Traffic Signal Warning System

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BACKGROUND

Safer roadways has been a collective community goal since the mass production of the Model T in 1913. Since then, many laws, regulations, and traffic control systems have been implemented to achieve that goal. However, there are still many areas of concern that could be addressed. The picture in Figure 1 shows a target intersection with safety hazards, where a large amount of infrastructure, lights, flags, and other obstructions block the view of the driver from behind the limit line. Specifically, unprotected right turns are the issue we wish to address.

Figure 1

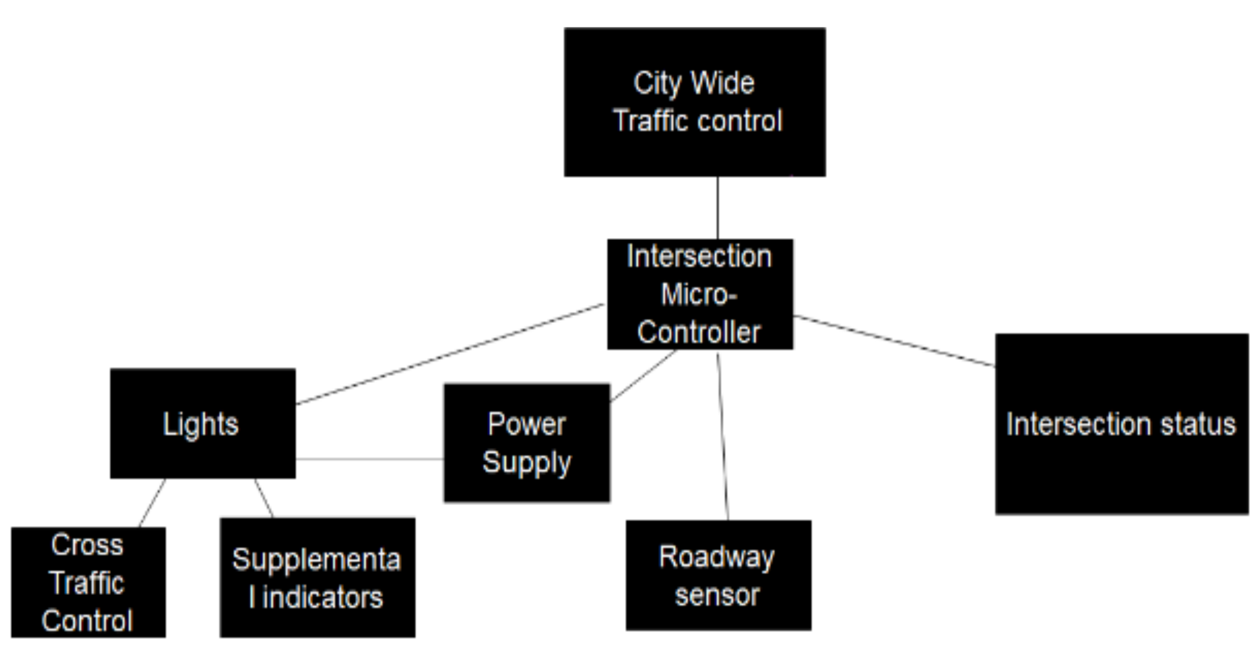
Intersection of 2nd Street and Madison Ave. in Mankato, MN

Intersections such as this force the driver to make a choice with limited information, or at best require them to move well into the traffic lane before the decision to proceed can be properly addressed. At worst, it causes T-bone collisions with a high injury rate as the driver door is directly struck, an occurrence not uncommon to this location. See also the Cherry Street and Riverfront Drive intersection.

PROPOSED SOLUTION

In order to address this problem, our team decided that a supplemental warning system implemented into the traffic signals would be easiest to integrate and be the least destructive to current infrastructure and property surrounding intersections in which to install the solution. This system would interact with a network of sensors installed in the roadway which trigger ahead of the sightline of a turning driver.

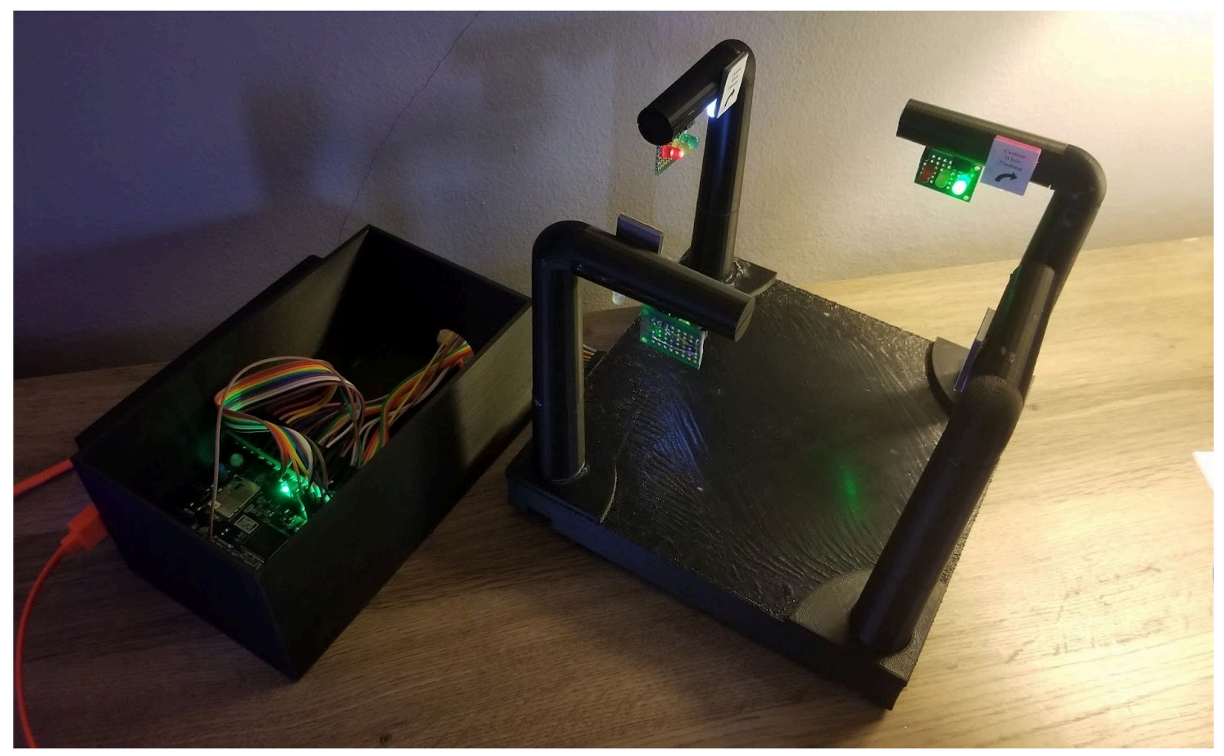
Figure 2



Functional Block Diagram

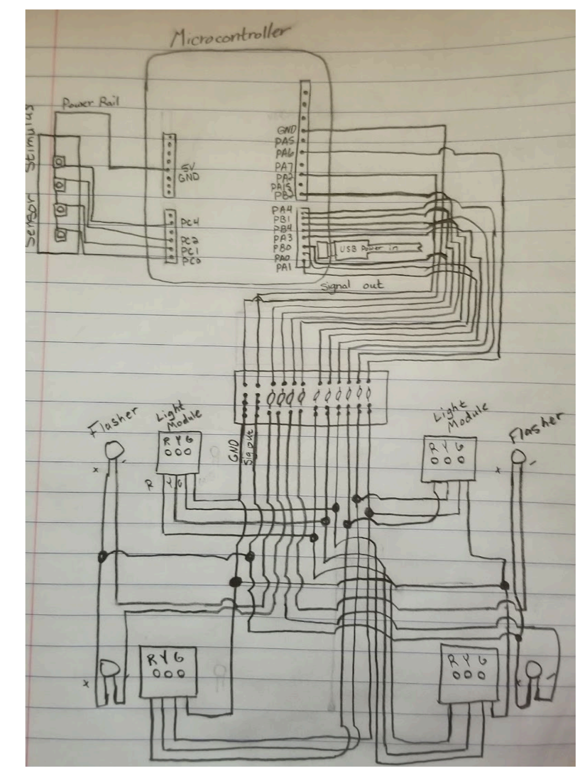
SYSTEM DESIGN

Figure 3



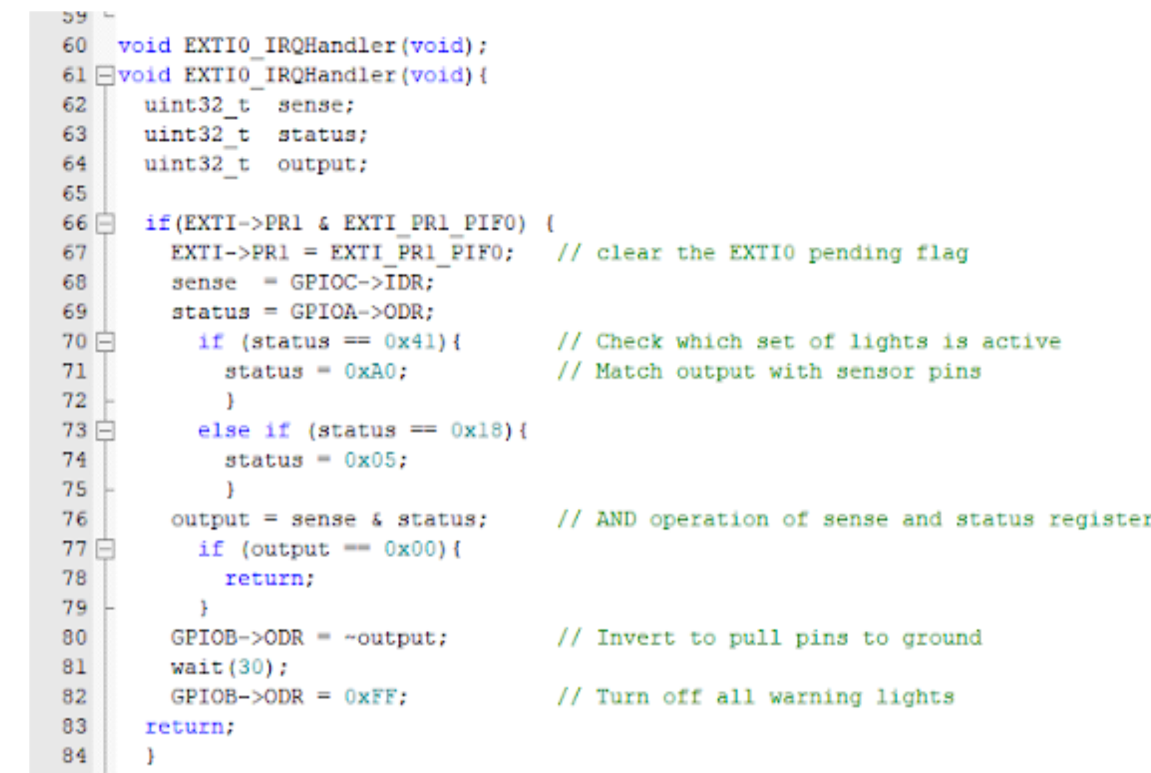
3D Intersection Model

Figure 4 **Figure 5**



Wiring Diagram and Microcontroller Housing

Figure 6



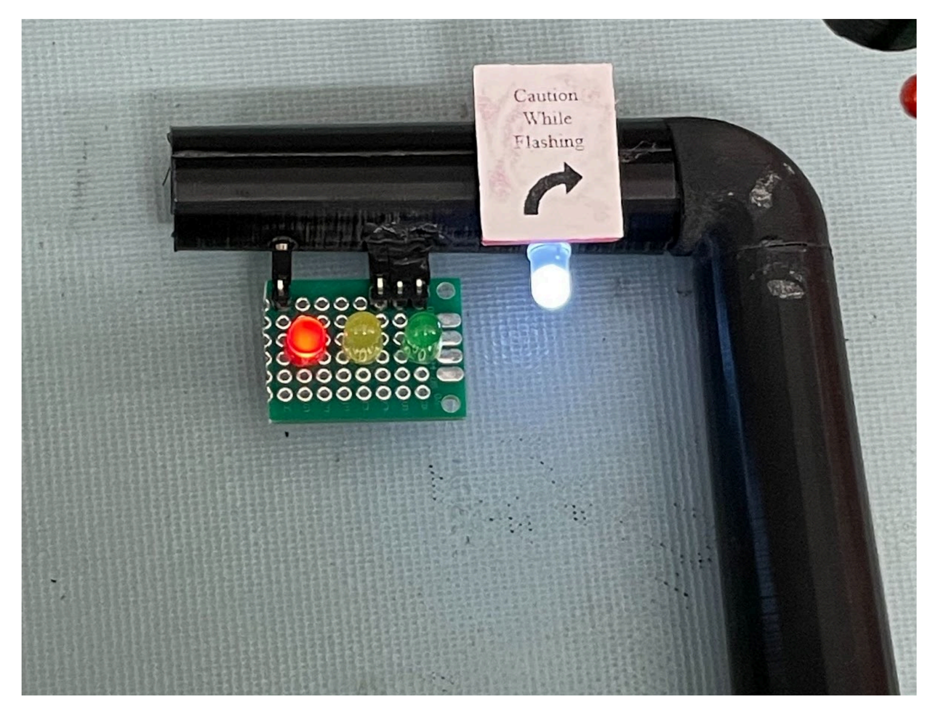
```c
void EXTI0_IRQHandler(void);
void EXTI0_IRQHandler(void){
  uint32_t  sense;
  uint32_t  status;
  uint32_t  output;

  if(EXTI->PR1 & EXTI_PR1_PIF0) {
    EXTI->PR1 = EXTI_PR1_PIF0;    // clear the EXTI0 pending flag
    sense  = GPIOC->IDR;
    status = GPIOA->ODR;
      if (status == 0x41){        // Check which set of lights is active
        status = 0xA0;            // Match output with sensor pins
        }
      else if (status == 0x18){
        status = 0x05;
        }
    output = sense & status;      // AND operation of sense and status registers
      if (output == 0x00){
        return;
      }
    GPIOB->ODR = ~output;         // Invert to pull pins to ground
    wait(30);
    GPIOB->ODR = 0xFF;            // Turn off all warning lights
  return;
  }
```

Main Functional Code Interrupt

The current model utilizes a board with buttons to act as the sensor input for vehicles in all four directions, which allows for the simulation of real time traffic. This then triggers the process outlined in Figure 8 and results in the appropriate light flashing for a driver in the right turn lane. In this design, we felt a supplementary sign was necessary to delineate the meaning of the signal, like those that provide notice to 'Yield on Flashing Yellow.' It is important to note that this warning system could act independently of the main function if the sensors were tied directly to this controller.

Figure 7

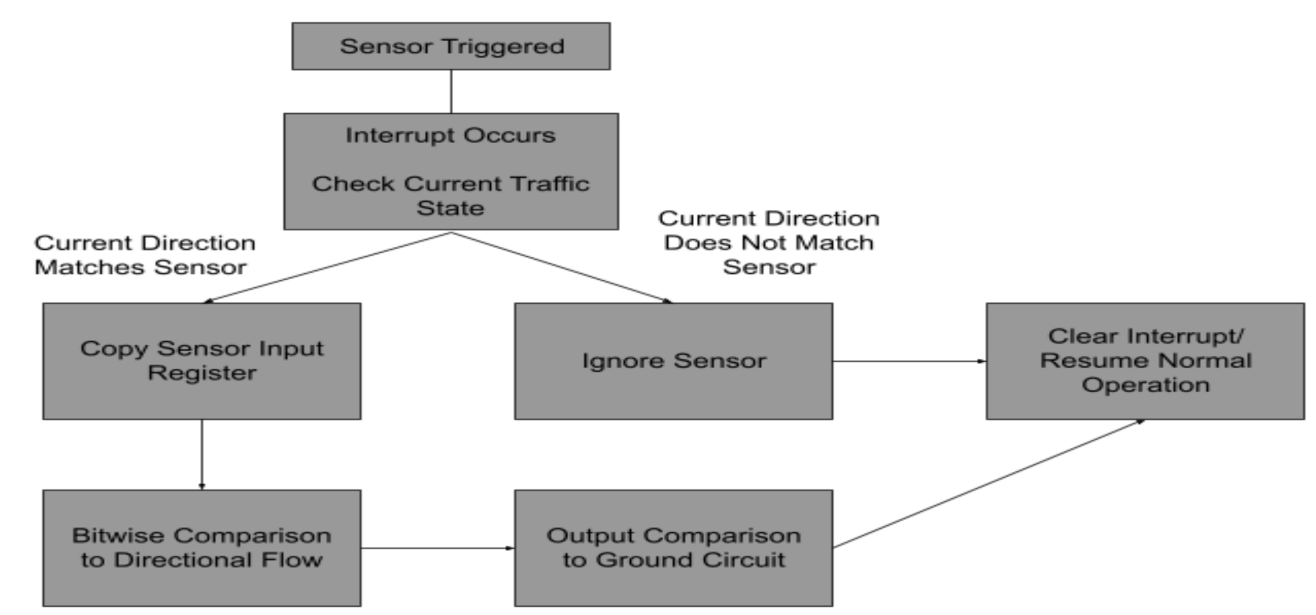


Single Pole Operation

SOFTWARE FUNCTIONALITY

The microcontroller selected for use was the STM32L475 which offered a range of flexibility with a lot of I/O ports and registers to interact with. This system operates in C. Visualized in Figure 8 is the operation of the code in Figure 6.

Figure 8



FUTURE DIRECTION

- Implement actual sensors into the design to test feasibility
- Use of a sensor array to calculate vehicle speed and warning time required
- Implementation into different environments? Roundabouts?
- Utilization of a different controller?
- Operation on solar power, already works with a small 5V power bank

REFERENCES

AECOM, "Systems Engineering Analysis for Standard Traffic Signal," *MN Department of Transportation,* May-2020. [Online]. Available: http://www.dot.state.mn.us/its/projects/2016-2020/cavreadiness/std-traffic-signal-requirements.pdf

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