Vehicle Location by Thermal Image Features

Team 11
Senior Project CS 426
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VLTIF

VLTIF

WHAT IS THE GOAL OF VLTIF?

- Detect any vehicles in image regardless of external conditions
- Accurately count vehicles passing through intersections regardless of external conditions

WHY DO WE CARE ABOUT COUNTING VEHICLES?

TO CONTROL TRAFFIC LIGHTS IN ANY CONDITIONS!

COUNTING VEHICLES AND TRAFFIC LIGHTS

- Accurately identifying and counting vehicles moving across an intersection is a necessary prelude to automated traffic light control and synchronization
- Counting and tracking cars manually is NOT practical
- Current sensors (like inductive loops) are expensive to install and maintain
- This project does not implement artificial intelligence to route traffic

WHY USE CAMERAS?

Our commercial rivals…

LIMITATIONS OF EXISTING SYSTEMS

- Rely on a single color camera as input sensor
- This means good performance is limited to
  - Daylight
  - Clear weather

WHY?

VLTIF

VLTIF

ORIGINAL OBJECTIVES FOR SECOND PRESENTATION

1. Develop labeled ground truth using Vatic.

2. Finish building segmentation module.

3. Integrate Qt GUI with Vision Module.

4. Achieve an accuracy of 80% with a PR Curve Area of over 0.6.

GROUND TRUTH

- Necessary to compare quality of competing algorithms
- Very painful

Ground Truth Metrics

- Total Video Footage Captured: 63 min.
- Total Video Footage Labeled: 48 min, 28s.
- Total Number of Labeled Frames: 87259 frames
- Total Number of Vehicles in Frames: 91770
- Note: Vehicle count means a single vehicle in a single frame.

IDEAL DEVICE SETUP

FLIR SR-19 Thermal Camera
White Box
Black Box

Major Equipment Challenge:
Our thermal camera auto-focus was broke.

VLTIF Vision Algorithm

- Camera Alignment
- Mixture of Gaussian Segmentation
- Tracking and Classification
- Analysis of Results to Ground Truth

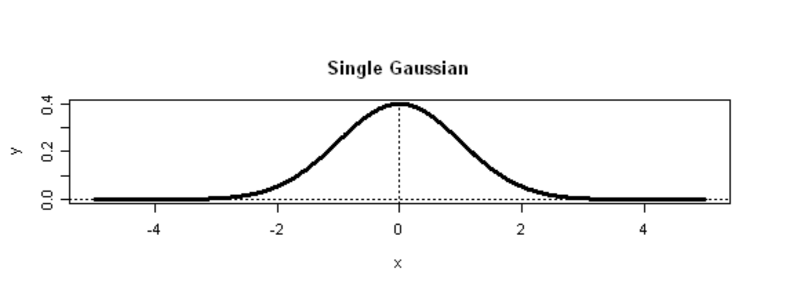
Camera Alignment

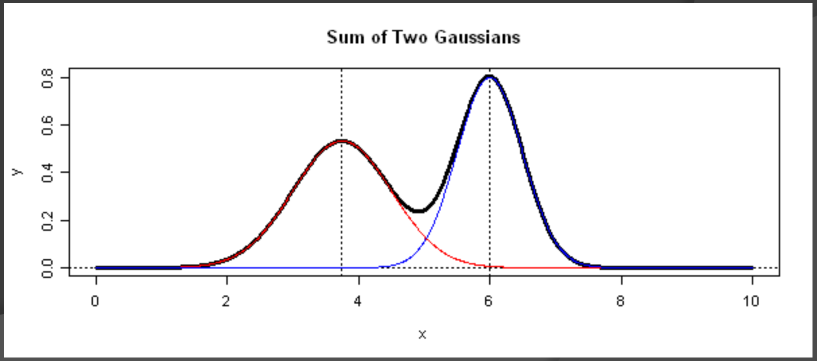
- Visible light is required for comparison.
- An affine transformation is computed using 6 common points between the videos.
- SVD is used to solve for the matrix values.

Background Segmentation

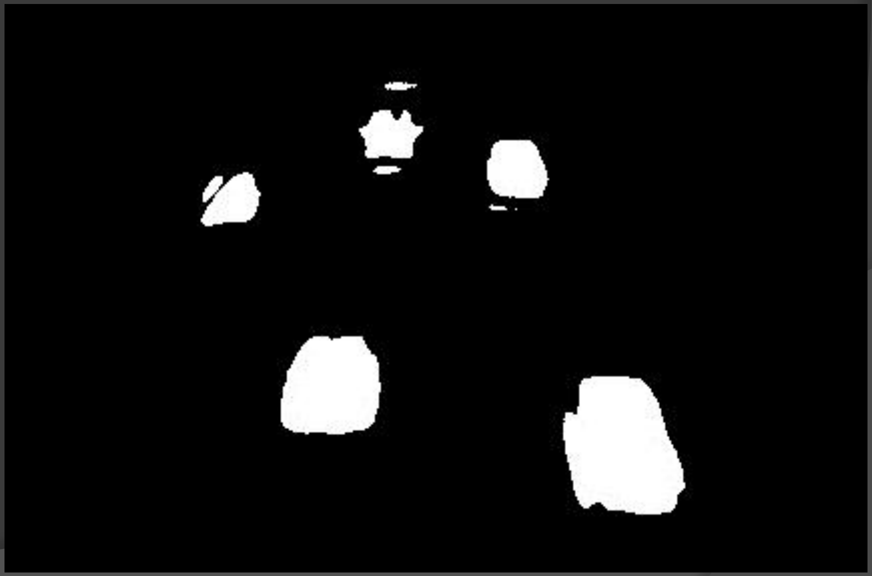
- In order to find vehicles, it is useful to separate the background from foreground (vehicles).
- Mixture of Gaussian!
- Model each pixel in a video sequence as a population of grayscale values.

$$n(x,\mu,\sigma) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)^2 / 2\sigma^2}$$



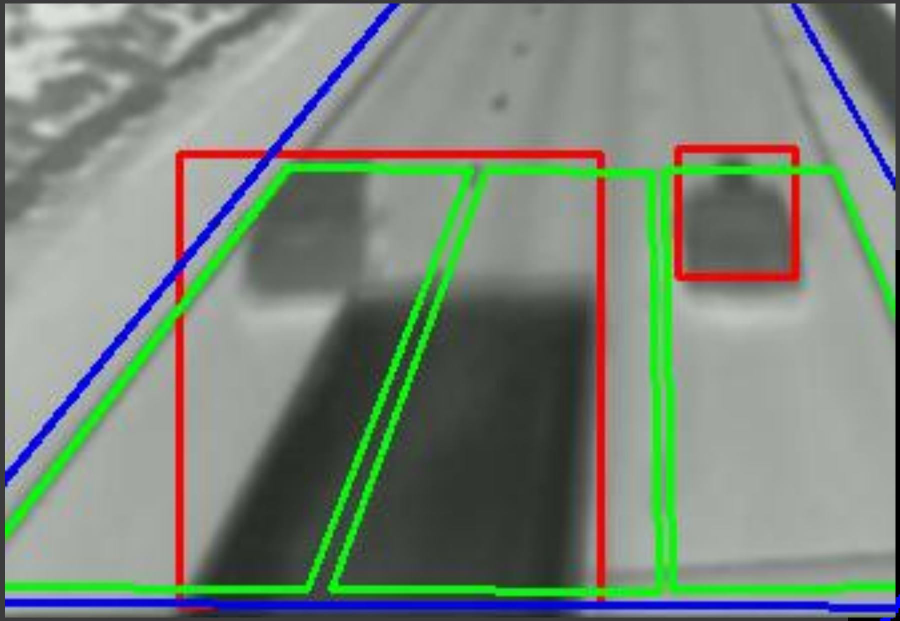


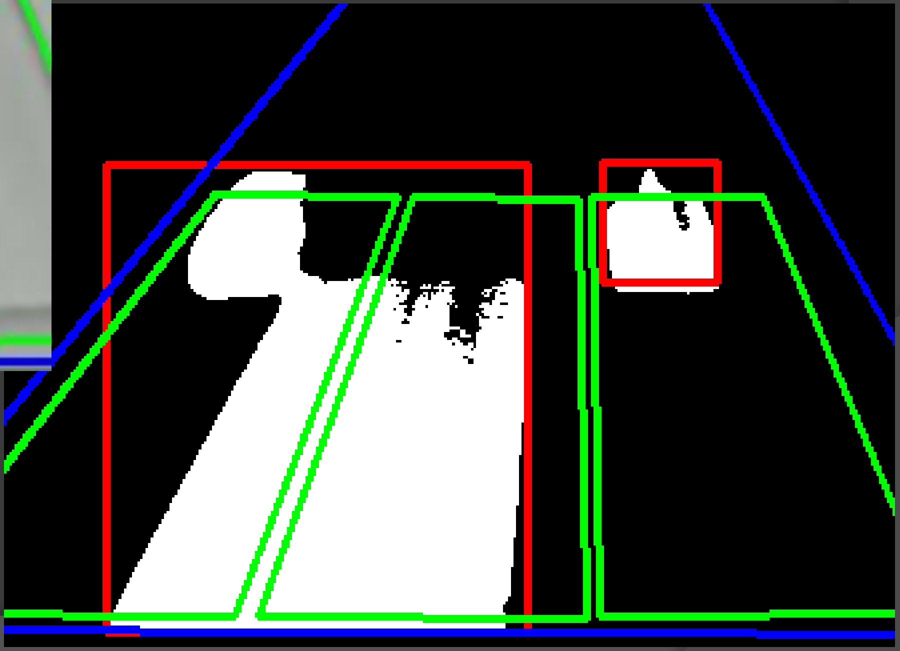
Mixture of Gaussian



Occlusion

Background Modeling Systems Do Not Like Occlusion

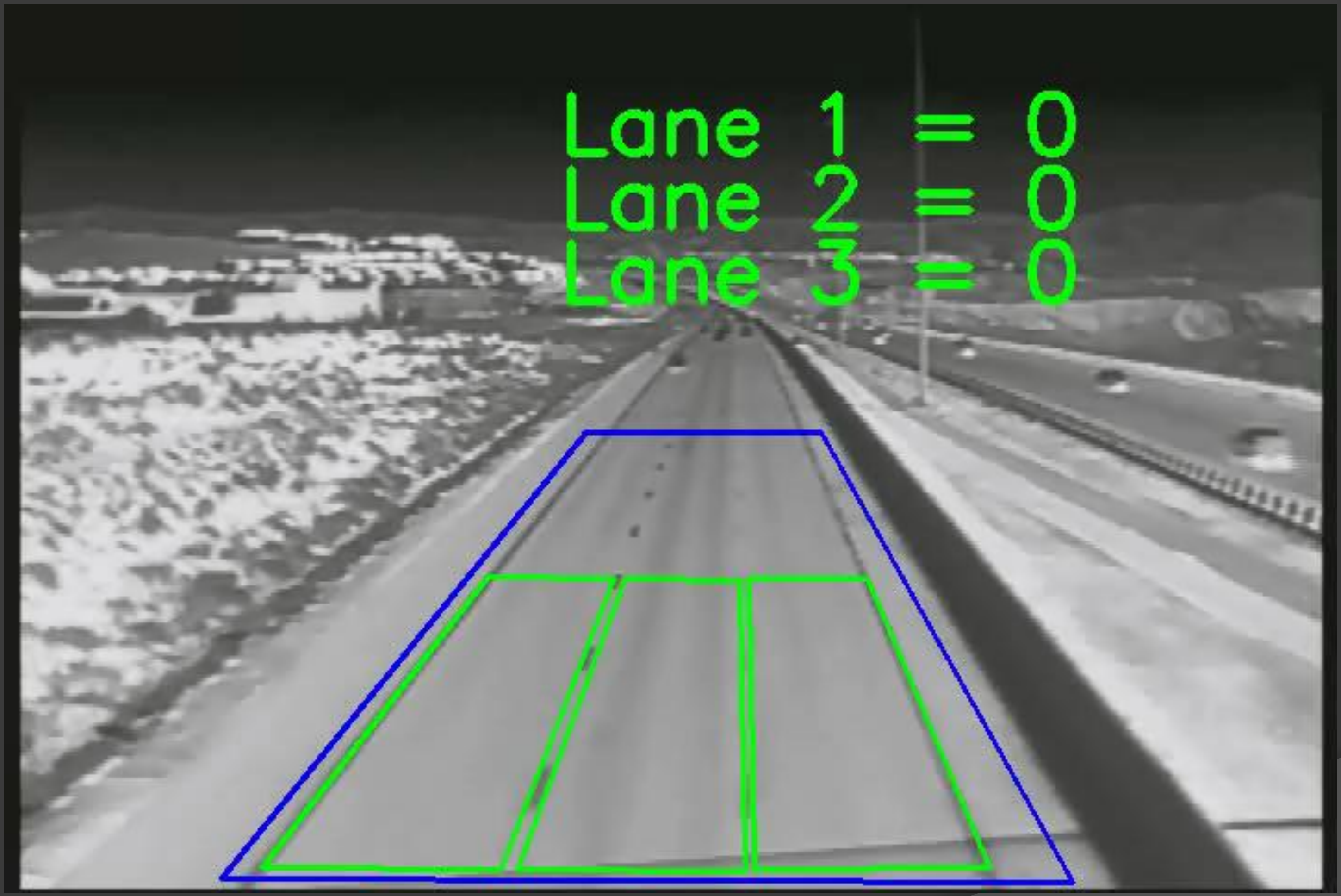




Tracking and Classification

- In order to count, we must track a car throughout its frame history.
- Our matching is based on shape, position, and color histogram comparison.
- Velocity is used to speed up searching.
- For tracking, we added another lane level to our algorithm.
  - Outer windows allow for global tracking.
  - Inner lanes are used for counting.

Results



Analysis

- We compare our VATIC ground truth against VLTIF results.
- Our comparison function is defined as the area of intersection divided by area of the union.

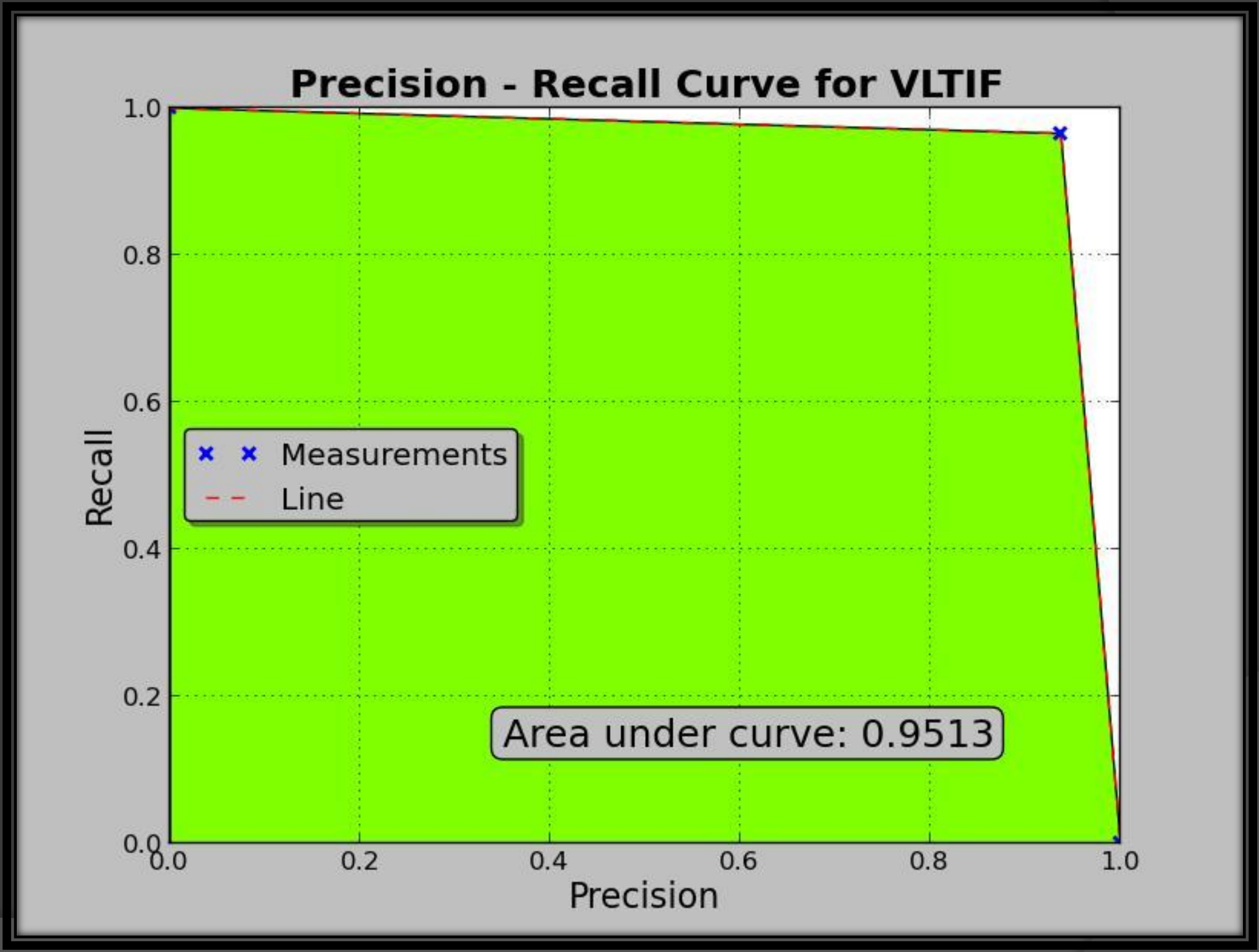
$$\text{Overlap Score} = \frac{\text{Test Region} \cap \text{Truth Region}}{\text{Test}\,Region \cup \text{Truth Region}}$$

Results

- Precision: tp / (tp + fp)
  - How much junk are we tracking which are not vehicles?

- Recall: tp / (tp + fn)
  - How many vehicles are we not tracking?

Results



Precision - Recall Curve for VLTIF
1.0
0.8
0.6
0.4
0.2
0.0
Recall
Measurements
Line
Area under curve: 0.9513
0.0
0.2
0.4
0.6
0.8
1.0
Precision

METRICS

Code Count:

12,587 lines
95 source code files
project sources,
unit tests, validation,
and utilities

Unit Test Coverage

15%

Packages

OpenCV, Qt4,
Boost (Geometry, Filesystem, Program Options)
NumPy/SciPy, NetworkX

Operating Systems

Tested on Linux and Mac OSX

Future Objectives

- Achieve Unit Test Coverage of 25%
- Achieve 95% Precision, 95% Recall
- Better address occlusion issues.