Richard Boadu Antwi[1], Michael Kimollo[2], Samuel Takyi[1], Alican Karaer[3], Eren Erman Ozguven[1], Thobias Sando[2], Ren Moses[1], Maxim Dulebenets[1]

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INTRODUCTION

- Efficient collection of roadway geometry data is crucial for effective transportation planning, maintenance, and design. Current land-based techniques are labor-intensive, dangerous, time-consuming and costly, prompting the need for more efficient methodologies.

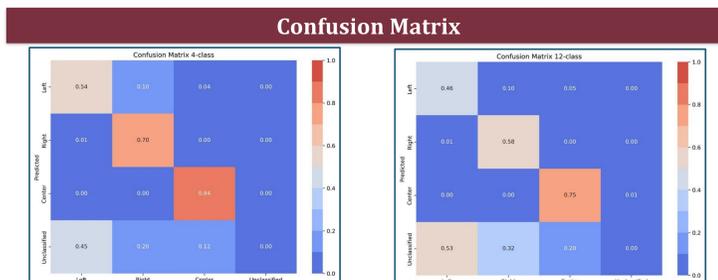- Hence, it is imperative to develop innovative, rapid, cheaper, and more efficient methodologies to collect roadway geometry data across the extensive roadway networks.
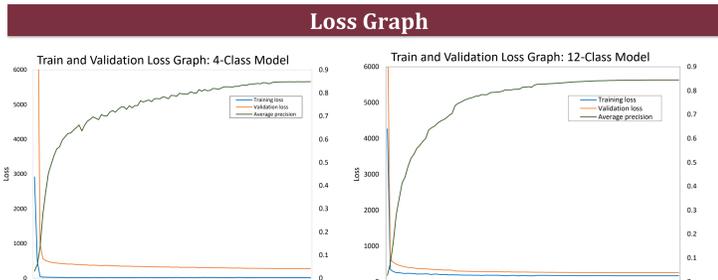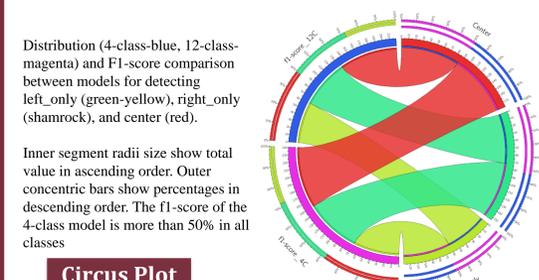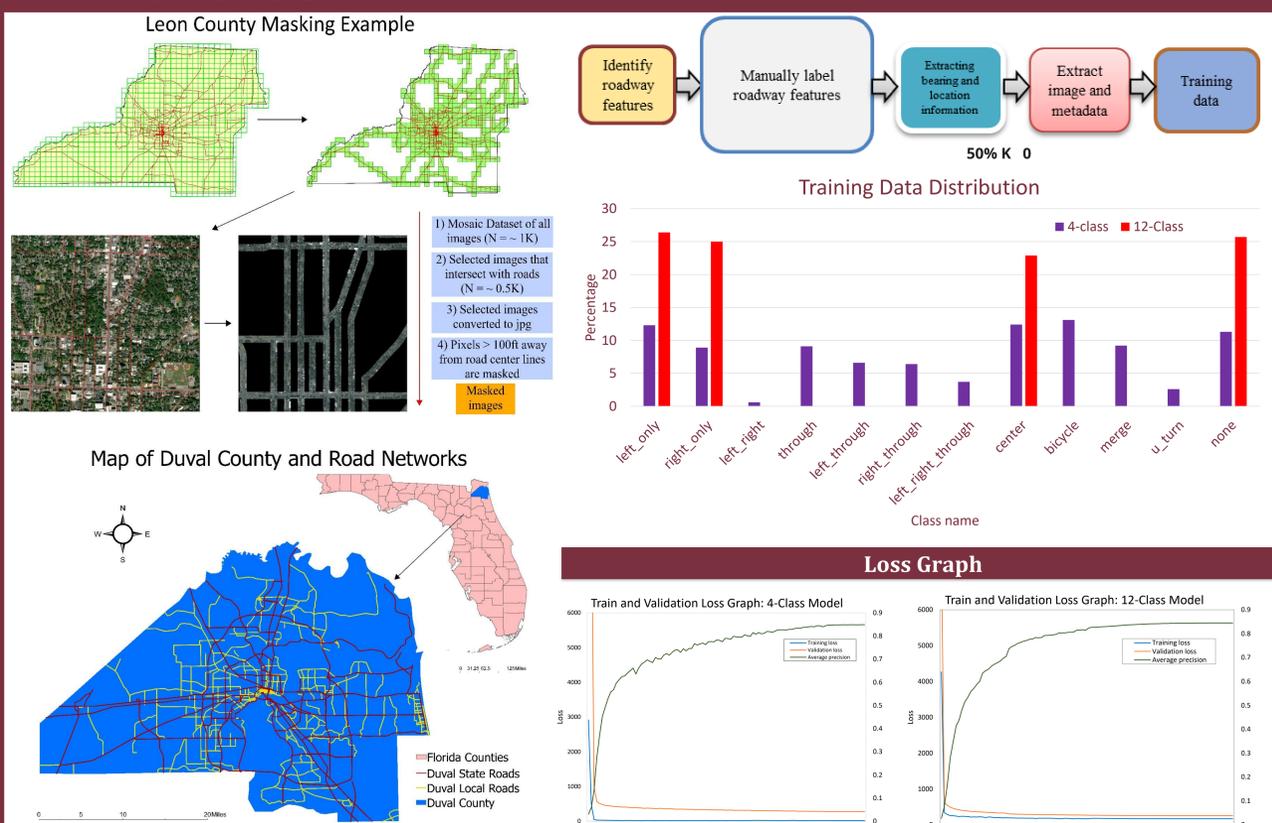
Literature Review

- RCI data includes all elements, such as, roadway geometry, traffic signals, lane counts, turning restrictions, intersections, pavement markings, signage, pavement condition.

- Traditional methods used for collecting roadway characteristics inventory data by DOTs include field inventory, satellite imagery, integrated GIS/GPS mapping, LiDAR, laser scanning, and photo/video logging.

Our Contributions

- Develop a multiclass object detection model based on YOLO to identify and extract features from aerial images,

- Evaluate the performance of the model with ground truth data, and

- Apply the model to aerial images to detect the all features creating an inventory for Florida's Northwest Counties public roadways.

METHODOLOGY

Leon County Masking Example

1) Mosaic Dataset of all images (N = ~ 1K)
2) Selected images that intersect with roads (N = ~ 0.5K)
3) Selected images converted to jpg
4) Pixels > 100ft away from road center lines are masked
Masked images

Identify roadway features → Manually label roadway features → Extracting bearing and location information → Extract image and metadata → Training data

50% K   0

Training Data Distribution

Map of Duval County and Road Networks

Florida Counties
Duval State Roads
Duval Local Roads
Duval County

Distribution (4-class-blue, 12-class-magenta) and F1-score comparison between models for detecting left_only (green-yellow), right_only (shamrock), and center (red).

Inner segment radii size show total value in ascending order. Outer concentric bars show percentages in descending order. The f1-score of the 4-class model is more than 50% in all classes

Circus Plot

Loss Graph

Train and Validation Loss Graph: 4-Class Model
Train and Validation Loss Graph: 12-Class Model

Confusion Matrix

Confusion Matrix 4-class
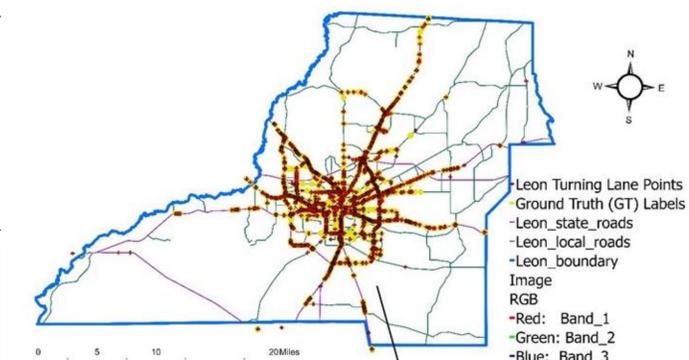Confusion Matrix 12-class

RESULTS

- Based on the findings, this automated 12-class model averagely detect 23% of features with 94% precision at 75% confidence level. At a lower confidence level of 5%, it can detect 73% of features with 96% precision. At 75% confidence level, the average quality of the model's detection is 16% whereas the average quality of the model is 59% at 5% confidence level.

- On average, the 4-class model recorded 42% of detections with 99% precision at 75% confidence level. At a lower 5% confidence level, 80% of detections were observed at 97% precision. The average quality of the 4-class model detections at 75% confidence level is 28% and 68% at 5% confidence level.

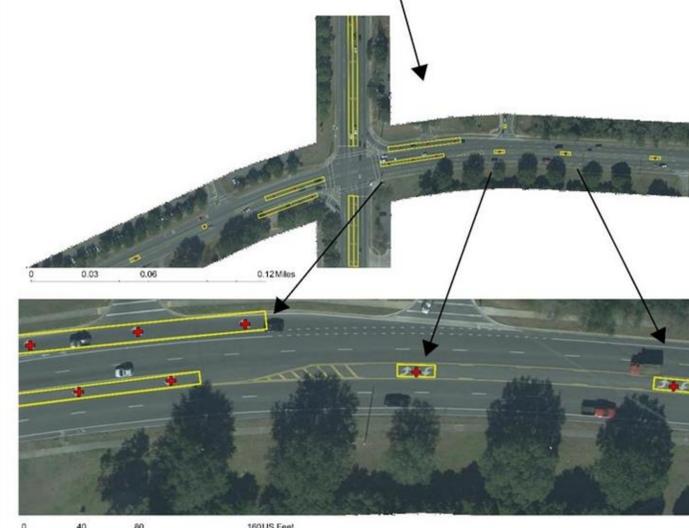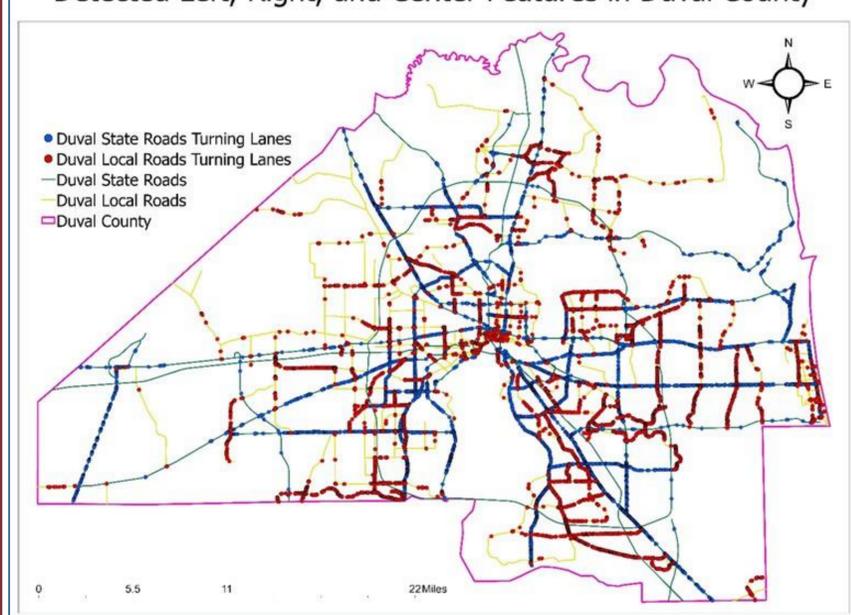Name | Examples of turning lane feature detection from images

Multiple features
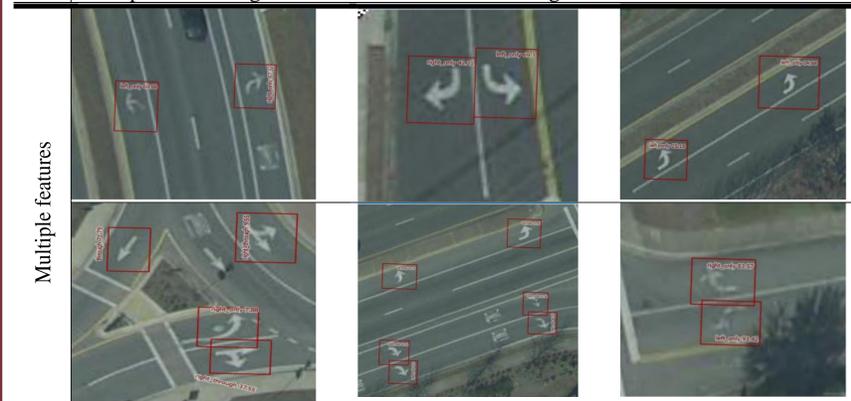
CONFIDENCE (%)	PRECISION (%)		RECALL (%)		QUALITY (%)	
	4-class	12-class	4-class	12-class	4-class	12-class
75	99	94	42	23	28	16
5	97	96	80	73	68	59

Leon County Ground Truth and Detected Turning Lanes

Leon Turning Lane Points
Ground Truth (GT) Labels
Leon_state_roads
Leon_local_roads
Leon_boundary
Image RGB
-Red: Band_1
-Green: Band_2
-Blue: Band_3

Detected Left, Right, and Center Features in Duval County

Duval State Roads Turning Lanes
Duval Local Roads Turning Lanes
Duval State Roads
Duval Local Roads
Duval County

CONCLUSIONS

- This study investigates the utilization of computer vision tools for roadway geometry extraction focusing on Florida Counties as a proof of concept.

- This innovative approach aims to replace labor-intensive manual inventory processes with computer vision technology, potentially reducing errors associated with manual data entry.

- By leveraging high-resolution imagery, the developed system can accurately identify turning lane markings from images, offering a cost-effective alternative to human inventory development procedures enhancing the quality of highway geometry data by minimizing manual errors.

- The benefits of this automated roadway data extraction approach for transportation agencies are manifold. It facilitates the identification of outdated or obscured markings, enables the comparison of turning lane locations with other geometric features such as crosswalks and school zones, and supports the analysis of accidents occurring in proximity to these locations.

- Findings were validated using ground truth data from Leon County, Florida and model was applied to detect features in Duval County, Florida.