Autonomous Snowplow

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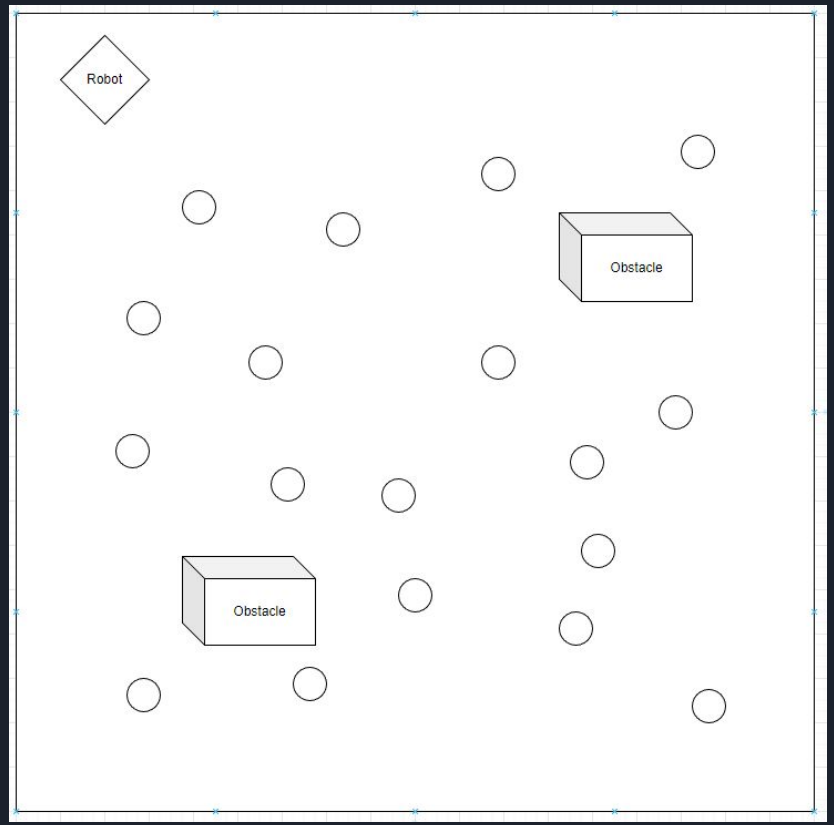
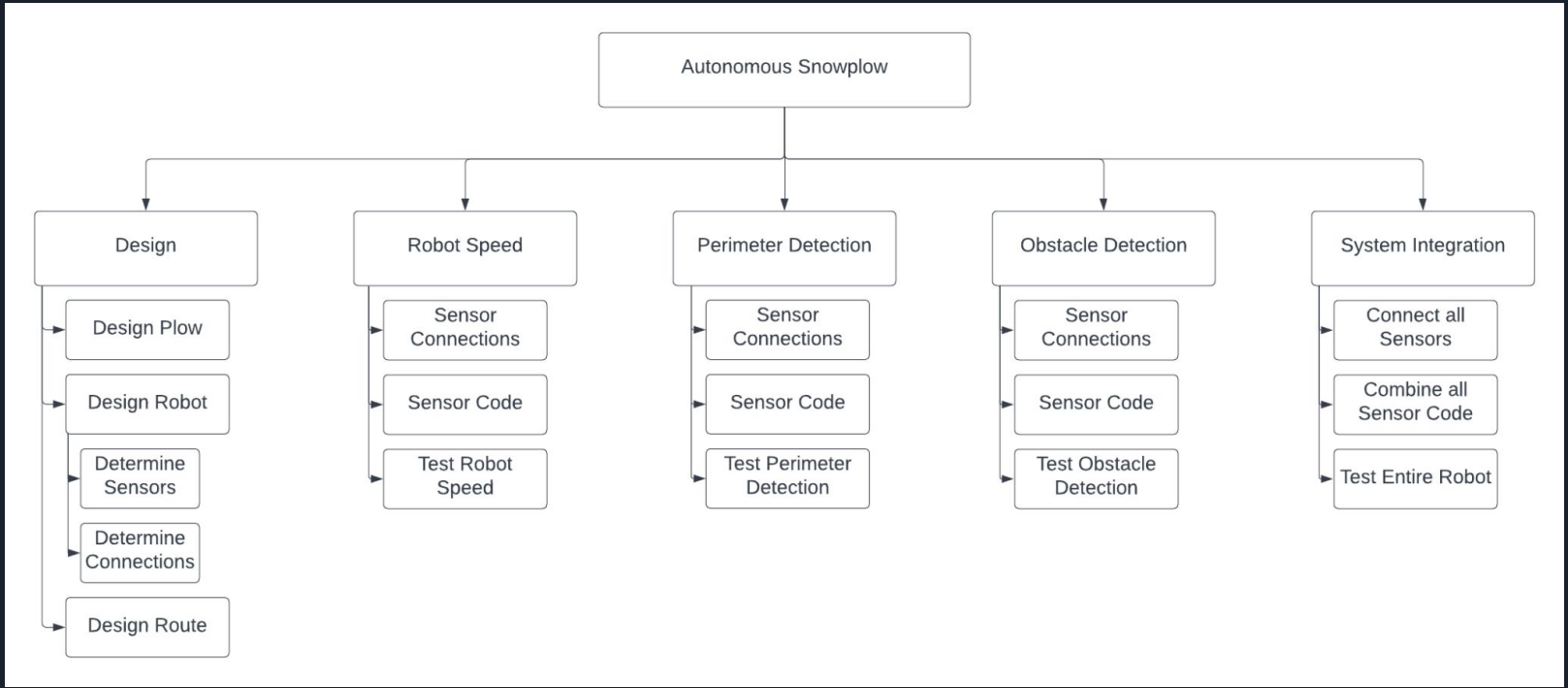
Snowplow

PROJECT STATEMENT

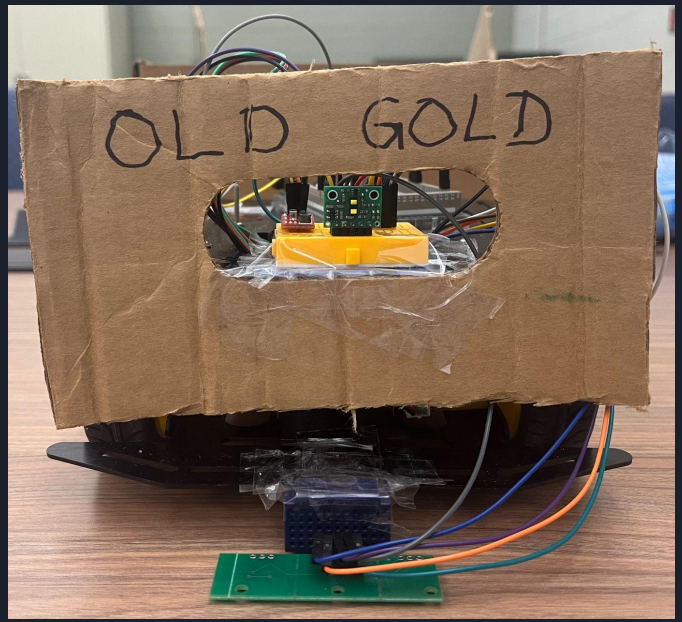
- *Robot can detect perimeter of arena*
- *Robot can detect and avoid obstacles*
- *Removes all the snowballs in the arena within 5 minutes*
- *Robot moves at a max speed of 30 cm/s*
- *Robot is a max size of 216 x 252 x 150 mm*

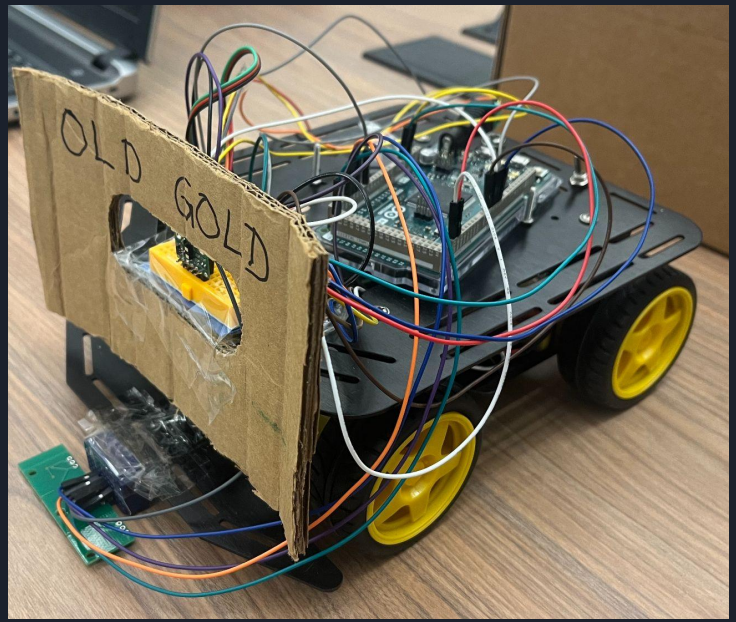


WORK BREAKDOWN STRUCTURE



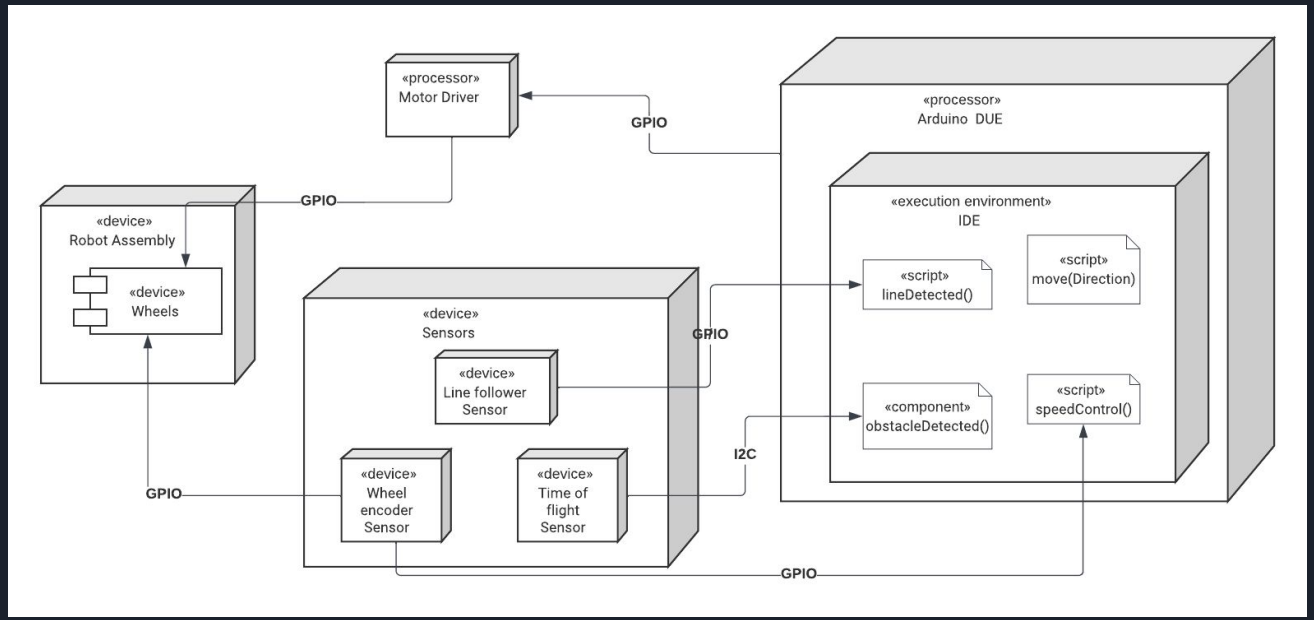
SOLUTION





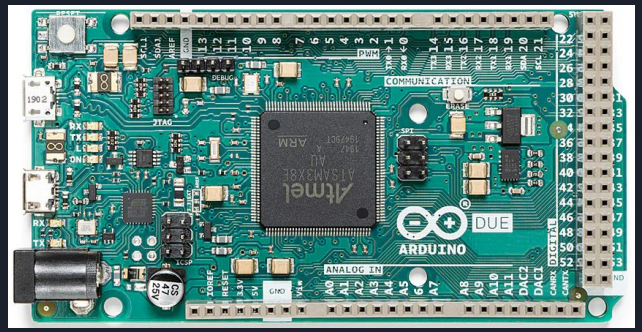
HARDWARE

- Arduino Due
- Motor Driver Board
- Line Follower Sensor
- Time of Flight Sensor
- Wheel Encoder Sensor



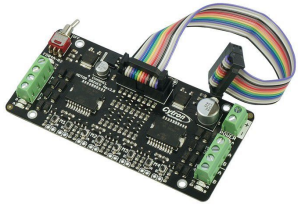
ARDUINO DUE

- Arduino Due
  - Microprocessor
  - Brain of the system and controls everything
  - Runs all our code



MOTOR DRIVER BOARD

- Motor Driver Board
  - Connects motors to Arduino
  - Controls direction and speed of each motor



```
//left_motor controls 2 wheels on left side of robot
//right_motor controls 2 wheels on right side of robot
#define left_motor_en 2
#define right_motor_en 3
#define left_motor_dir 4
#define right_motor_dir 5

//move robot forward using driver board
void forward(){
  printf("FORWARD\n");
  analogWrite(left_motor_en, 200);
  analogWrite(right_motor_en, 200);
  digitalWrite(left_motor_dir, LOW);
  digitalWrite(right_motor_dir, HIGH);
}

//move robot forward at slower speed
void slowForward(){
  printf("FORWARD SLOWER\n");
  analogWrite(left_motor_en, 150);
  analogWrite(right_motor_en, 150);
  digitalWrite(left_motor_dir, LOW);
  digitalWrite(right_motor_dir, HIGH);
}
```

```
//move robot backward
void backward(){
  printf("BACKWARD\n");
  analogWrite(left_motor_en, 255);
  analogWrite(right_motor_en, 255);
  digitalWrite(left_motor_dir, HIGH);
  digitalWrite(right_motor_dir, LOW);
}

//turn robot left
void left(){
  printf("LEFT\n");
  analogWrite(left_motor_en, 255);
  analogWrite(right_motor_en, 255);
  digitalWrite(left_motor_dir, HIGH);
  digitalWrite(right_motor_dir, HIGH);
  delay(1000); //turn left for 1s
}
```

```
//turn robot right
void right(){
  printf("RIGHT\n");
  analogWrite(left_motor_en, 255);
  analogWrite(right_motor_en, 255);
  digitalWrite(left_motor_dir, LOW);
  digitalWrite(left_motor_dir, LOW);
  delay(1000); //turn right for 1s
}

//stop robot movement
void stop(){
  printf("STOP\n");
  analogWrite(left_motor_en, 0);
  analogWrite(right_motor_en, 0);
  digitalWrite(left_motor_dir, LOW);
  digitalWrite(right_motor_dir, LOW);
}
```

LINE FOLLOWER SENSOR

- Used to detect the perimeter (black tape)
- Consists of 3 sensors
- Attached to front of robot facing the ground
- Black tape detected if at least 1 of the 3 sensors detect black


```
#include "lineDetector.h"

#define line_detector_front1 A9
#define line_detector_front2 A10
#define line_detector_front3 A11

//method for perimeter detection using line sensor
bool checkForLine(){

  //read from each sensor
  int ex1 =  analogRead(line_detector_front1);
  int ex2 =  analogRead(line_detector_front2);
  int ex3 =  analogRead(line_detector_front3);

  //print readings
  printf("Left analog: %i Middle analog: %i Right analog: %i\n", ex1, ex3, ex2);
  //return true if black detected for any sensor false otherwise
  if (ex1 > 900 || ex2 > 950 || ex3 > 900)  //different tested threshold for all sensors
    return true;
  else
    return false;
}
```

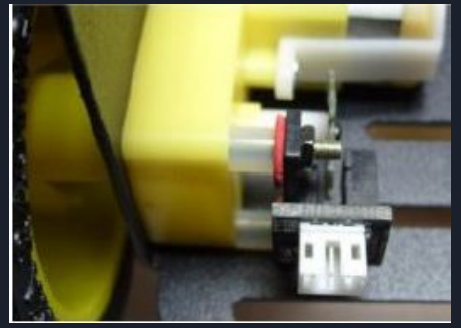
TIME OF FLIGHT SENSOR

- Used as a distance sensor for detecting obstacles
- Makes use of I2C protocol to communicate with Arduino
- Attached at the front at the top of our robot
- Detects obstacle if detected at least 20 cm in front of the robot

```
//ToF sensor
sensorToF.setTimeout(500); //0.5s timeout
if (!sensorToF.init()){
  Serial.println("Failed to detect and initialize ToF sensor.");
  while(1);
}
sensorToF.setDistanceMode(VL53L1X::Short); //ToF in short mode
sensorToF.setMeasurementTimingBudget(20000);
sensorToF.startContinuous(50);
```

```
//method for obstacle detection using ToF sensor
bool checkForObstacle(){
  sensorToF.read();
  Serial.println(sensorToF.ranging_data.range_mm);
  if (sensorToF.ranging_data.range_mm <= 200) //if obstacle detected within 200mm of robot
    return true;
  else
    return false;
}
```

WHEEL ENCODER SENSOR



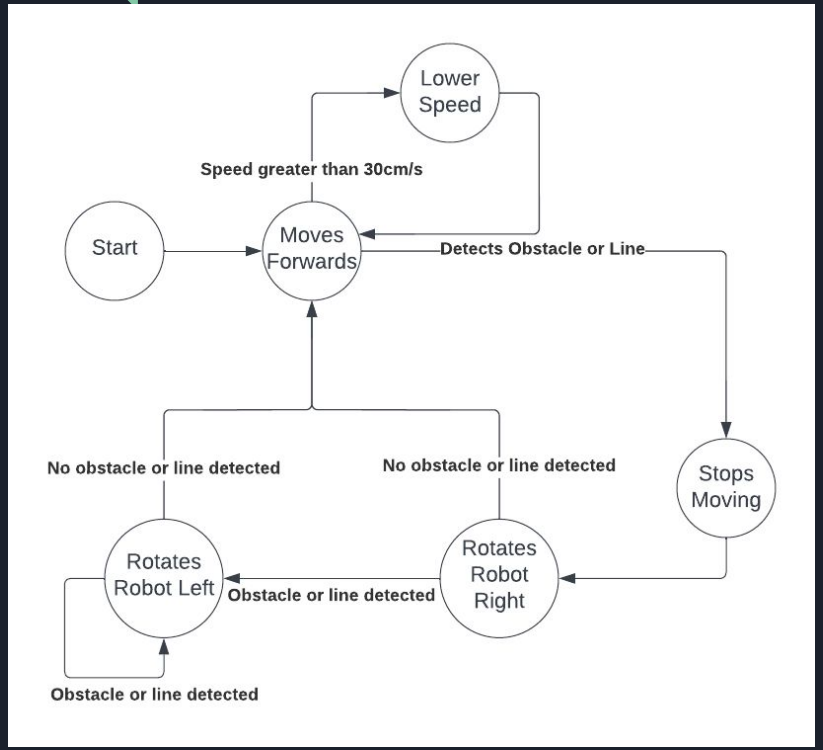
- Used to determine the speed of the robot
- Attached to the front wheels
- Ensures robot is going at a specified speed and doesn't exceed the limit
- Sends control flag if robot is going above 30 cm/s

```
  //Wheel encoder
  PMC->PMC_PCER0 |= PMC_PCER0_PID28; // Timer Counter 0 channel 1 IS TC1, TC1 power ON
  TC0->TC_CHANNEL[1].TC_CMR = TC_CMR_TCCLKS_TIMER_CLOCK1 // capture mode, MCK/2 = 42 MHz
    | TC_CMR_ABETRG // TIOA is used as the external trigger
    | TC_CMR_LDRA_RISING// load RA on rising edge of TIOA
    | TC_CMR_ETRGEDG_RISING; // Trigger on rising edge
  TC0->TC_CHANNEL[1].TC_CCR = TC_CCR_SWTRG | TC_CCR_CLKEN; // Reset TC counter and enable
  TC0->TC_CHANNEL[1].TC_IER |= TC_IER_LDRAS; // Trigger interrupt on Load RA
  NVIC_EnableIRQ(TC1_IRQn); // Enable TC1 interrupts
}
```

```
if (CaptureFlag) { //wheel encoder interrupt
  CaptureFlag = 0; //Reset the flag,
  speed = (19.648/(CaptureCountA/42000.0/1000.0)/10.0); //calculate speed
  printf("Speed: %f cm/s\n", speed);
  if (speed > 30){
    speedFlag = true; //robot going too fast
  } else {
    speedFlag = false; //robot moving below max allowed speed
  }
}
```

```
void TC1_Handler() { //interrupt handler
  uint32_t status = TC0->TC_CHANNEL[1].TC_SR; //Read status register, Clear status
  if (status & TC_SR_LDRAS) { // If ISR is fired by LDRAS then ....
    CaptureCountA = TC0->TC_CHANNEL[1].TC_RA; //read TC_RA
    speed = (19.648/(CaptureCountA/42000.0/1000.0)/10.0);
    if (speed < 40) { //debouncing any extremely high speed reports
      CaptureFlag = 1; //Inform the main loop of an update
    }
  }
}
```

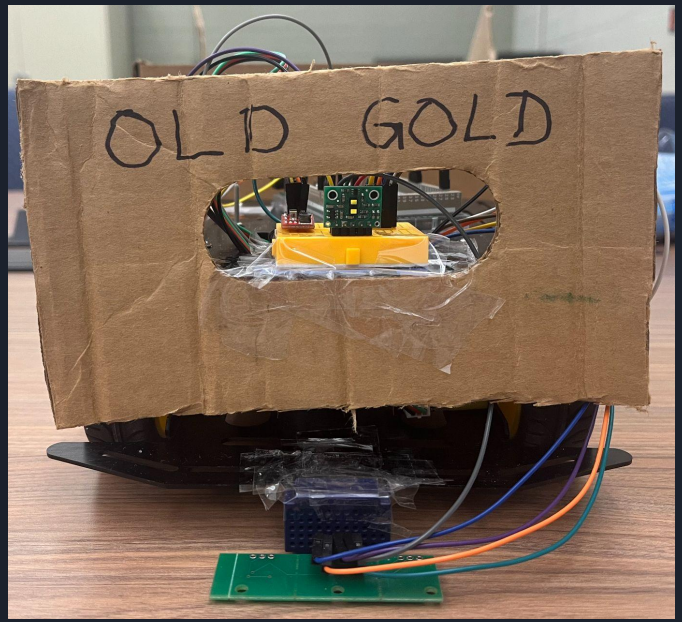
MOVEMENT ALGORITHM




```
switch(state){ //state machine
  case 0: //move forward state
    if (speedFlag){ //check if robot moving too fast
      slowForward();
    } else {
      forward();
    }
    if (line || obstacle){ //check for perimeter or obstacle
      stop();
      state = 1; //turn right
    } else {
      state = 0; //continue forward
    }
    break;
```

```
    case 1: //turn right state
      right();
      if (line || obstacle){
        stop();
        state = 2; //turn left
      } else {
        state = 0; //continue forward
      }
      break;
    case 2: //turn left state
      left();
      if (line || obstacle){
        stop();
        state = 2; //turn left again
      } else {
        state = 0; //continue forward
      }
      break;
}
delay(500); //poll every 0.5s
```

TESTING RESULTS



- Demonstration Expectations
- Demonstration Results
- Resolutions

Questions?