

Abstract

The City of Arlington has established real-time access to citywide traffic monitoring cameras via a dedicated fiber connection to the ACTION Lab at the University of Texas at Arlington (UTA). This infrastructure enables advanced, data-driven traffic management initiatives. The ACTION lab at UTA developed AVAST(AI-Empowered Vehicle Analytics for Smart Transportation) to count vehicles and detect near-misses at an intersection. Although the AVAST platform currently supports real-time traffic counting, lack capabilities for traffic signal state recognition. Direct access to signal-phase data from traffic controllers remains challenging due to infrastructure restrictions and restricted access.

To overcome this barrier, the ACTION Lab is developing a non-invasive, vision-based system for live detection of traffic signal states using YOLOv11, a state-of-the-art object detection model distinguished for its speed, accuracy, and efficiency in real-time applications. The system uses existing camera feeds to detect and classify signal states without requiring controller integration.

A custom dataset comprising approximately **732** annotated images was collected at Arlington intersections, capturing different conditions, including varying angles and layouts. The dataset focuses on four primary classes: green, yellow, red, and flashing yellow. YOLOv11 was trained on this dataset and evaluated on live citywide camera streams. This approach delivers useful insights for evaluating signal performance, optimizing timing, reducing congestion, and enabling reliable, real-time signal-state monitoring through computer vision, the system promotes broader intelligent transportation goals without invasive modifications to existing infrastructure.

Objective

- Develop a real-time traffic signal detection system using **YOLOv11** to accurately classify signal states (red, yellow, green, and flashing yellow).
- Create and train a custom annotated dataset of traffic signal images collected from **Arlington, Texas**, covering diverse conditions such as lighting, angles, and distances.
- Provide a non-invasive solution for traffic signal monitoring using existing camera feeds to support traffic management and provide traffic signal state when detecting traffic safety events.

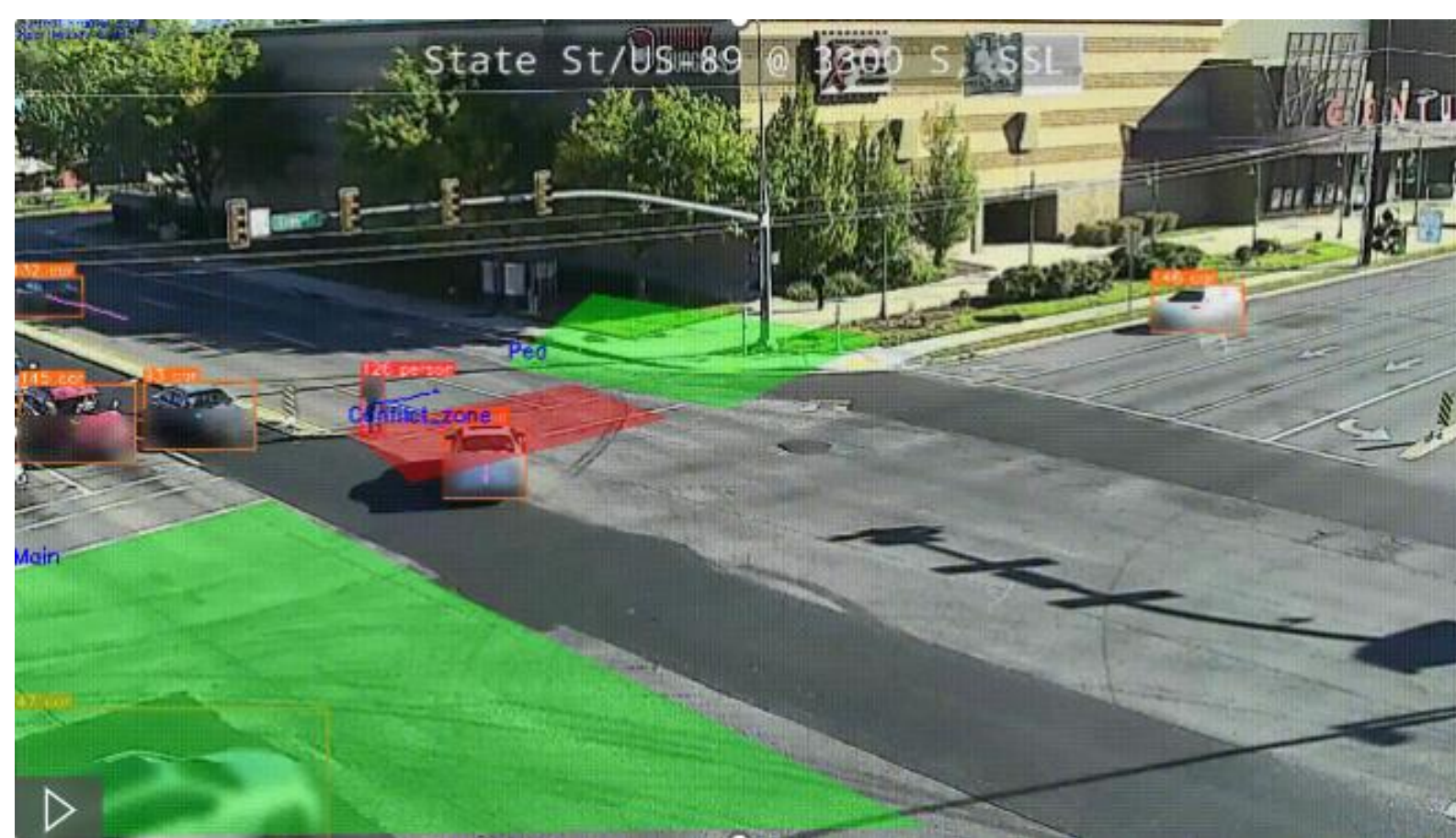


Fig.1 Near-miss event captured by AVAST at the intersection

Methodology Workflow

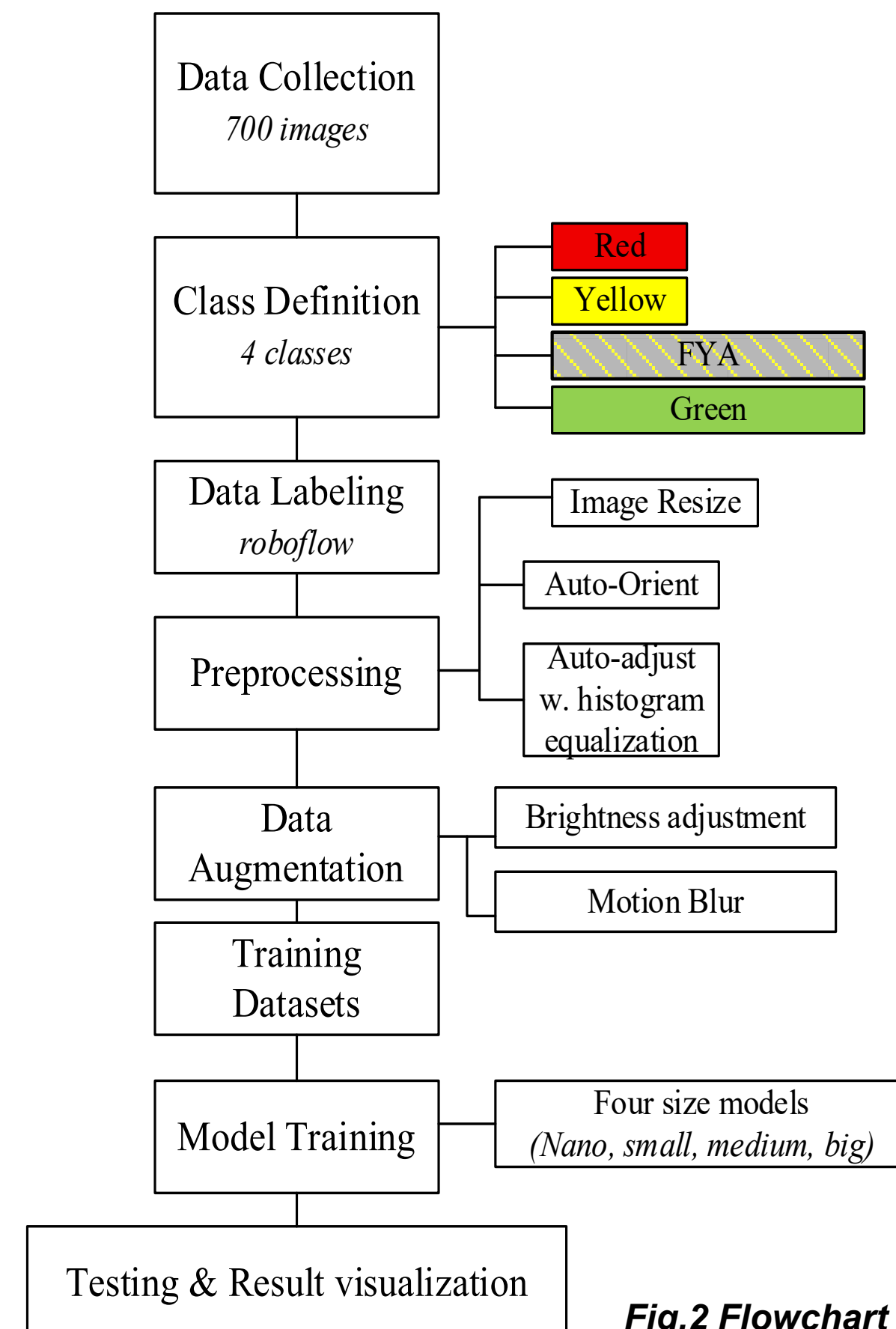


Fig.2 Flowchart of methodology

- The proposed methodology consists of three main steps: Collecting and annotating the dataset. Training the object detection model using the YOLOv11 framework. Evaluating the model's performance.
- Image Resize:** Resizes all images to the same dimensions for consistent model input and faster processing.
- Auto-Orient:** Automatically corrects image rotation using metadata to ensure proper orientation.
- Auto-Adjust with Histogram Equalization:** Enhances image contrast to make traffic light colors clearer and more visible.
- Brightness Adjustment:** Randomly changes image brightness to help the model handle different lighting conditions.
- Motion Blur:** Applies simulated motion blur to improve detection under real-world movement or camera shake.

Data Collection

- Collected **732 images** of traffic signals from Arlington traffic cameras and Google Street View
- Images cover **four classes**: Red (352), Green (269), Yellow (51), and FYA (60)
- Captured **various angles, lighting conditions, and intersection layouts** for robust training



Fig.3 Data Images

Data Labelling

- Annotated all relevant traffic signal objects with axis-aligned bounding boxes and assigned class labels (red, green, yellow).
- Used **Roboflow** for dataset management, annotation, preprocessing, and exporting in YOLO-compatible format.
- Each image is paired with a label file containing normalized bounding box information for supervised YOLOv11 training.

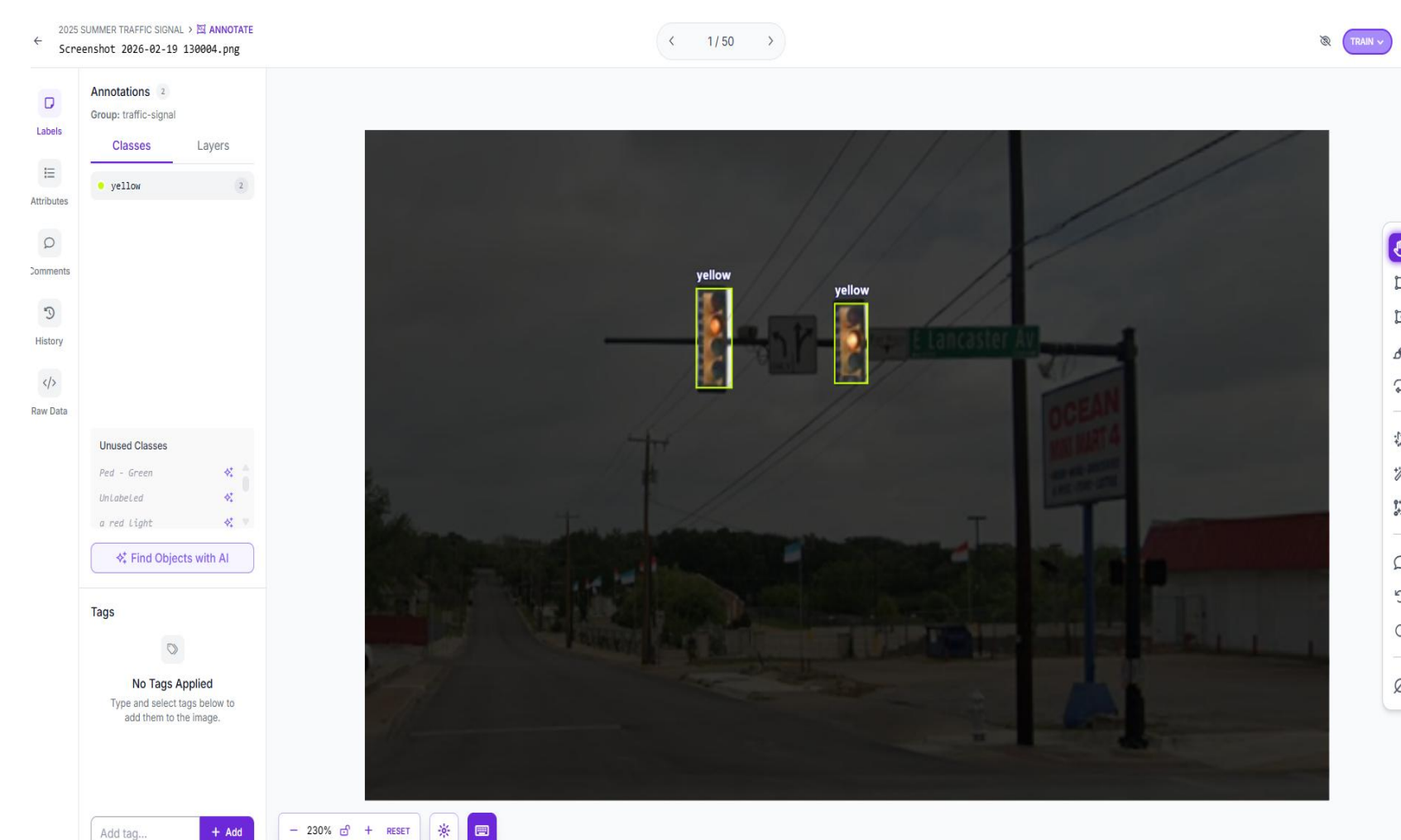


Fig.4 Roboflow Annotate Tool

Model Training

- Roboflow converted annotations into YOLO PyTorch TXT format with normalized center coordinates and dimensions for YOLOv11 compatibility.
- Models were trained on a local workstation with **Intel Xeon Platinum 8168 CPU (24 cores)** and **NVIDIA Quadro RTX 4000 GPU (8 GB)**; nano to large YOLOv11 models were successfully trained.
- Best-performing weights (**best.pt**) from each model size were selected for testing and performance evaluation; the x-large model could not be trained due to memory limitations.

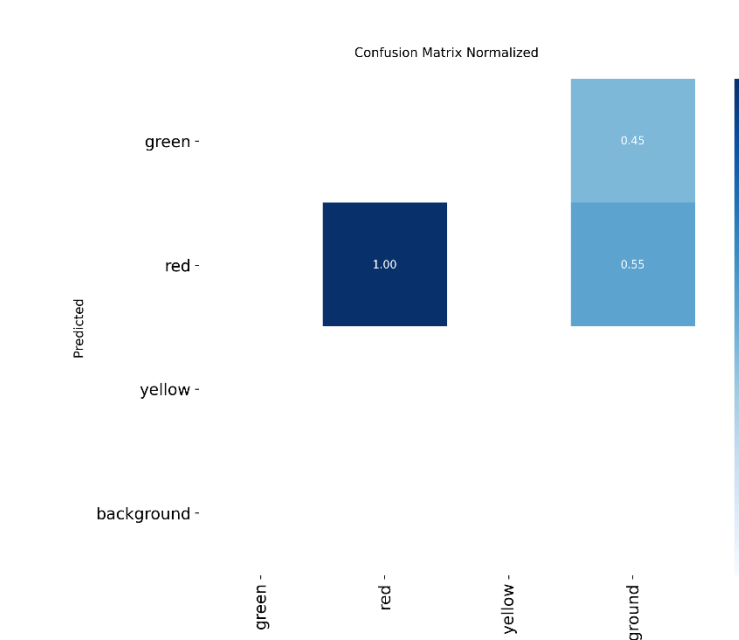
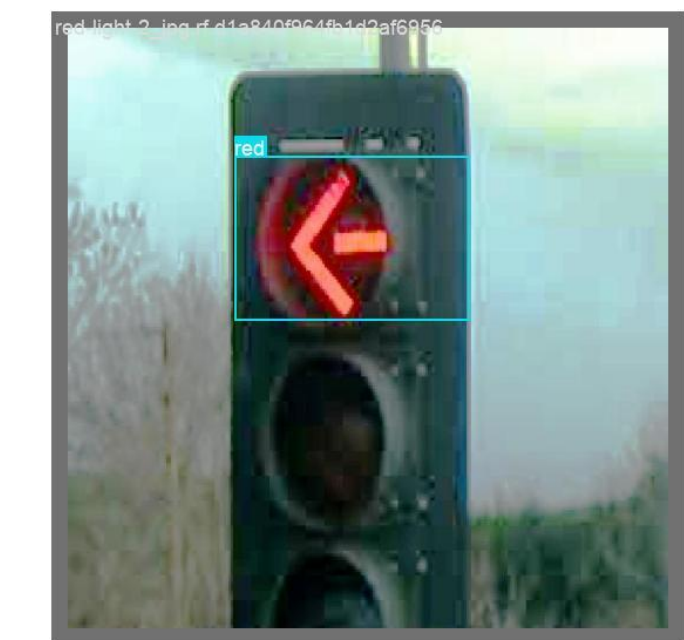


Fig.5 Model Training



Testing the Model

- Evaluated each trained YOLOv11 model using the test videos to measure accuracy, precision, and overall performance.



Fig.6 Traffic state detection with signal duration summary

- High accuracy for Green & Red signals (confidence > 0.75); lower for Yellow (0.68) and Flashing Yellow Arrow (0.52).
- Lower yellow/FYA accuracy due to fewer training samples and visual similarity.
- To make robust signal timing detection, any events that are less than 0.1 seconds are ignored.
- Model effectively summarizes signal durations for traffic analysis and near-miss detection.

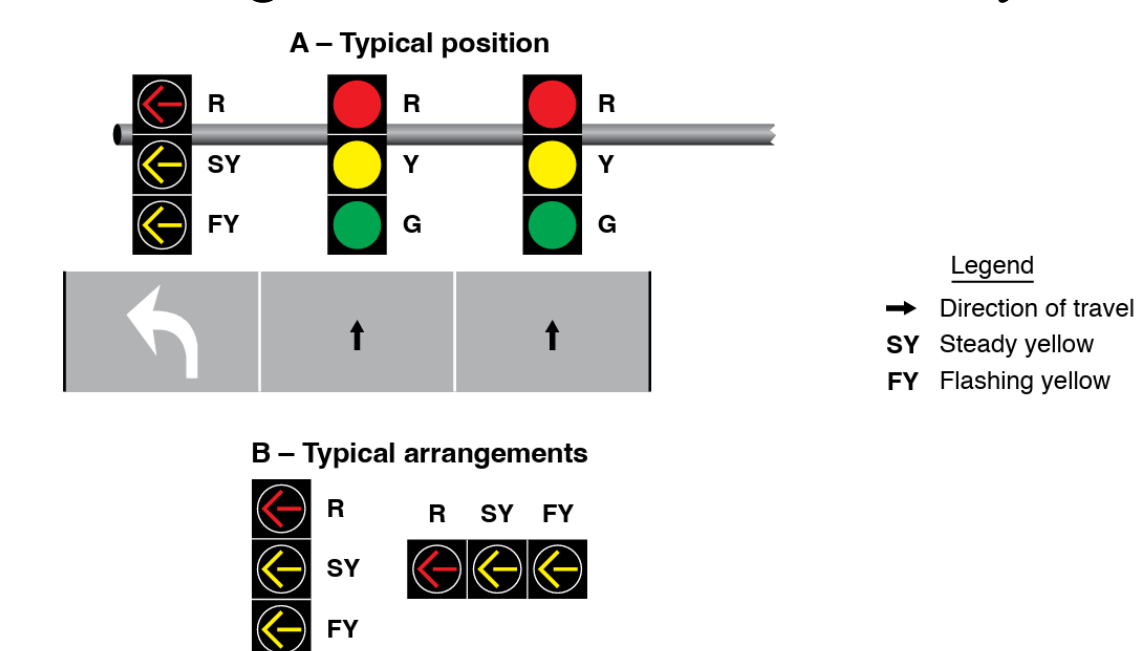


Fig.4 Typical Position and Arrangement of Signal Faces(R: Red, Y: Yellow, G:Green, SY: Steady Yellow and FY: Flashing Yellow) Credit: MUTCD Figure 4F-2

Acknowledgement

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References

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