, a smart traffic light system can be implemented. By utilizing the current sensors in/ above the roadways, the inputs of the computer are existing and can be tapped into. The computer of choice will have a specific program containing relevant algorithm(s) to interpret the input data and output to the lights at an ever-changing interval. Many of the sensed lights have been programmed given the average traffic flow of the adjoining road per day, whereas the smart system will sense each part of the intersection and adjust the timing accordingly. Utilizing wireless communications will allow two or more intersections to send traffic data to each other, enabling coordination over a wider area.

Review of Literature

Most of the previous research used IR sensors [1] to detect vehicles and a processor to determine the appropriate light times, while others used cameras for detection and an algorithm for light times. Research suggests using more powerful processors, while others suggest placing more sensors before an intersection to assess the incoming traffic more accurately. Studies show and conclude that an algorithm is more effective at directing traffic, as this method is capable of accounting for a wider range of variables than a sensor. Utilizing sensors or other data collection methods [2] the traffic flow can be well estimated. From the given traffic flow at a point, the light timing can be determined using several algorithms [3] similar in likeness to machine learning applied to fluid dynamic models. Given, there must be provisions for extreme emergency scenarios within the smart systems. In doing so, the light times are ever changing to attain the goal of creating the most efficient system on average. RFID [21] can be used for unique identifiers of each car on the road as a redundant method of certifying the accuracy of the sensors. With the sensors comes the need for interpolation of the incoming data; this can be done using a non-cooperative game theory method. To transmit the data to each corresponding light and cars, LoRaWAN [27] can be used as it is a long-distance and high efficiency communication method. When it comes to outlier situations, a Peripheral Interface Controller (PIC) [30] controller may be utilized to ease the traffic and allow passage of certain vehicles. With the incorporation of wireless communications in vehicles and traffic devices comes vulnerability which must be exploited to fix. As an example, Atlanta is extremely congested and spending a lot of money to solve the problems. Traffic light times must be optimized by mathematical methods.

Materials & Tools

- TI-BeagleBone Black
- Black
- Python3 with the following Libraries:
  - Socket
  - OS
  - Threading
  - NumPy
  - Time
  - Random
- Debian Linux 10
- PuTTY
- WinSCP
- TightVNC
- Anaconda
- Nano
- Spyder
- Balena Etcher

Design/Procedure

The group has decided upon using a microcomputer in tandem with a sensor network(simulated) to collect traffic data, interpret the data, and switch light states based on volume, density, flow, time, and capacity of traffic in a roadway.

Figure 3. Low Traffic Volume Intersection Data **Figure 4. High Traffic Volume Data**

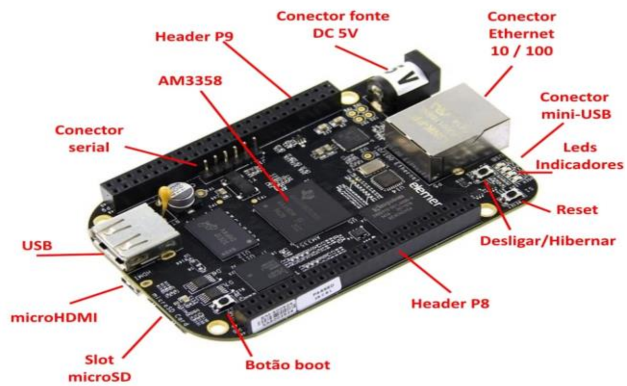

Fig. 5. Schematic of TI-Beagle-Bone Black with Wireless Connectivity (source-TI)

Two TI-Beagle-Bone Black (TI-BBB) Processor were updated to the latest version of Python. Functionality was verified by attempting to turn an LED on using the TI-BBB. A model of a four-way traffic intersection was created using LEDs and a breadboard, and a traffic algorithm will be programmed into the TI-BeagleBone Black to test a traffic simulation. This algorithm was improved to detect incoming cars, compare the traffic volumes at each lane of the intersection, and adjust the traffic light times to optimize the flow of traffic. Further testing was conducted to compare improvements the algorithm made. A second TI-BeagleBone Black was programmed with the same traffic algorithm, and adjustments were made to the program to allow the two TI-BeagleBone Blacks to send and receive traffic data from each other, allowing coordination between the two intersections and additional reductions in travel time. The code flowchart of the project is shown below.

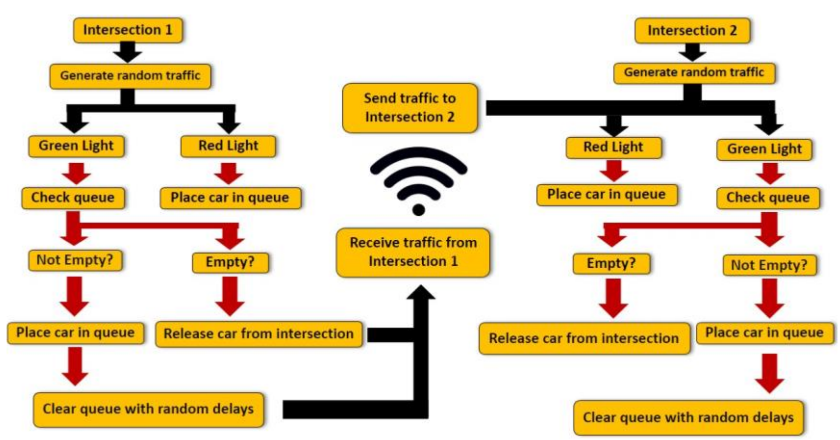

Figure 6. Traffic Optimization ~ Code Flowchart

Results

The TI-BeagleBone Black can successfully run a program to simulate a traffic intersection and generate incoming vehicles at intervals based on real-world traffic data collected from the intersection of HWY120 and HWY41. The code distinguishes between different volumes of traffic and adjusts light times accordingly. The TI-BeagleBone Black is also able to wirelessly connect to a server and send or receive data, enabling the coordination of more than one intersection.

	120 41N		120 41S		120E 41		120W 41		Day	Time
Sample#	Left	Straight	Left	Straight	Left	Straight	Left	Straight	3/22/2022	
7	7	47	8	33	0	26	8	37	3/22/2022	4:16PM
8	0	20	0	17	0	18	2	0	3/22/2022	4:16PM
9	4	8	7	6	0	24	8	39	3/22/2022	4:18PM
10	5	36	12	19	0	17	1	2	3/22/2022	4:19PM
11	3	13	9	14	0	60	8	35	3/22/2022	4:21PM
12	3	35	9	51	0	15	2	10	3/22/2022	4:22PM
13	7	6	3	3	0	44	3	34	3/22/2022	4:23PM
14	8	17	6	21	0	17	3	3	3/22/2022	4:24PM
15	10	15	12	1	0	54	4	33	3/22/2022	4:26PM
16	11	40	20	31	0	13	4	10	3/22/2022	4:28PM
17	3	4	4	2	0	38	9	26	3/22/2022	4:29PM
18	3	24	7	22	0	15	0	0	3/22/2022	4:30PM
19	5	4	10	4	0	27	1	31	3/22/2022	4:31PM
20	4	5	8	4	0	28	3	32	3/22/2022	4:37PM
21	4	25	13	20	0	0	0	3	3/22/2022	4:38PM
22	0	0	0	0	0	32	4	26	3/22/2022	4:39PM
23	8	6	9	7	0	0	0	0	3/22/2022	4:40PM
24	0	30	0	26	0	0	0	0	3/22/2022	4:40PM
25	0	3	0	1	0	0	0	0	3/22/2022	4:41PM
26	0	0	0	0	0	35	5	28	3/22/2022	4:42PM
27	0	0	15	0	0	0	0	0	3/22/2022	4:43PM
28	0	30	0	24	0	0	0	0	3/22/2022	4:44PM
29	0	0	0	0	0	15	6	33	3/22/2022	4:45PM

Figure 7. Sample Traffic Data

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