Motion-Detecting Sentry
GROUP 33 CDR

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MOTIVATION

- ENTERTAINMENT/RECREATION

- PERSONAL/BUSINESS SECURITY

- MILITARY APPLICATIONS

GOALS AND OBJECTIVES

- Primary Goals:
  - Identification of targets through computer vision
  - Paintball gun capable of aiming at and hitting targets
  - Warning light
  - Non-lethal ammunition
  - Modifiable
  - Easily transportable
  - Sufficient Power Supply

KEY SPECIFICATIONS

Specification	Requirement
Accuracy (minimum)	70%
Traverse	180° horizontally, 45° vertically
Range	10 – 75 feet
Power Supply Duration	3 hours
Ammunition Capacity (minimum)	20 rounds
Weight (minimum)	40 pounds
Multiple Target Acquisition	Up to 3 separate targets
Warning Time	5 seconds

HARDWARE SPECIFICATIONS

- Turret should have a camera with high enough resolution such that human figures can be determined from a range of up to 75 feet

- Warning system to indicate the turret is about to fire, with a timer of 5 seconds

- Fully automatic fire

- Magazine of at least 20 rounds

- Turret should be lightweight, roughly 40 pounds or less, enabling a single individual to safely lift and relocated the turret as desired

- Internal power supply lasting up to 3 hours

- Cost of no more than $600

SOFTWARE SPECIFICATIONS

- Should use computer vision to identify targets within range of 30 feet

- Motion sensor activates the camera to check for targets within 30 feet

- Should be able to identify up to 3 targets at once and prioritize them according to distance from the turret

- Should give a 5-second warning when a target enters the firing range

- Should stop firing when the target leaves 30-foot range

- Should adjust turret's aim as target moves to maintain accuracy

OVERALL BLOCK DIAGRAM
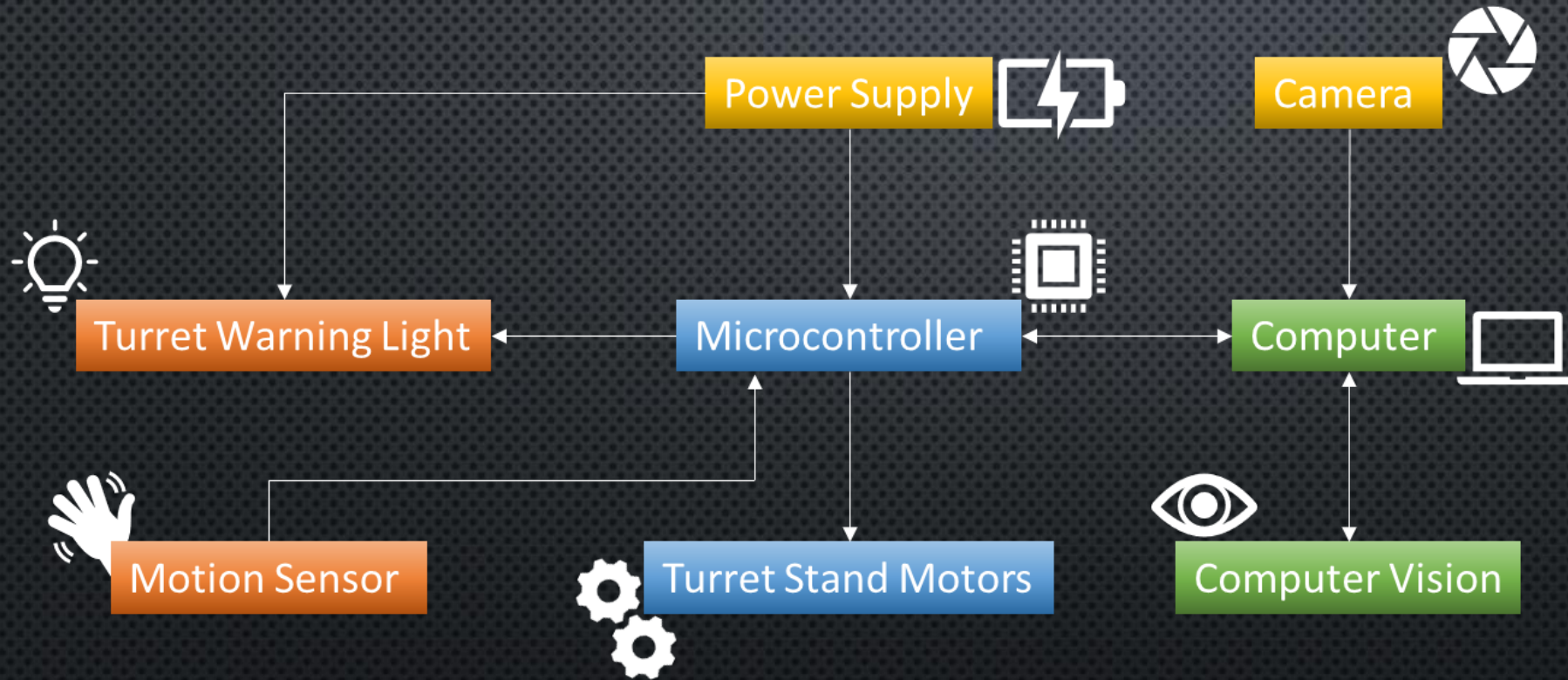
STRUCTURE DESIGN

STRUCTURE MATERIAL SELECTION

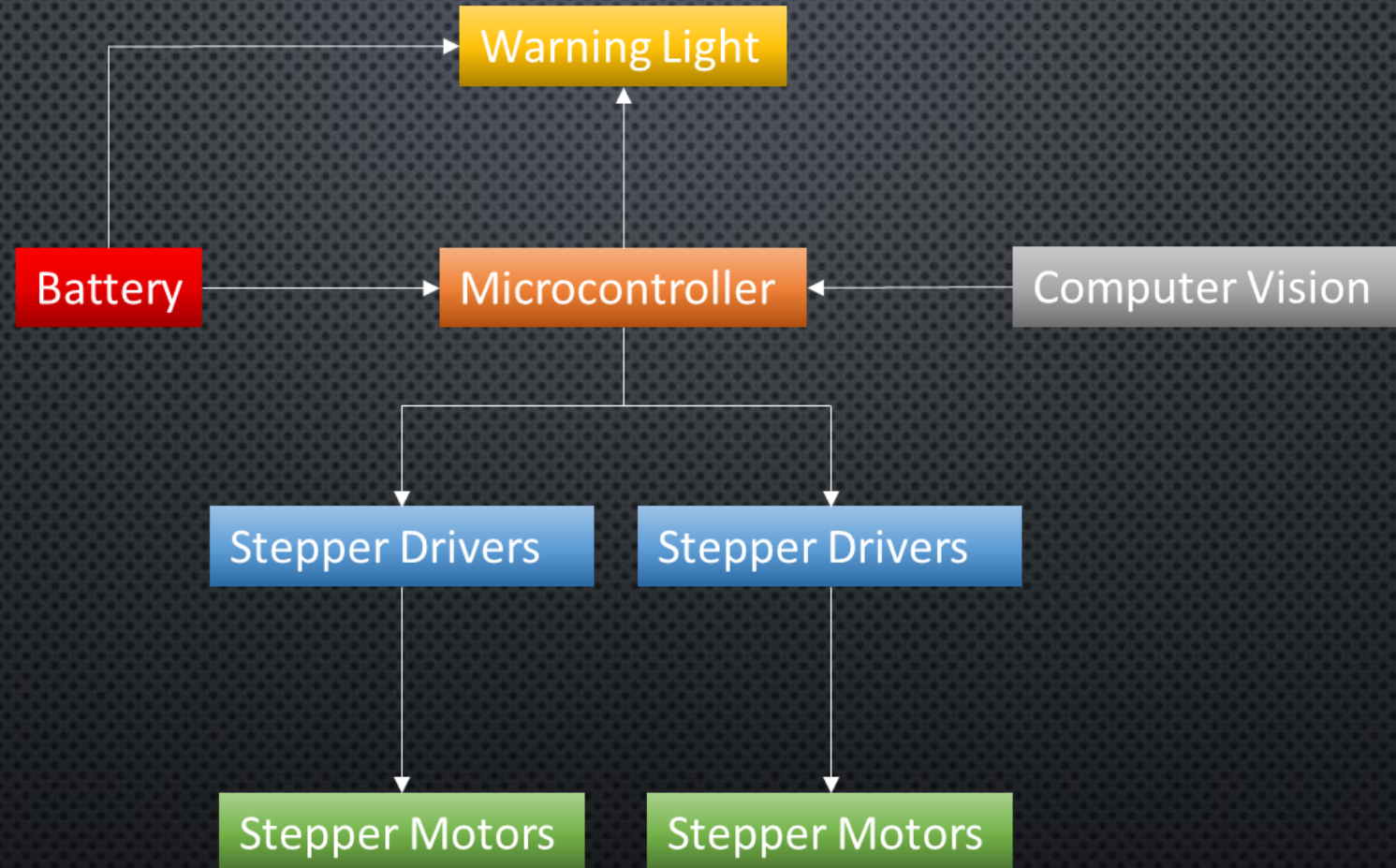| Material	Cost
Pine Wood	~$20
Medium-Density Fiberboard	~$30
Aluminum	~$60
Steel	$58.89

BASE
DESIGN

HARDWARE

PCB BLOCK DIAGRAM

MICROCONTROLLER SELECTION

- Originally thought we could do both turret control and computer vision using a Single Board Computer (SBC)

- Concerns over performance & price restrictions changed strategy

- Considered Arduino Microcontroller + Laptop

- Eventually used the ATMEGA MCU from the Arduino on a custom PCB instead

  - ATmega 328 is compatible with Arduino IDE, easier to program

  - Sufficient Input/Output pins

- Laptop has processing power, but limits portability & self sufficiency

LIGHTING SELECTION

Warning Light	Voltage used	Features	Wire Installation	LEDs contained	Cost
AgriEyes Amber Beacon Light	12 – 24 V	Seven different flashing modes	Red, black, yellow	30	$26.99
Industrial Warning Safety Flashing Beacon	12 –24 V	4 different flashing/strobing modes Plays an audio warning	Red, black, yellow, green	15	$29.99
Bolt Beam 12mm LED Light	9 – 14.5 V	None	Red and black	3	$2.95

CAMERA SELECTION

Camera	Resolution	Frames Per Second	Field of View	Lens Type	Weight (ounces)	Cost
Logitech C270	720p	30	60°	Plastic	2.65	$27.99
Logitech C920s	1080p/720p	30	78°	Glass	5.71	$59.99
Logitech C922	1080p/720p	30/60	78°	Glass	5.71	$99.99

MOTOR SELECTION

Motor Type	Advantages	Disadvantages
Stepper	• Precise positioning • Precise speed control • Excellent torque at low speed • Excellent torque to maintain position	• Limited torque at high speed • Low efficiency • More complex to control
DC	• Efficient • Reliable • Simple control	• Some brushless motors require a specialized regulator to control • Imprecise
Servo	• Consistent torque at varying speeds • Excellent torque at high speed • High variety in size and torque ratings • Direct control over positioning	• Limited range of motion, usually 180 degrees • Small adjustments while attempting to hold a steady position

STEPPER MOTOR SELECTION

Frame size	Diameter (mm)	Typical torque range (Nm)	Typical speed range (RPM)
NEMA 17	42	0.2 - 1	0 - 1000
NEMA 23	57	0.5 - 3	0 - 1000
NEMA 24	60	1.2 - 4.6	0 - 1000

Motor	E-Series Nema 23	P-Series Nema 23 x76	Nema 17
Dimensions	57x57x56mm	57x57x76mm	42x42x34mm
Step Angle	1.8 degree	1.8 degree	1.8 degree
Holding Torque	1.26Nm (178.4oz.in)	1.9Nm (269oz.in)	0.26Nm (36.8oz.in)
Rated Current / Phase	2.8A	2.8A	0.4A
Number of Leads	4	4	4
Lead length	300mm	500mm	1000mm
Price	$26.78	$32.05	$22.89

SERVO SELECTION

Servo	Power	Speed	Torque	Rotation Angle	Size (L x W x H)	Price
Tower Pro MG995	4.8V - 6.0V DC	60 deg in 0.2 sec	8.5 kg-cm	120 deg	40.7mm x 19.7mm x 42.9mm	$11.99
Tower Pro MG995R	4.8V - 6.0V DC	60 deg in 0.20 sec	9.4 kg-cm	120 deg	40.7mm x 19.7mm x 42.9mm	$19.95
Hitec HS-311	4.8V - 6.0V DC	60 deg in 0.19 sec	3.0 kg-cm	96 deg; 202 deg with travel turner	40.0mm x 20.0mm x 36.5mm	$13.49
Hitec HS-645 MG	4.8V - 6.0V DC	60 deg in 0.24 sec	7.7 kg-cm	90 deg; 197 deg with travel turner	40.2mm x 19.8mm x 39.0mm	$35.99

STEPPER MOTOR DRIVERS

Driver	Operational Voltage	Continuous current/phase	Max current/phase	Micro-steps	Price
DRV 8825	8V - 45V	1.5 A	2.2 A	Full, ½, ¼, 1/8, 1/16, 1/32	$11.95
DRV 8880	6.5V - 45V	1.0 A	1.6 A	Full, non-circular ½, ½, ¼, 1/8, 1/16	$8.95
A4988 (Black)	8V - 35V	1.2 A	2.0 A	Full, ½, ¼, 1/8, 1/16	$7.49
TB67S128FTG	6.5V - 44V	2.1 A	5.0 A	Full, ½, ¼, 1/8, 1/16, 1/32, 1/64, 1/128	$13.95

POWER SUPPLY

Power Supply	Type	Voltage (V)	Capacity (Ah)	Weight (lbs)	Size (in)	Price
Tmezon Power Adapter	Power Adapter	12	N/A	N/A	N/A	$8.99
Universal Battery UB1280	Rechargeable Battery	12	8	4.96	5.94 x 2.56 x 3.94	$20.89
TalentCell PB240A1	Rechargeable Battery	24	22.4	1.43	0.94x2.48x 4.13	$72.79
Duracell Ultra DURDC12-55P	Battery	12	55	42.26	8.98x 5.39x 9.06	$174.99 (FREE)

POWER SYSTEM IMPLEMENTATION

| Load on the 24-Volt Source	
Microcontroller	5V
Stepper Motors (2)	24V
Servo Motor	5V
Warning Light	12V
Stepper Motor Drivers	5V

TRIGGERING SERVO (TOWER PRO MG995)

- Speed & position feedback

- Consistent torque at varying speeds (8.5 kg-cm)

- Direct control over positioning (rotation angle: 120 degrees)
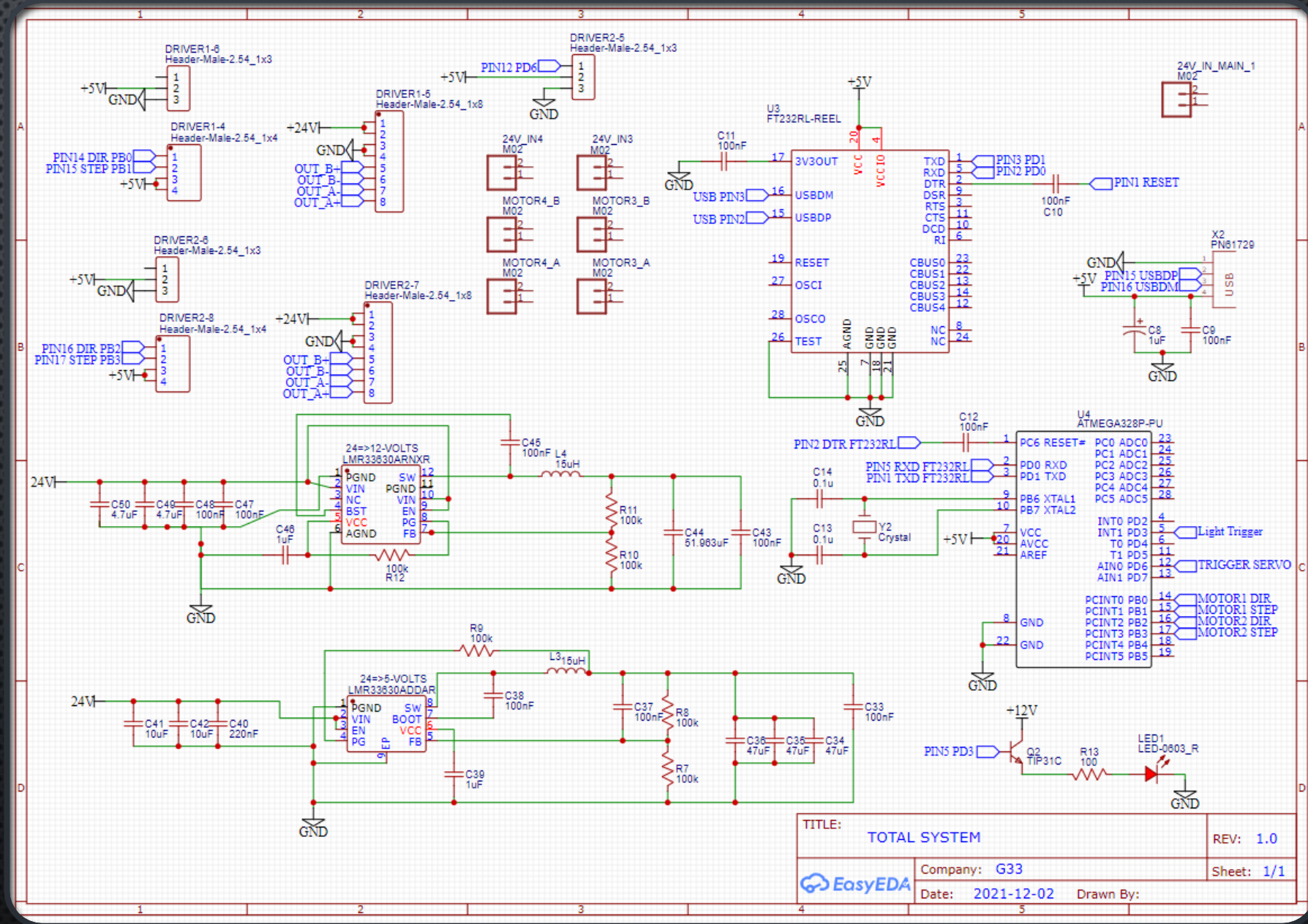
- Low power consumption (4.8 V – 6.0 V DC)

SERIAL COMMUNICATION

- FT232RL
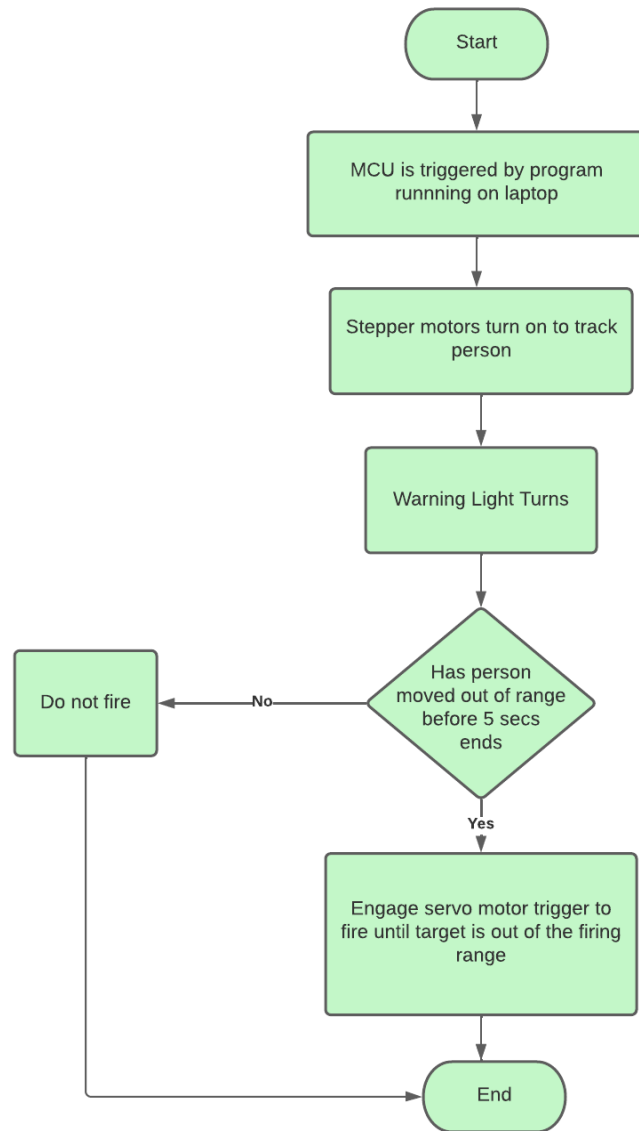
- ALLOWS COMMUNICATION BETWEEN MCU & PC
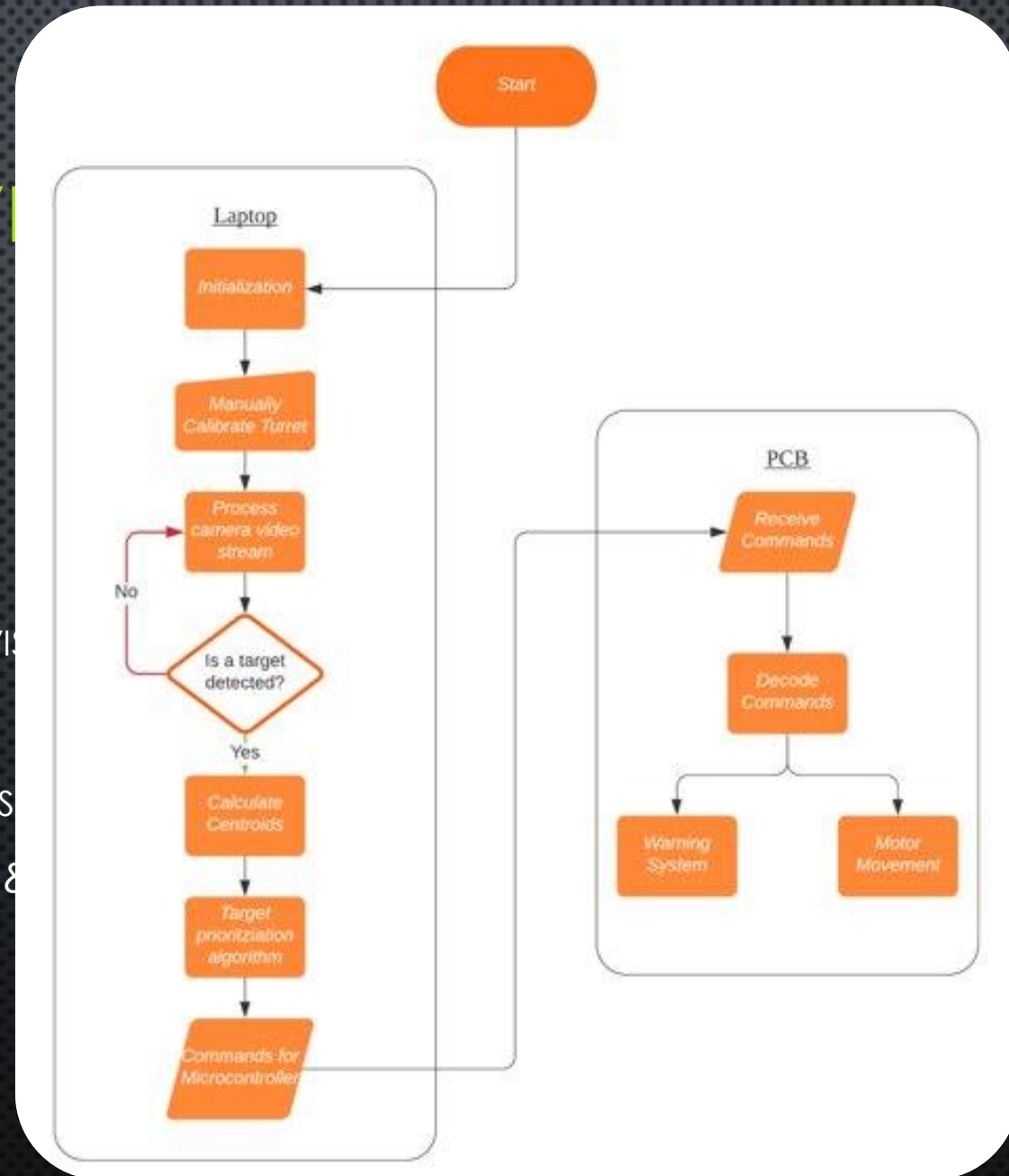
  - SERIAL - USB
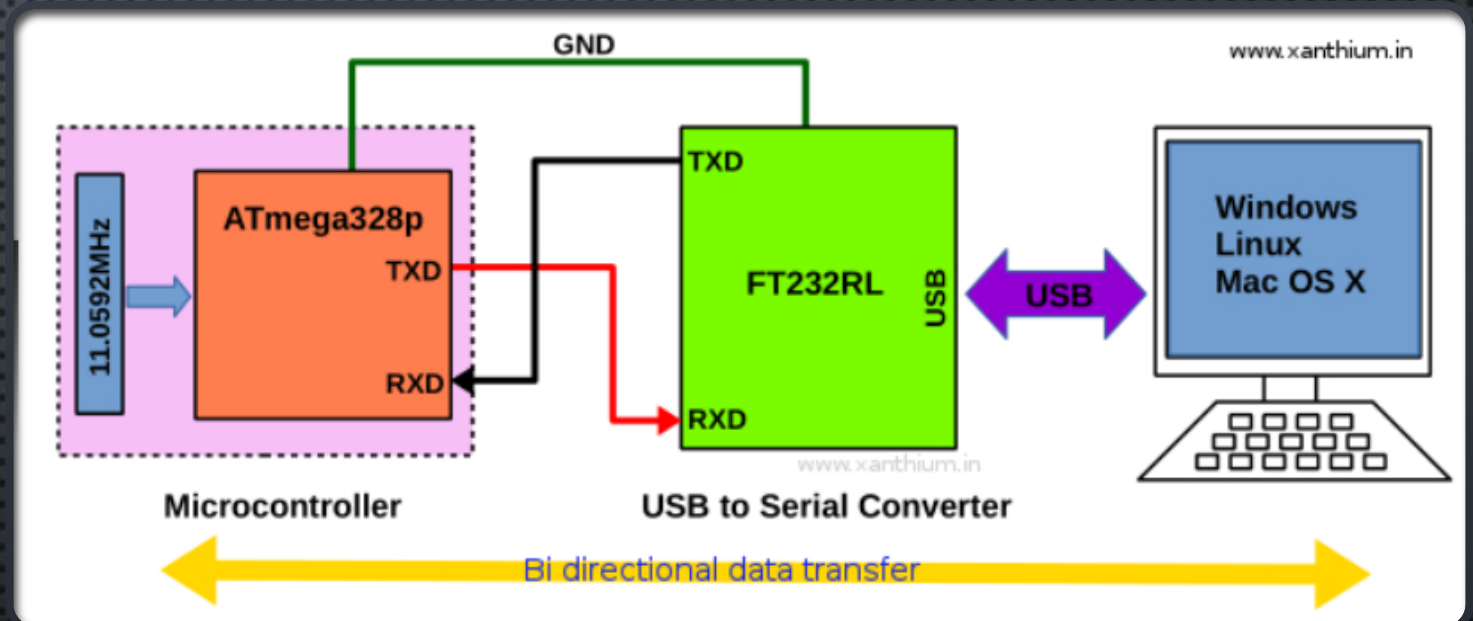
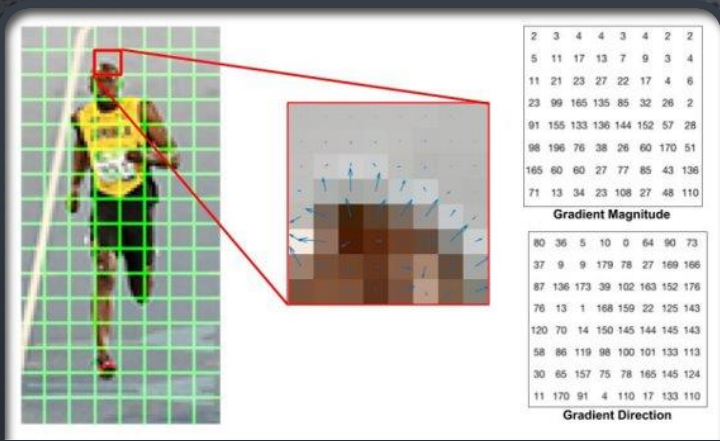# PCB SCHEMATIC

HARDWARE FLOWCHART

SOFTWARE

SOFTWARE OVERVIEW
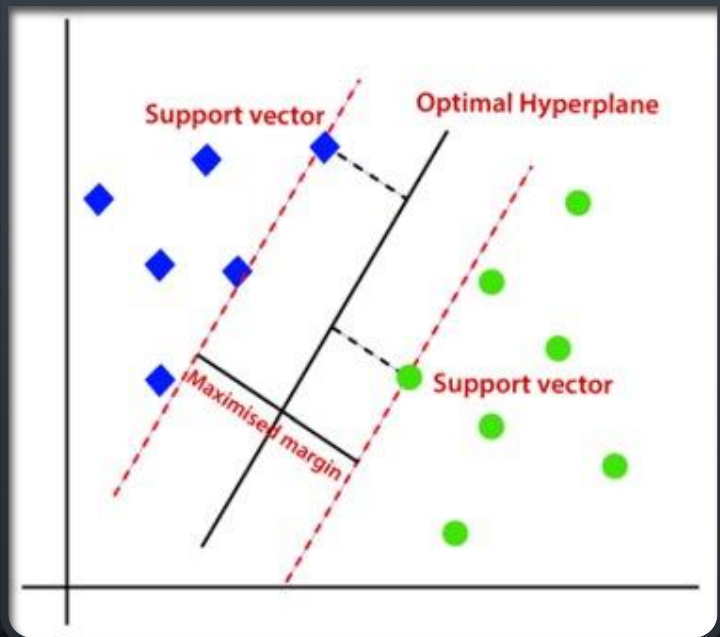

- Laptop
  - Handles computer vision
- PCB
  - Receives instructions
  - Commands motors &

LAPTOP

- OpenCV
  - Acquiring & processing video stream from camera
  - Histogram of Oriented Gradients
    - Feature Detection
  - Linear Support Vector Machine
    - Feature Classification
- Python
  - Faster to write, easier to debug
  - PySerial communication
- Calculations
  - Calculate target steps
  - Formulate & Send instructions

PCB

- ATMega 328 - arduino ide can be used
- Receives instructions from laptop as binary
  - Translates these binary numbers into instructions for functions
  - Pan & Tilt Stepper Motors
  - Trigger Servo
  - Warning Light

ADMINISTRATION

PROJECT TIMELINE

Senior Design II		
Number	Milestone	Planned Completion Week
1	Finish ordering parts	1/17/2022
2	Start building	2/7/2022
3	Start Initial Testing	2/14/2022
4	CDR Presentation	2/25/2022
5	Mid-Term Demo	3/21/2022
6	Final Demo	4/18/2022
7	Final Documentation	4/26/2022

PROTOTYPING

PHASE I

- SOFTWARE PROTOTYPING WITH ARDUINO DEVELOPMENT BOARDS
- COMPUTER VISION PROTOTYPING WITH LAPTOP & ITS INBUILT CAMERA

PHASE II

- BUILDING THE PHYSICAL UNIT
- TESTING THE CODE WITH PCB TO ENSURE ALL PARTS OF UNIT IS FUNCTIONING
- MAKING NECESSARY CHANGES

PHASE III

- ENSURE THE UNIT IS FUNCTIONING AS INTENDED AND READY TO DEMO

BUDGET

Item	Quantity	Price Estimate
Camera	1	$60
PCB	1	$30
Power Cord	1	$10
Internal Power Supply	1	$(175) Free
Paintball Gun	1	$92
Paintballs	1	$35
Air Tank	1	$30
Motors	3	$60
Microcontroller	1	$30
Jumper Wires	1	$5
Paint	1	$10
Screws and Washers	2	$20
Adhesive	1	$12
Red Warning Light	1	$13
Materials for Structure	1	$100
Total	-	$507

INDIVIDUAL RESPONSIBILITIES & WORK DISTRIBUTION

Team Member	Warning Light	Mounting & Casing Design	Camera Selection	Computer Vision Processing	Power System/ PCB Design	Software Coding	Validating and Checking
Kaitlyn		P			P		
Quintin							P
Michael				P		P	
Liderma	P	S	P				

DESIGNS CONSTRAINTS

- MONEY

- SCHEDULES

- DURABILITY

- ENERGY

- DETECTION

- COMMUNICATION (MCU)

CURRENT PROGRESS

- PARTS ORDERED AND READY FOR ASSEMBLY

- FIRST PROTOTYPE OF PCB ORDERED

- PHYSICAL DESIGN COMPLETED

- ALL STRUCTURAL PARTS ORDERED AND ASSEMBLED

- CODE PROTOTYPED ON ARDUINO

UPCOMING GOALS

- Building and Testing

- Mounting points from stepper motor to paintball gun

- Trigger mechanism sizing

- Finalizing design

- Finalizing documentation

THANK YOU!

ANY QUESTIONS?