Density Based Traffic Signal with Remote Override in Emergency

Abstract:

Traffic light control systems are widely used to monitor and control the flow of automobiles through the junction of many roads. They aim to realize smooth motion of vehicles in the transportation routes. Conventional systems do not handle variable flows approaching the junctions. In addition, the mutual interference between adjacent traffic light systems, the accidents, the passage of emergency vehicles, and the pedestrian crossing are not implemented in the existing traffic system. This leads to traffic jam and congestion.

In this project, we focused on features that can be added to existing traffic light control system as mentioned below:

1. Fair chance to every route
2. Time duration of signal varies with vehicle queue length
3. Separate lane for ambulance with emergency override (implemented only for two routes)

Approaches:

Prototype 1:

Figure below shows the first implementation idea that we were about to implement. Our primary intention with this approach was to be able to count the number of vehicles on each route. Each route would have two IR sensors, one on left turns(IR1) and other on the route(IR2). The left signal is always ON for a route. So, vehicle density would have been determined as (IR2 – IR1) count. But there was a problem that IR1 would have counted the vehicles from opposite and right route too. So, we thought of adding two magnetic sensors on route intersection to calculate vehicle number. This approach had complex calculations and processing.

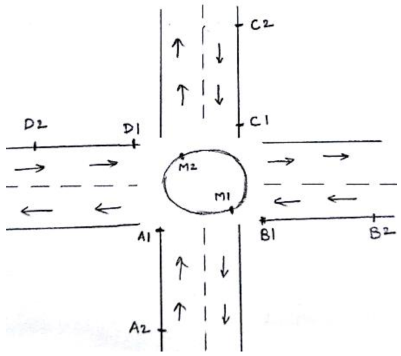

Figure 1 Prototype 1

With the short time we had to work on this project, we thought of implementing a simpler idea first and then proceed with this approach. But then we spent quiet huge amount of time on exploring the FRDM board and FreeRTOS. But FreeRTOS port wasn't available for the board. So, we moved to Keil RTOS v2.

Implementation:

Hardware Components:

Freescale board(K64F)

IR and photodiodes

LM 358

Decoder IC (74138)

Inverter IC (7404)

LEDs

Software Used:

Keil µvision 5 (CMSIS RTOS v2)

Hardware Setup:

The figure shown below shows the prototype of our project.

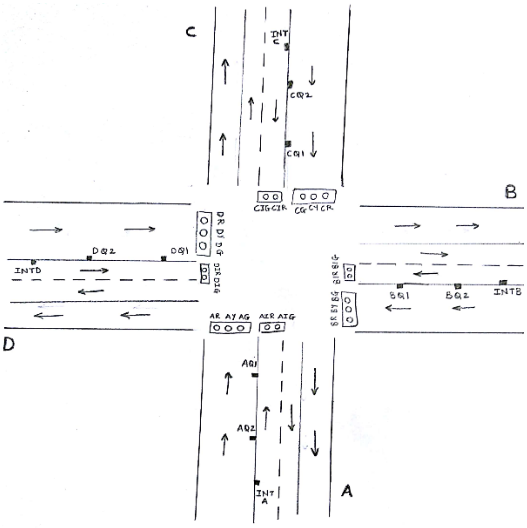

Figure 2 Implemented Prototype

Each road has two IR sensors to detect queue length as shown in the figure below. Consider four routes as shown in the figure. AQ1, AQ2, BQ1, BQ2, CQ1, CQ2, DQ1 and DQ2 represents the position of IR sensors to detect queue length. AR, AY, AG, BR, BY, BG, CR, CY, CG, DR, DY and DG represents the traffic lights for each route for path A, B, C and D respectively. INTA and INTB represents IR to detect interrupts for emergency. AIR, AIG, BIR and BIG represents traffic lights for INTA and INTB respectively.

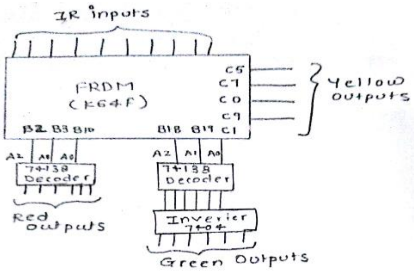

Figure 3 Hardware setup for Red and Green traffic ligths

Select lines			**Output**
A2(Port B2)	**A1**(Port B3)	**A0**(Port B10)	
0	0	0	AR
0	0	1	BR
0	1	0	CR
0	1	1	DR
1	0	0	AIR
1	0	1	BIR

Select lines			**Output**
A2(Port B18)	**A1**(Port B19)	**A0**(Port C1)	
0	0	0	AG
0	0	1	BG
0	1	0	CG
0	1	1	DG
1	0	0	AIG
1	0	1	BIG

Inputs are directly fed to FRDM board. But as we were short of port IO pins on development board, we used two decoders for green and red traffic lights which reduced the need of 16 IOs to 6 (used for select lines of decoders). 74138 decoder provides active low output for given select input. For RED traffic lights, only one will be OFF at a time so decoder output can be used as it is. Whereas, for Green traffic lights, only one will be ON at a given instance, so we used inverter along with decoder. Four IO pins of FRDM are directly used to connect yellow traffic lights.

AQ1, BQ1, CQ1 and DQ1 represents short queue length whereas AQ2, BQ2, CQ2 and DQ2 represents long queue length.

Software Implementation:

To give fair chance to each route, the normal traffic light implementation is kept sequential. The table below represents the state transitions for a traffic signal on route A.

Sr No	Previous State	Next State
1	AG	AY Blink
2	AY Blink	AY
3	AY	AR Blink
4	AR Blink	AR
5	AR	BG

Instead of using countdown timers to let drivers know about the stopping timings, we used the blink state for yellow and red traffic lights that represents the upcoming signal state for corresponding route.

Duration for which Green signal should be ON for each route depends on queue length.

t_H – Maximum time for green signal

t_M – Medium time for green signal

t_S – Small/ Default time for green signal

Considering example of route A, all vehicles resides before AQ1 or no vehicles on route A indicates that queue is very short. So, signal will be ON for time, t_S. Vehicle queue in between AQ1 and AQ2 represents medium queue length and signal will be ON for time, t_M. Vehicle queue beyond AQ2 represents long queue length and signal will be ON for time, t_H. Yellow traffic light duration, blink duration for red and yellow are same for all the routes.

Emergency override feature is implemented using software interrupts in threads. Priority driven approach is used for scheduling the threads. Each thread has different priority. Whenever any of the interrupt arrives, all traffic lights will be red until the interrupt is served. For a given time, if two interrupts come at the same time, they should not be served to prevent accident. So, we used mutex with priority inheritance to make sure that only one interrupt is served at a given time.

Future Scope:

- Vehicle density calculations used in this project depends on queue length. So, project can be expanded to get exact number of vehicles for vehicle density calculation.

- Instead of IR sensors we can use camera to detect vehicle density with which accident prevention features such as over speeding of vehicles, violating traffic rules can be captured.

References:

1. https://os.mbed.com/platforms/FRDM-K64F/
2. http://docs.zephyrproject.org/1.8.0/boards/arm/frdm_k64f/doc/frdm_k64f.html
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