Intelligent Urban Asset Analysis: A Scalable Deep Learning Based Inspection System

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***Abstract*— Urbanization spurs economic growth, but its rapid pace strains infrastructure. Balancing benefits with responsible management is key. This paper focusses on the implementation of a Deep Learning-based inspection system for Guwahati city that utilizes state-of-the-art object detection algorithms trained on a custom urban assets dataset. The system swiftly identifies and locates vital urban assets like traffic signs, garbage bins, and trees, delivering their real-time geolocation data, enabling efficient management by leveraging on-ground real time data for predictive maintenance. We validated our method on two important routes in the city of Guwahati. Qualitative and quantitative results demonstrate the feasibility, scalability and effectiveness of the proposed solution.**

***Keywords*— Urban asset management, Object detection, Geotagging, Computer Vision, Data Visualization**

I. Introduction

Guwahati, the largest city in Assam and a rapidly developing urban centre in India, grapples with various challenges, including traffic congestion, deforestation, and littering, etc. This paper proposes the implementation of a smart automated inspection system to monitor the presence of urban assets in the city such as traffic signs, garbage bins and trees in real-time. The system aims to be cost-effective and quick responsive, utilizing custom deep learning model for efficient detection of the objects of interest (namely traffic signs, trees and garbage bins) and retrieve their geolocation and store the necessary information in a database.

The system is equipped with a visualization module that projects the detected objects over a map segment of the respected testing route, with the help of the coordinates retrieved from the GPS-module in real time. The stored data is later organised to perform a data analysis and get effective inferences regarding the presence of assets that could facilitate government authorities for better asset management. For the task of asset detection, two state-of-the art object detection architectures of YOLO (v5) and YOLO (v8) are trained over a custom dataset G.U.A.D (Guwahati Urban Asset Dataset) which is developed based on the city of Guwahati. The models are then evaluated based on their detection accuracy using their respective mAP scores. This project aligns with the city's need for innovative solutions to address these challenges and contributes to the broader literature on urban asset management systems.

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II. Proposed System

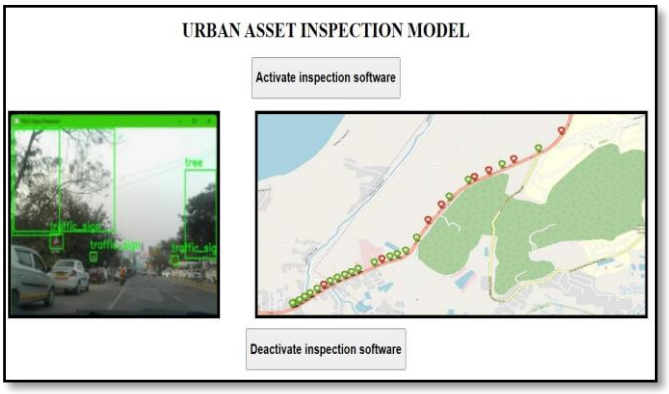

Fig-1. Urban Asset Inspection System interface

At the initial visual information capture phase, individual frames are extracted from the live camera stream and fed to the object detection model. A YOLOv5 model, trained on the custom dataset, identifies urban assets and marks them with bounding boxes in each frame. An SKG13 GPS module connected to Arduino continuously transmits real-time location data. Tiny GPS library in Arduino processes data and sends it to Python via serial port with a 0.5-second delay. Detected object IDs and location data are used to display assets in real-time on a map with unique markers, and are stored in a database for map visualization (Fig. 1).

III. CONTRIBUTIONS

Our contributions are three-fold:

1. Version 1 of GUAD: a custom multi-class dataset with images and annotations of Guwahati city's urban assets (trees, garbage bins, Indian traffic signs) from major routes of the city.
2. An end-to-end real-time urban asset inspection system equipped with state-of-the-art detection model for real-time asset detection and geolocation.
3. A detailed analytical and visualized outcomes for two major routes, offering insights and comprising essential inferences for future urban development.

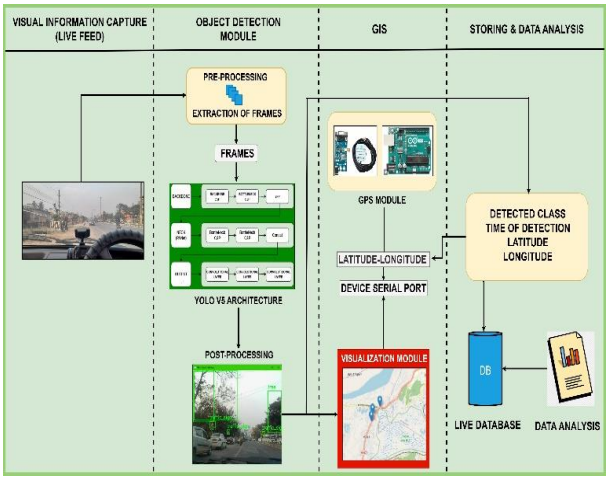

Fig-2. Inspection system pipeline diagram

IV. DATASET

A. *Dataset:*

GUAD combines datasets for trees, traffic signs, and garbage bins. Video recordings of Guwahati routes capture traffic signs, garbage bins and trees (Fig. 3). A custom Python script extracts frames and later manual annotation is performed over them in YOLO format for multiclass detection.

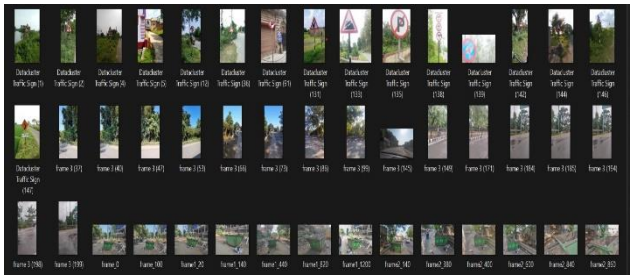

Fig-3. G.U.A.D dataset

V. RESULTS AND ANALYSIS

A comparative analysis is performed on the performance results of the YOLO v5 model.

A. YOLO (v5):

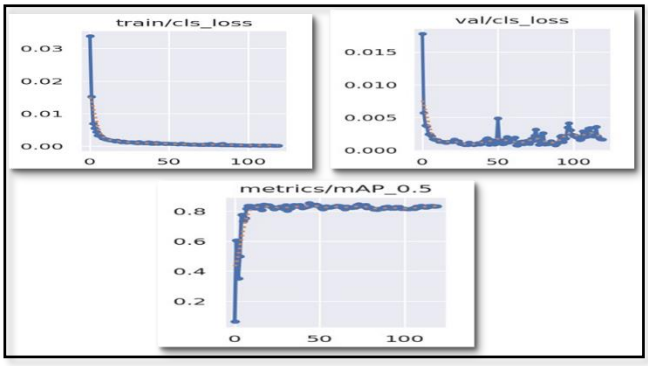

Fig-4. Train/cls loss (b) val/cls loss (c) metrics/maP_0.5

Classification Fig-4 (a): Rapid improvement stalls near 0.01 loss, indicating proficiency after a certain point. **Validation loss** Fig-4 (b): Drops initially (0.015 to 0.005), suggesting better early bounding box classification, then plateaus for stable performance. **mAP@0.5** Fig-4 (c): Sharp rise (0-0.08) signifies enhanced object detection and classification (50% overlap with ground truth), followed by a plateau for stabilized performance.

B. INSPECTION RESULTS

Fig-5 (a). Map visualization of assets “Trees” and “Traffic signs” for Route-1 and Route-2. Figure 5 (b). Asset distribution in Route-1 and Route-2

Route-1 (NH-17, Ganakpara, Guwahati 781017 to Ganakpara, Guwahati 781017, Assam)

Total distance covered- 2km (approx.)

While NH-17's beauty and clear directions are attractive, lacking proper garbage bins risks littering, potentially breeding health concerns. Ensuring readily available bins is crucial for responsible waste management and a cleaner environment for everyone.

Route-2 (Dharapur, Guwahati 781013, Assam to Gauhati University Byepass Road, Jalukbari, Guwahati 781014, Assam)

Total distance covered- 5.5km (approx.)

While Route-2 boasts scenic greenery and clear directions, it appears to lack a crucial element for responsible waste management: garbage bins. This could lead to littering, hence prioritizing proper waste disposal through readily available bins would enhance the overall experience and promote responsible behavior for everyone using NH-17.

VI. CONCLUSION

Rapid urbanization brings economic diversification and innovation, but also demands efficient management of various urban assets. This paper proposes a real-time inspection model using a state-of-the-art object detection algorithm trained on a custom dataset (GUAD) specific to Guwahati city. The model effectively detects and locates traffic signs, garbage bins, and trees, providing valuable geolocation data for efficient resource allocation and predictive maintenance, ultimately enabling better urban asset management. In future, the system will be tested on about a dozen city routes as part of this ongoing project.

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