Subsystem 2 – Fire Detection and Extinguishing

Description of sub-system and objectives

Another objective of the SLAM Firefighting Bot was to detect and extinguish obstacles with a “fire”. The “fire” was in the form of a light bulb with a thermistor attached. It was detected with phototransistors and then extinguished with a fan from a distance. This was implemented as a sub-system in the overall structure of the machine’s intelligence.

How it was implemented

Two phototransistors were used for fire detection. These phototransistors were positioned on either side of the fan. The set-up is as shown in figure 1. The fan was positioned at the front of the robot and mounted on a servo motor. This was to allow for the fan to rotate towards the fire if the fire was not directly in front of the robot. Due to the way the coverage of the track was set up, the obstacle with the fire on it will always be approached from the front. It should be noted that the phototransistors are mounted with the fan and so will move as the fan moves. This enabled better tracking.

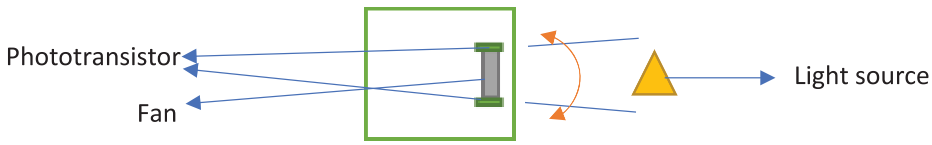

Figure 1 Set up of sub-system

As their input readings exceed a certain threshold, the fan will be prompted to turn on through the switching circuit. The amplification and switching circuit are as shown in figures 2 and 3 respectively. The amplifier was used due to ensure a larger range of ADC units were utilised for better sensor readings. The gain used for the amplifier was R4/R3 = R6/R5 = 5.67. This allows a readable voltage for the ADC on the Arduino.

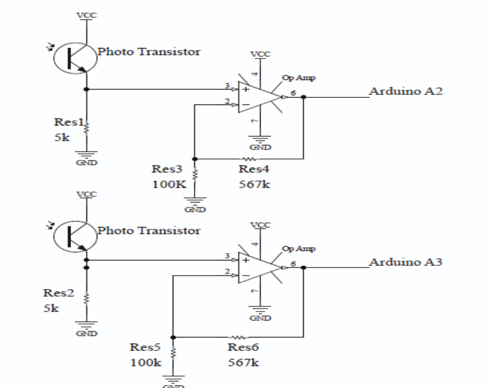

Figure 2 Schematic of amplifying circuit

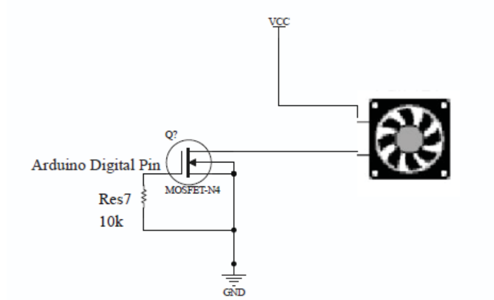

Figure 3 Fan switching circuit

Regarding the code for the fire extinguishing process, the readings from the phototransistors were first obtained. If the readings for the phototransistor positioned to the left or the right of the fan indicated a reading above background level readings, the detection system switched state from passive to active. The minimum threshold used was 350 analog units, which was determined through calibration and correlating analog units to distance from the light source.

Once the minimum threshold was reached, the phototransistor readings were compared. The servo was programmed to move towards the phototransistor with the higher reading. Once the readings for both phototransistors was roughly equal with a tolerance of 50; the fan was facing the closest light source. If the final average reading between the phototransistors exceeded 740 analog units; the fan was switched on. The fan remained on until the reading dropped below 740. Having decided the fire was extinguished, it would switch to a passive state once again and only switch back to an active state once a reading above 350 was detected once more. The states are summarised within figure 4.

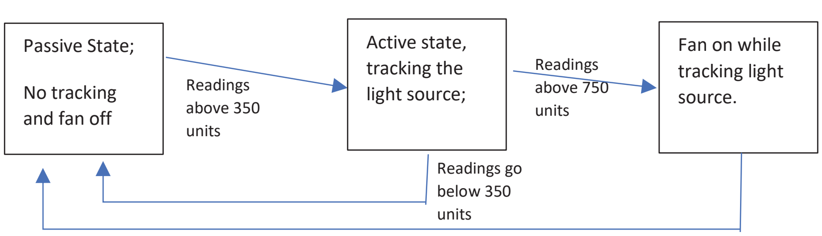

Figure 4 Summary of states

Subsystem 1 - Obstacle Avoidance

Description of sub-system and objectives

An objective of the SLAM Firefighting Bot was to utilise the available sensors to detect obstacles and carry out motion to dodge them while on the coverage trajectory. Each obstacle detected with a sensor triggers a state which must lead to avoidance without collision into obstacles. This was implemented as a sub-system in the overall structure of the machine's intelligence.

How it was implemented

The sensors that were calibrated and utilised were: the ultrasonic sensor, and the four IR sensors with two long ranged and two short ranged. The short-ranged IR sensors were calibrated, and a function found on R to correlate voltage and distance. The conversion was done via the equation: $\frac{13}{(AnalogReading)\ (0.004883)}$ = distance in cm

The long-ranged IR sensors utilised a look up table which correlated analog voltage readings to distances. The sonar used PWM to discern the time between a pulse trigger and the echo which was converted using the speed of sound. 4 The layout of the sensors and system working is as shown on figure 1.

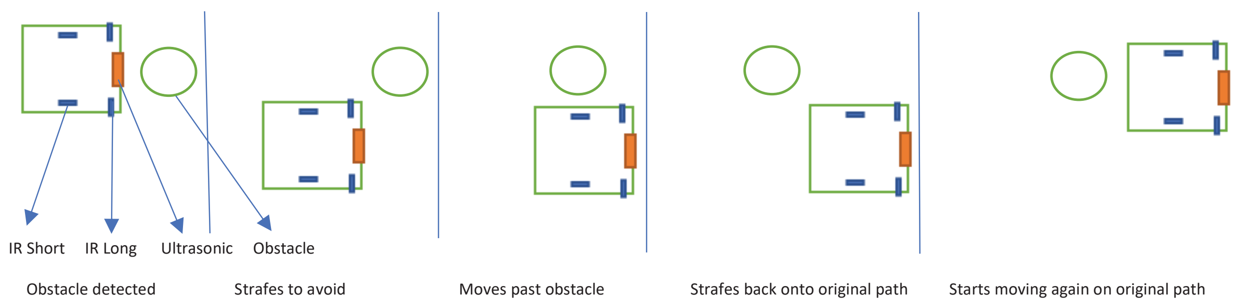

Figure 1 Example of obstacle avoidance with the sensor layout.

The detection and avoidance were implemented via a state machine structure. The start or "normal" state was to move forward in its trajectory to cover the track. The general case for avoidance is as shown in figure 1. If an obstacle is encountered, it strafes to either the left or right. The strafing direction is decided depending on two conditions. The first is dependent on the sensor that detected the obstacle. The second is whether either of the side IR sensors are detecting any hinderance to movement within a threshold of 25cm. The time taken to strafe is recorded and strafing is only stopped once the obstacle isn't being detected by one of the two IR front sensors. Once strafing has stopped, the distance on the sonar is recorded. It then moves forward for 25 cm with the side IR sensors ensuring the obstacle is a sufficient distance away. The distance moved is measured via subtraction of current sonar reading from the stored distance. This is in conjunction with a fail-safe time corresponding to the current speed and distance covered. This will ensure that failure of the sensor will not cause system failure. Once the distance according to specified threshold is covered, the machine then strafes back to its original position using the stored time. The original state is then entered, and it keeps on with its trajectory until another obstacle is detected. A summary of the states is as shown in figure 2.

State Machine for Obstacle Avoidance

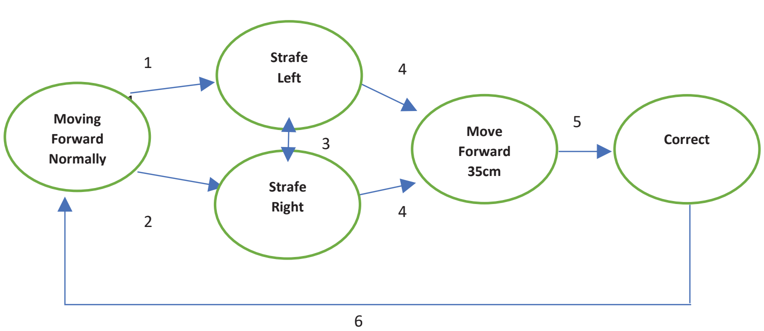

Figure 2 Summary of states for obstacle avoidance

Table 1 Conditions required for each state change

	Condition for state change
1	Left front IR sensor detected obstacle
2	Sonar or right front IR sensor detected obstacle
3	Obstacle encountered while strafing sideways
4	Obstacle no longer being detected
5	Have moved 35cm and so have gone past obstacle
6	Strafed back same time it took to strafe out