Assessing the Impact of Hurricanes on Roadway Closures and Accessibility: A Machine Learning-based Case Study of Hurricanes Ian and Idalia

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INTRODUCTION

- Hurricanes have been responsible for a great number of fatalities and property damage among any weather-related catastrophes in the U.S. history.
- Between 1980 and 2021, the approximate total cost of damages caused by weather and climate disasters in the U.S. was more than $2 trillion(National Oceanic and Atmospheric Administration (NOAA) n.d.).
- Hurricane Ian also severely impacted Florida's transportation network in 2022, causing extensive damage.
- Assessing this damage following the hurricane is essential for post-event reconstruction and humanitarian aid.

Traditional approaches of assessing post-hurricane roadway conditions and accessibility rely on manual observations and reports, which can be challenging and prone to error.

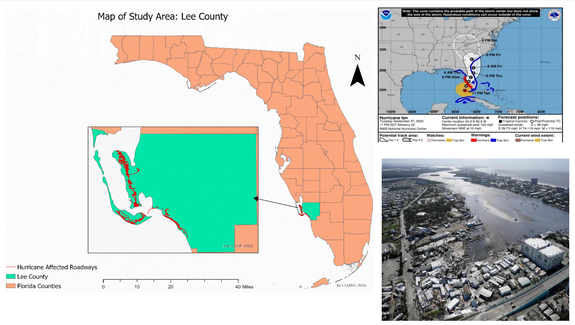
Literature Review

- In the literature, several studies have used machine learning and other remote sensing techniques to assess the impact of natural disasters.
- While it is possible to manually analyze remotely sensed images using skilled human analysis and image annotation tools, this would be very labor-intensive and would slow down the ability to respond quickly to natural disasters like hurricanes.

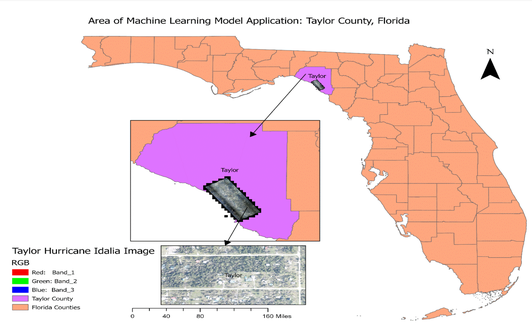
Our Contributions

- This study introduces a novel application of machine learning techniques to assess the impact of Hurricane on roadway closure and accessibility. By leveraging satellite imagery and other geospatial data analytics, this research offers a data-driven approach to understanding and managing post-disaster transportation challenges.
- The findings from this research provide actionable insights for disaster management and urban planning.

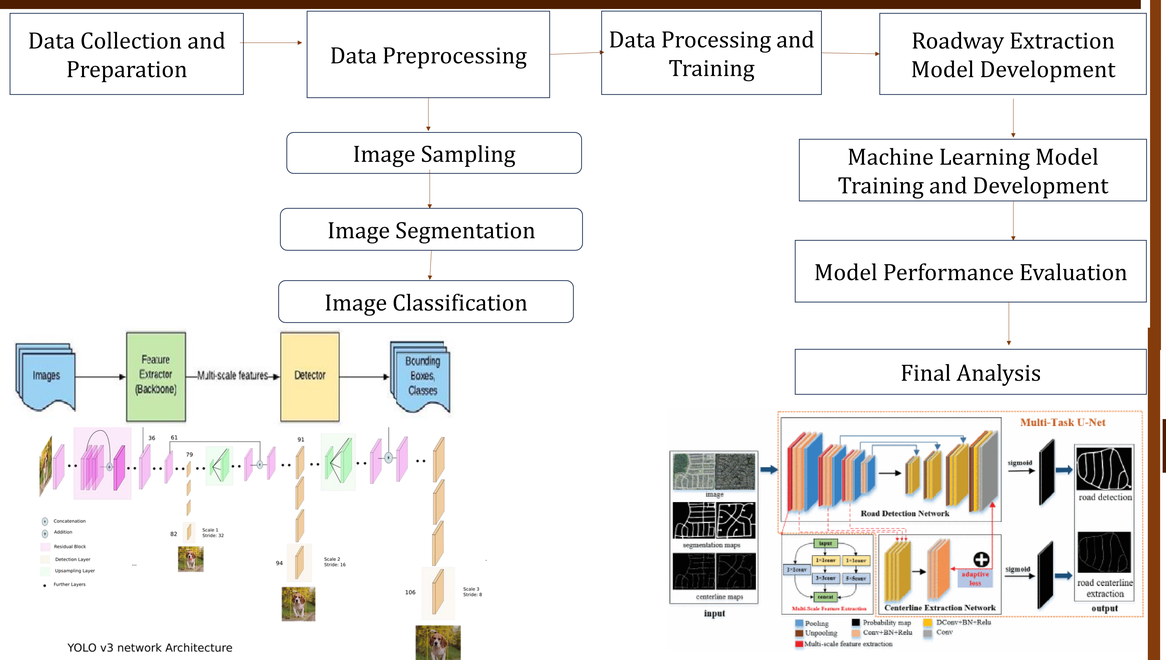
Lee County



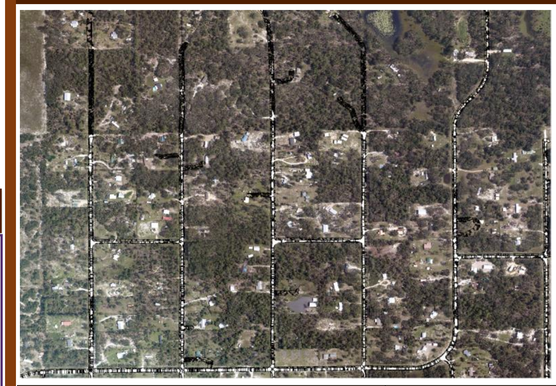
Taylor County

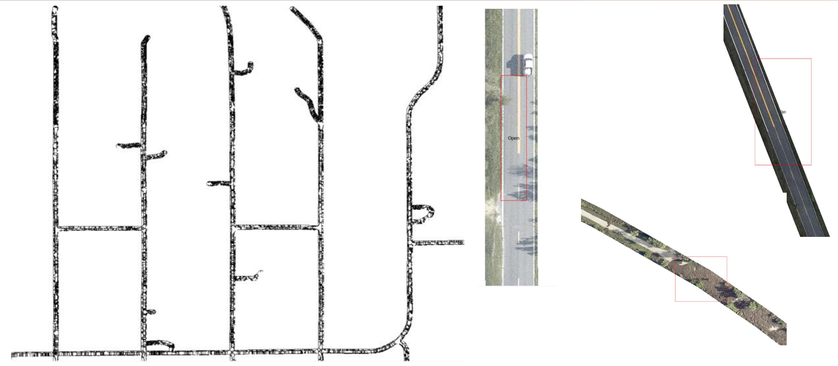


METHODOLOGY



RESULTS





Roadway Classification	Count
Open Roadways	110
Fully Closed Roadways	55
Partially Closed Roadways	96

	Predicted Class		
Actual Class	Open	Fully Closed	Partially Closed
Open	104	9	48
Fully Closed	6	38	3
Partially Closed	1	5	47

	True Positive (TP)	False Positive (FP)	False Negative (FN)
Open	104	57	7
Fully Closed	38	9	14
Partially Closed	47	6	51

	Precision (%)	Recall (%)	F1-Score (%)
Open	65	94	77
Fully Closed	81	73	77
Partially Closed	89	48	62

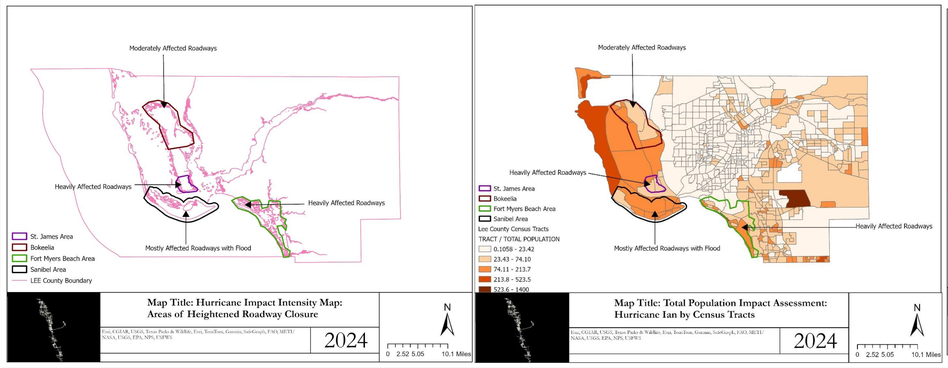
Combined Metrics and Performance Evaluations for Roadway Classification Models for Hurricane Ian

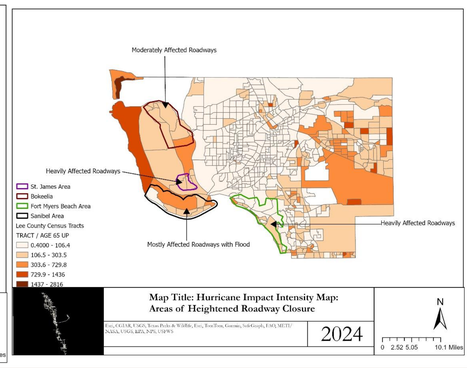
Class	Open	Partially Closed	Fully Closed	Total
Number of Detections	115	16	38	169

	True Positive (TP)	False Positive (FP)	False Negative (FN)
Open	93	22	
Fully Closed	36	2	7
Partially Closed	15	1	17

	Precision (%)	Recall (%)	F1-Score (%)
Open	81	100	90
Fully Closed	95	84	89
Partially Closed	94	47	63

Model Performance Evaluations of Hurricane Idalia





CONCLUSIONS

- The machine learning methodology revealed that post-hurricane roadway conditions can be effectively categorized, providing critical insights for disaster response.
- Roadways with high debris occlusion and dynamic conditions are more challenging to classify accurately, highlighting key areas for model improvement.
- Public infrastructure near coastal and debris-prone regions faces heightened vulnerability, requiring tailored emergency and recovery strategies.
- Findings support initiatives like improving resilience planning and optimizing emergency response for hurricane-prone areas.

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