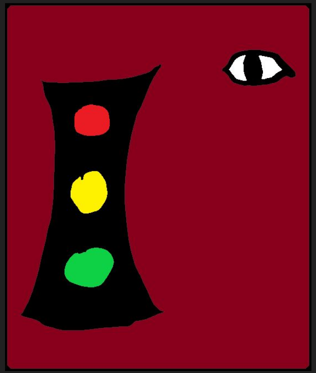


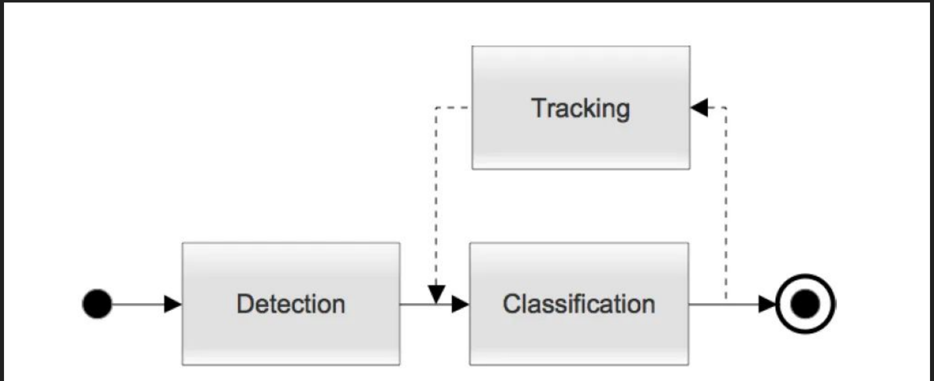
Project Proposal – 2A1

Traffic Light Detection and Tracking

Morgan Roberts, Aaryan Shenoy, Clayton Gowan, Xiaohu Huang, Robert Madriaga

Project Background

Background



The Problem

- Fast and reliable detection of traffic light, and light states
- Can be broken down into 3 parts
    - Detection
    - Classification
    - Tracking (loops back to classification)

Background

Traffic Light Detection Requirements

- Detection
  - Identify image
  - Deep Learning is a natural solution
    - Can be computationally expensive
- Classification
  - Lights must be classified by:
    - Type (arrow direction, solid, blinking, etc)
    - Color (red, yellow, green)
- Tracking
  - conserve data between frames
    - Compensates for lack of data from detection

Needs Statement

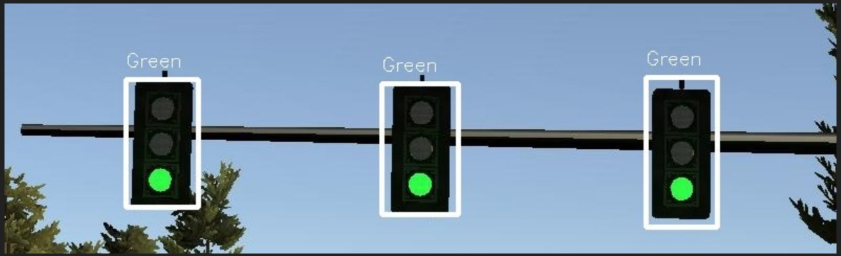
Needs Statement

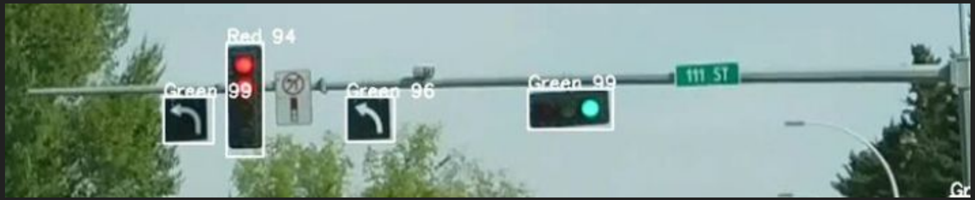
- Need – to detect, track and classify traffic lights
  - Prioritize speed and accuracy
  - Track lights across multiple frames
- Why – Self-driving vehicles must react to traffic lights.
  - Many systems use image data for this purpose.
  - These algorithms are usually to slow.
    - Reaction times are vital for safety

Goals and Objectives

Goals and Objectives

- Goal: Develop a speed-focused detection model for traffic light types and colors, analyze the states of the lights, track detection results across multiple frames, and integrate with ROS.
- Motivation:
  - Fast detection and tracking speeds are crucial in autonomous driving applications
  - Modularization of detection and tracking components





Literature Review

Literature Review

1. Traffic Lights Detection and Recognition Method Based on the Improved YOLOv4 Algorithm
2. A YOLO Based Approach for Traffic Light Recognition for ADAS Systems
3. Traffic Light Recognition — A Visual Guide
4. HDTLR: A CNN based Hierarchical Detector for Traffic Lights
5. A deep learning approach to traffic lights: Detection, tracking, and classification

Design Constraints/Feasibility

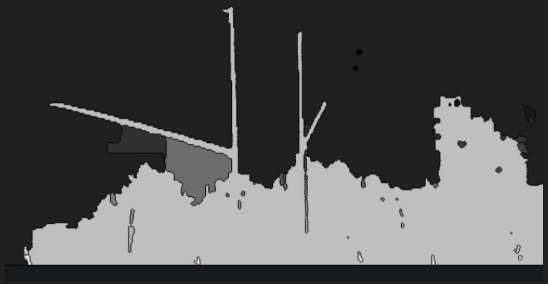
Design Constraints/Feasibility

- Time constraints
  - Due dates limit time to perfect product
- Experience constraints
  - Some members have little experience with machine learning
  - All members must take time to learn tools (ROS, DeepSort, YOLOv8)
- Hardware constraints
  - Specifications of team’s hardware (GPU, CPU)
  - Time required to train and operate model
- Program constraints
  - Allowed confidence level of the model
  - output an array of traffic light data in ONNX format

Alternative Solutions

Alternative Solutions

1. Modify YOLO model to use grayscale and feed hitboxes into deepsort
2. Use the HDTLR algorithm as an alternative to YOLO
3. Change YOLO model using statistics and machine learning techniques
4. Use single-object tracking algorithms in OpenCV (KCF, CSRT, MOSSE, etc.) or use simpler multi-object tracking (SORT) as opposed to DeepSORT
5. Use Mini-YOLOv3 instead of full YOLO to improve performance on lower end hardware



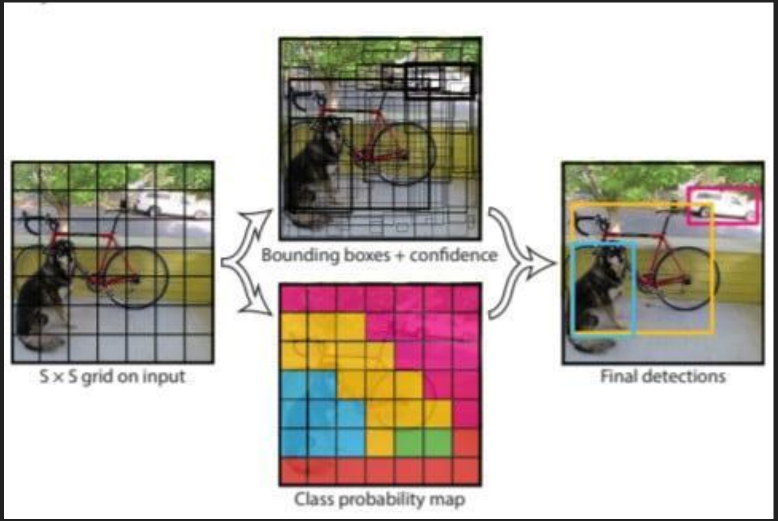
Proposed Design

Proposed Design

- Input: ROS Bag Datasets
- Output: Camera frames with detected traffic lights labeled
- Tools to Use:
  - Machine learning framework
    - YOLOv8 detection model
    - DeepSORT algorithm
  - LISA Traffic Light Dataset
  - ROS node system

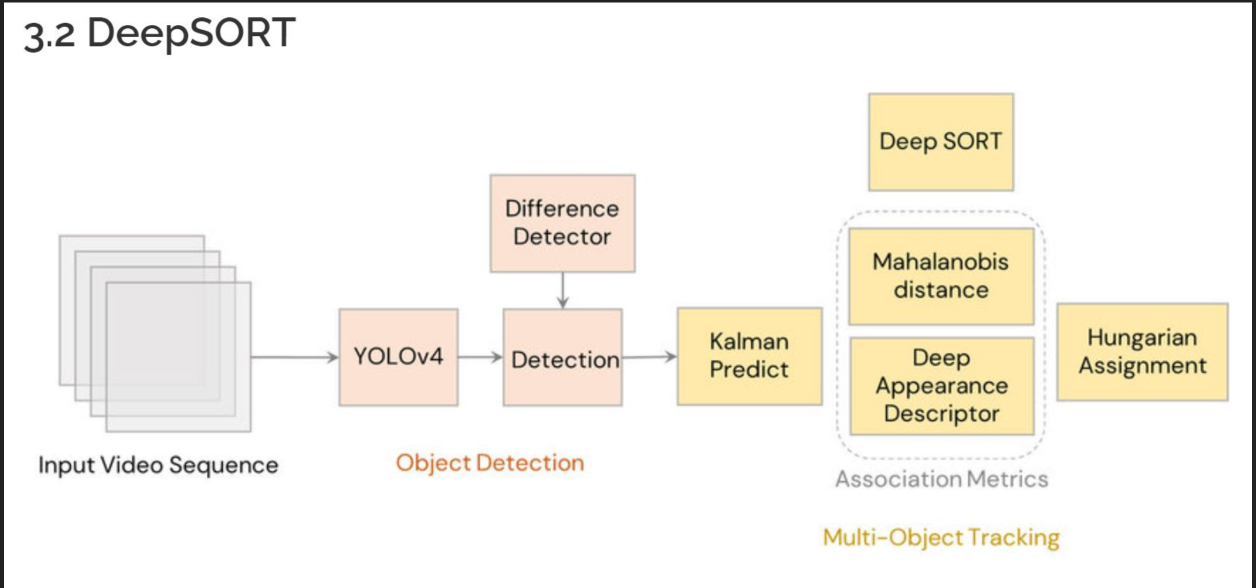
Proposed Design

- YOLOv8 detection model
  - Fastest model for object detection in individual camera frames



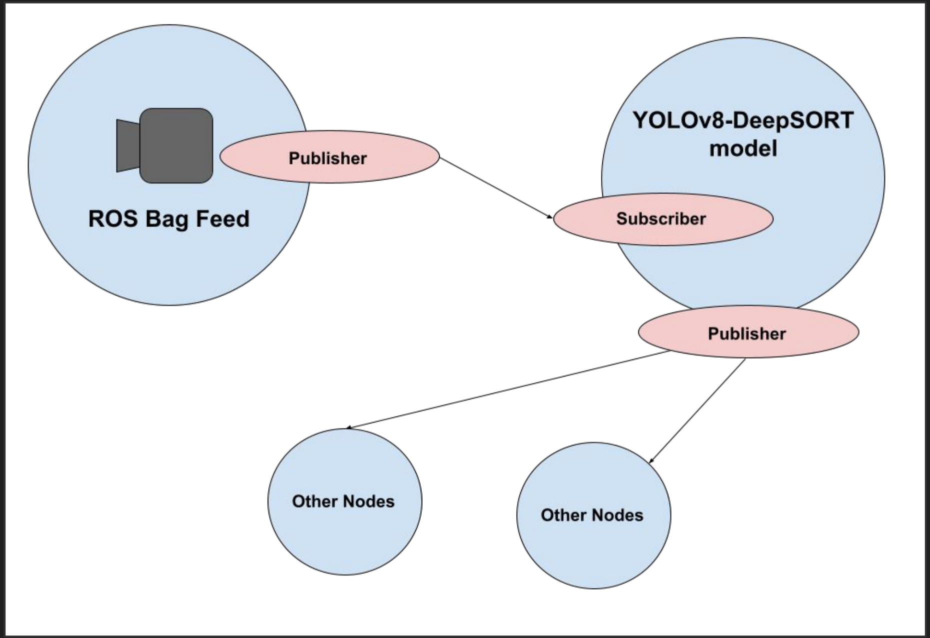
Proposed Design

- DeepSORT algorithm
  - Highly effective multi-object tracking algorithm compatible with YOLOv8



Proposed Design

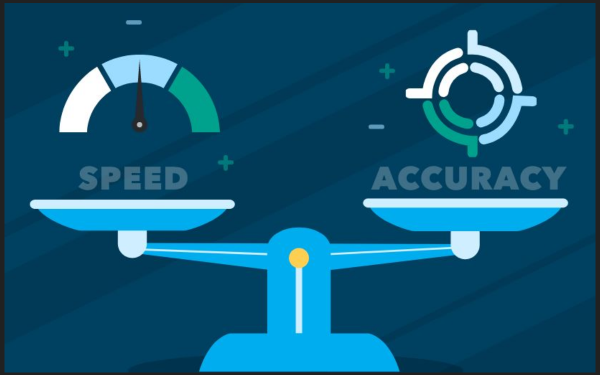
- ROS and machine learning integration via publisher-subscriber model



Approach for Design Validation

Approach for Design Validation

- Ensure we are running at an adequate framerate with good detection speed while also maintaining a high level of confidence and accuracy in detection
  - Measurements: FPS, detection model confidence levels
- Find an optimal balance between model size, speed, and accuracy
  - Compare pre-trained models/different datasets with custom models
- Verify that multiple objects can be tracked accurately across frames
- Make sure pipeline functions correctly with desired formats/outputs



Economic Analysis/Budget

Economic Analysis/Budget

Each team gets a $500 Budget, and out of our budget we spend:

Human Labor - $0

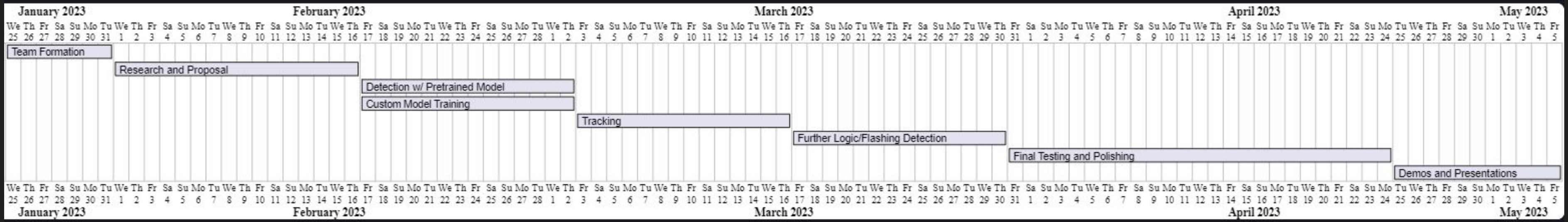
Software - Open Source - $0

Software - Closed Source / Cloud Services - $variable

Schedule of Tasks

Gantt Chart

- Estimation of development schedule (subject to change)



Project Management and Teamwork

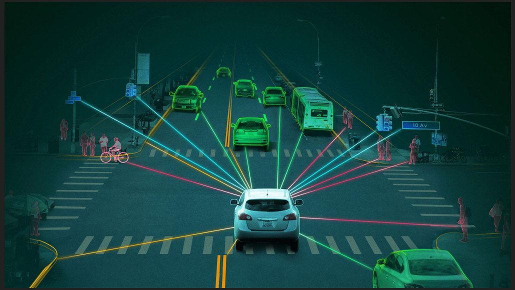
Team Roles

- Morgan Roberts: Team Leader
- Aaryan Shenoy: Systems Design
- Clayton Gowan: Software Design
- Xiaohu Huang: Software Design and Testing
- Robert Madriaga: Technical Writing and Model Training

- There will be weekly in-person team meetings on Tuesdays/Thursdays and Discord meetings as needed
- Members may assist in other roles/responsibilities as needed

Societal, Safety, and Environmental Analysis

Societal, Safety, and Environmental Analysis



- Autonomous vehicles have the potential to improve convenience and quality of life.
  - Optimal travel times
  - Increased accessibility to transportation
- Privacy Concerns
  - Requires monitoring equipment
- Safety Concerns
  - Even minute errors in software or hardware can be catastrophic
  - Lead to loss of life and property damage
- Safety Benefits
  - With ideal monitoring, computation, and decision making, a self driving car can react to and avoid dangerous situations faster than humans and with more consistency
- Environmental Benefits
  - Effective navigation leads to a reduction in emissions

Questions