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LANE MORPH: Machine Learning Powered Divider For Traffic Volume Adaptation

Lavanya N L . Anvith Krishna N . Arun Kumar V Savanvur . Shrivatsa R S . Udaya Kumar Shetty

Department of Computer Science and Engineering, East West College of Engineering, Visveswaraya Technological University, Bengaluru, Karnataka 560064.

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Abstract — LaneMorph is a machine learning-powered system designed to optimize urban traffic management using IoT and real-time video processing. By dynamically adjusting road dividers based on traffic density, the system enhances lane utilization, reduces congestion, and prioritizes emergency vehicles. This paper details the architecture, implementation, and potential impact of LaneMorph in smart city infrastructure. Additionally, the system integrates various sensor technologies, predictive algorithms, and automation mechanisms to improve traffic flow efficiency and ensure road safety.

Index Terms – Smart Traffic Management, Machine Learning, IoT, Real-time Vehicle Detection, Dynamic Road Dividers

I. INTRODUCTION

A Machine Learning-Powered Traffic Management System (LaneMorph) is an intelligent road infrastructure solution that requires minimal human intervention for operation. We propose a dynamic road divider system capable of real-time traffic surveillance, vehicle detection, emergency vehicle prioritization, lane reallocation, and an IoT-integrated dashboard that receives live traffic data and optimizes lane distribution accordingly. The system continuously adapts based on traffic density and emergency scenarios, ensuring efficient road space utilization and improved traffic flow [1] .Automating the assessment of subjective scripts is a benefit to teaching fraternity, which can be achieved through recent developments in natural language processing (NLP) and machine learning. The invention of transformers, a kind of neural network design is used and transformed NLP developed, it is one of the most important developments in this area. The Lane Morph system is an

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intelligent, [2] adaptive traffic management solution that leverages machine learning and IoT to dynamically reallocate road space based on real-time traffic conditions [3]. It is a scalable and automated system capable of optimizing lane usage, reducing congestion, and prioritizing emergency vehicles with minimal human intervention. Traditional traffic management systems are constrained by static dividers and fixed signal patterns, which limit their ability to respond to changing traffic conditions [4]. However, the integration of smart sensors, real-time video analytics, and IoT-powered automation allows engineers to implement adaptive road infrastructure that continuously adjusts lane distribution.

Originally, dynamic road systems were explored in highly controlled environments such as highways and tollways, but with advancements in AI-based traffic surveillance and IoT connectivity, [5][6][7] such solutions have become feasible for urban roads. *LaneMorph* operates with varying levels of automation—ranging from manual overrides by traffic control authorities to fully autonomous lane reallocation, where the system uses real-time traffic density analysis and emergency detection to optimize road usage. This level of adaptability makes *LaneMorph* an ideal solution for urban traffic congestion, emergency response optimization, and smart city integration.[8][9] The LaneMorph system can be deployed in various urban traffic scenarios to enhance road efficiency and emergency response. It assists in reducing congestion during peak hours, supports emergency services by prioritizing ambulances and fire trucks, and enhances road safety through real-time vehicle detection. The system also contributes to smart city infrastructure, enabling traffic authorities to monitor and optimize road usage dynamically.Beyond urban traffic management, LaneMorph has the potential to integrate with autonomous vehicle navigation, assist in disaster evacuation planning, and support real-time traffic analysis for city planners. With its ability to adapt to different road conditions, it serves as a scalable and indispensable tool for modern transportation networks.

II. BACKGROUND

The adoption of intelligent traffic management systems has significantly increased in recent years due to the rising challenges of urban congestion and inefficient road utilization. Traditional static road infrastructure struggles to adapt to real-time traffic fluctuations, leading to bottlenecks, delays, and increased fuel consumption. To address these challenges, LaneMorph, a Machine Learning-Powered Dynamic Traffic Divider, leverages real-time video analytics, IoT-based automation, and AI-driven lane reallocation to optimize road usage [10]. The LaneMorph system is designed for traffic surveillance, vehicle detection, lane reallocation, emergency response optimization, and adaptive traffic control. By integrating camera-based vehicle detection, AI-powered object tracking, and IoT-enabled road dividers, LaneMorph ensures dynamic lane adjustments based on real-time traffic density, minimizing congestion and maximizing road efficiency [11].

For example, in high-density urban areas, [12] LaneMorph can continuously monitor traffic patterns, detect congestion hotspots, and reallocate lanes accordingly. In emergency situations, such as an ambulance approaching, the system automatically creates a priority lane by shifting the road divider, [13] ensuring uninterrupted passage for emergency responders. Beyond urban traffic control, LaneMorph also plays a role in smart city integration, intelligent transportation planning, and automated traffic monitoring. Its ability to dynamically adapt to road conditions in real-time makes it a valuable tool for reducing travel time, improving fuel efficiency, and enhancing overall road safety [14][15].

III. PROBLEM STATEMENT

This paper explores whether a machine learning-powered road divider can dynamically adapt to real-time traffic conditions and emergency scenarios, optimizing lane utilization and response times.Traditional static dividers fail to accommodate fluctuating traffic, causing congestion and inefficient road usage. This project addresses the problem by integrating AI-driven adaptability and IoT-based automation, enabling real-time lane reallocation and priority passage for emergency vehicles. The aim of this paper is to design and implement a smart, adaptable road divider system capable of addressing the dynamic challenges of urban traffic. The system will feature real-time vehicle detection using advanced image processing algorithms to accurately count vehicles on both sides of the road. Based on real-time traffic density data, a dynamic lane adjustment mechanism will optimize lane usage and reduce congestion. To prioritize emergency vehicles, the system will integrate visual and auditory detection capabilities, ensuring unobstructed passage for ambulances and other critical responders. Additionally, RGB LED indicators will provide clear and dynamic traffic signaling, minimizing confusion during lane reallocations. IoT-enabled automation will streamline the management of road dividers and traffic signals, reducing the need for manual intervention. Ultimately, this smart system aims to enhance overall traffic flow efficiency, reducing delays for regular commuters and significantly improving emergency response times.

VI. SYSTEM DESIGN

The LaneMorph system is designed to dynamically adjust road dividers based on real-time traffic conditions using IoT sensors, machine learning, and automated mechanisms. The system operates by continuously monitoring vehicle density on both sides of the road through camera-based object detection and computer vision algorithms.The movable road divider is controlled using DC motors and an Arduino-based microcontroller, which shifts the divider in response to traffic flow patterns. The divider's movement is guided by real-time traffic analysis, ensuring optimal lane reallocation as shown in Fig. 1.

Additionally, RGB LED indicators are used to signal lane changes, providing visual guidance to drivers. Emergency vehicles such as ambulances are detected using sound sensors and image recognition, allowing the system to create a priority lane by automatically repositioning the divider.By integrating machine learning for traffic prediction, IoT for automation, and real-time decision-making, LaneMorph ensures efficient road utilization, improved emergency response times in urban environments. In a dynamic traffic management system, the movement of the smart road divider is influenced by real-time traffic density, much like how a quadcopter adjusts its position based on propeller speeds. When one side of the road experiences higher traffic congestion, the system detects this imbalance using machine learning and image processing techniques. The divider then shifts towards the less congested side, ensuring optimal lane allocation.

Similar to how a quadcopter's propellers generate torque in opposite directions to maintain stability, the smart divider system balances traffic flow by dynamically redistributing lanes. If more vehicles are detected on one side, the divider moves accordingly to equalize traffic distribution. The system's movement is controlled by IoT-enabled actuators, analogous to how a quadcopter adjusts its propellers to maneuver . Additionally, just as propeller blade designs ensure consistent airflow direction despite opposing rotations, the LaneMorph system employs synchronized adjustments in lane configurations. By integrating real-time vehicle detection, smart signaling, and automated control mechanisms.

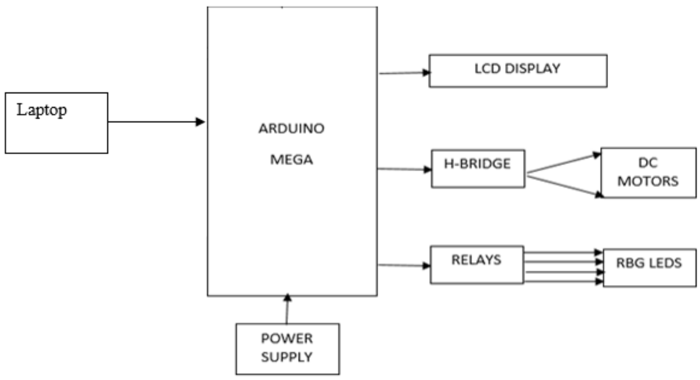


Fig 1: System Architecture of LaneMorph

V. SYSTEM IMPLEMENTATION

a) Traffic Surveillance Module

The Traffic Surveillance Module is designed to monitor and analyze real-time traffic conditions, ensuring efficient lane management and congestion reduction. It utilizes high-resolution cameras strategically positioned along roadways to capture continuous video feeds. These feeds are processed using the YOLO object detection algorithm, which accurately detects and classifies vehicles, enabling dynamic traffic adjustments. The system integrates IoT-enabled sensors that collect real-time data on vehicle density, movement patterns, and traffic flow variations. This information is transmitted to a central processing unit that analyzes congestion levels and determines optimal lane configurations. Additionally, the module incorporates emergency detection capabilities, identifying ambulances and prioritizing their movement by reallocating lanes. The data collected is stored for further analysis, allowing authorities to study traffic trends and improve long-term road planning. RGB LED indicators provide real-time visual cues to drivers, enhancing road safety and ensuring smooth transitions during lane adjustments. Through automation and intelligent decision-making, the Traffic Surveillance Module plays a critical role in optimizing urban mobility and reducing delays as shown in Fig. 2.

b) Object Detection Module

The object detection for RPAS utilizes the YOLO algorithm, which stands for "You Only Look Once." This method identifies and detects multiple objects within an image. The object detection process in YOLO treats the task as a regression problem, providing class probabilities for the identified objects.

Fig 2: Traffic Surveillance Module

The YOLO approach employs convolutional neural networks (CNN) to quickly recognize items. As the name suggests, it requires only one forward pass through the neural network to detect objects. This means that a single execution of the algorithm can make predictions for the entire image. The CNN simultaneously predicts multiple class probabilities and bounding boxes. The YOLO algorithm works by splitting the image into N grids, each with an equal-sized area of 5X5. Each of these N grids is involved in detecting and localizing the object it contains. In turn, these grids predict the coordinates of bounding box B in relation to their cell coordinates, along with the object label and the confidence level of the object's presence in that cell. The YOLO algorithm is notable for several reasons: its speed, high accuracy, and strong learning capabilities

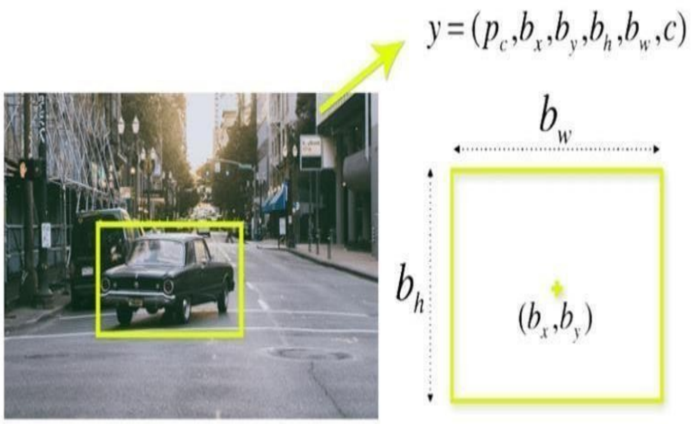


Fig 3: Object Detection

c) Emergency Vehicle Detection Module

A critical feature of LaneMorph is its ability to prioritize emergency vehicles through AI-powered detection mechanisms. The system uses a combination of computer vision, auditory sensors, and IoT-based automation to identify ambulances, fire trucks, and police vehicles in real time. Emergency vehicles are detected through visual markers, such as color schemes, logos, and vehicle shapes, and through audio-based siren recognition, ensuring instant lane reallocation. Once an emergency vehicle is detected, LaneMorph automatically shifts the road divider, creating a dedicated emergency lane to facilitate uninterrupted passage. The system synchronizes with smart traffic signals, ensuring that emergency vehicles receive green-light priority throughout their route.

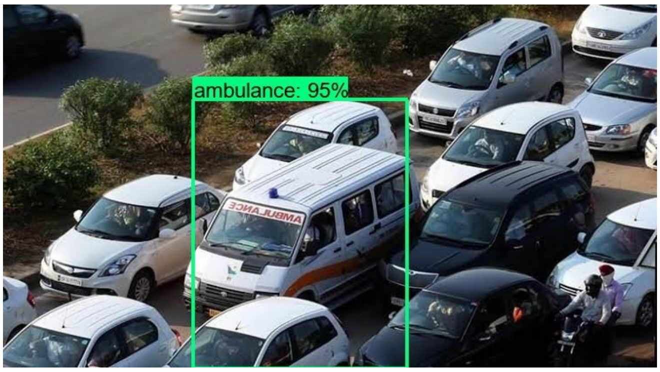
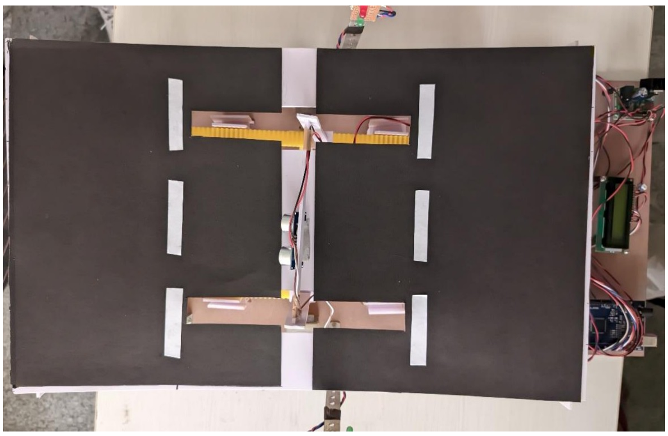


Fig 4: Emergency Vehicle Detection Module

d) Traffic Mapping and Lane Reallocation

The LaneMorph system incorporates real-time digital mapping to continuously assess lane usage and optimize road space dynamically. The system collects data on vehicle distribution across lanes, identifies underutilized road sections, and reallocates lanes to balance traffic density. This mapping is performed using machine learning-based predictive models, ensuring optimal lane usage based on historical and real-time data. The movable road divider is controlled by an Arduino-powered actuator system, which adjusts its position based on traffic demand. The system automatically increases lane availability for high-density traffic areas and reduces road space for less occupied sections, improving overall traffic efficiency. Additionally, RGB LED indicators are installed along the divider, providing clear visual signals to road users, ensuring a smooth transition during lane shifts.

VII. RESULTS



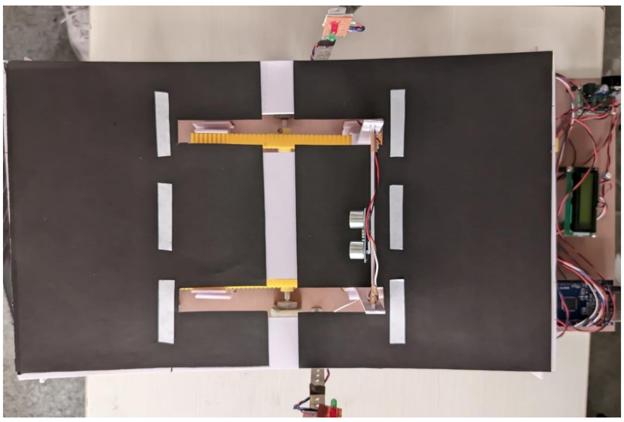
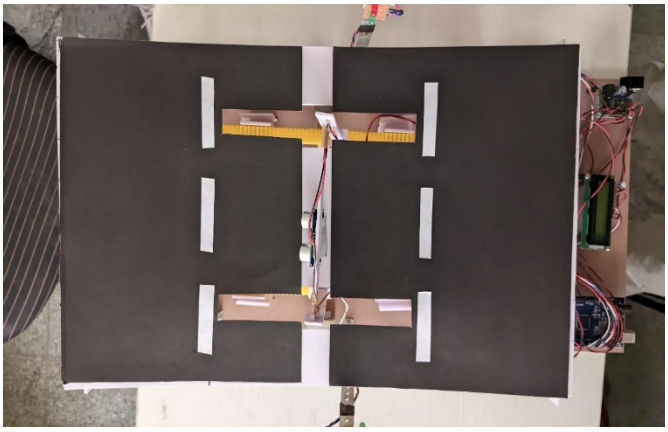


Fig 5a: Divider during low traffic volume

Fig 5b: Divider during higher traffic volume on road



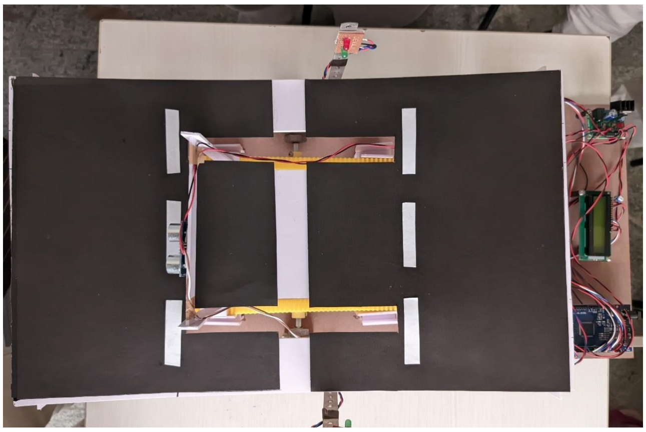


Fig 6a: Divider at the middle again during low traffic volume

Fig 6b: **Divider during higher traffic volume on road2**

The LaneMorph system provides a scalable and adaptive approach to urban traffic management, ensuring efficient lane allocation, reduced congestion, and improved emergency response times. The integration of machine learning, IoT automation, and real-time data processing allows for a fully autonomous traffic optimization system that operates with minimal human intervention. One of the key advantages of LaneMorph is its ability to adjust dynamically to fluctuating traffic conditions. Unlike static road dividers, which fail to accommodate peak-hour congestion, LaneMorph ensures continuous lane optimization, leading to shorter travel times and reduced road stress. The system's reliance on computer vision and AI-driven automation makes it an ideal solution for smart city applications, paving the way for seamless integration with future autonomous vehicle networks.

To address these concerns, LaneMorph can be further enhanced by incorporating thermal imaging cameras for low-visibility scenarios and cloud-based AI models for remote traffic monitoring and control. Future developments may also include integration with vehicle-to-infrastructure (V2I) communication, allowing cars to interact directly with the system, further enhancing road safety and traffic flow. By continuously adapting to modern urban challenges, LaneMorph represents a new era of intelligent traffic management, ensuring efficiency, safety, and sustainability for the future of urban mobility.

IX. CONCLUSION

In this paper, we have presented an efficient and intelligent approach to dynamic traffic management using *LaneMorph*, a machine learning-powered road divider system. The system integrates real-time traffic surveillance, vehicle detection, emergency vehicle prioritization, adaptive lane reallocation, and IoT-enabled traffic control to optimize road utilization.We first explored various traffic monitoring techniques and their impact on congestion reduction. We then analyzed different computer vision-based object detection algorithms, ultimately implementing the YOLO algorithm for high-speed, real-time vehicle recognition. Additionally, the integration of smart sensors and IoT automation allows for autonomous lane reconfiguration, ensuring optimal traffic distribution based on real-time conditions.The development of this system is a multidisciplinary effort, combining artificial intelligence, IoT, automation, and real-time data analytics to address modern urban mobility challenges. By ensuring faster emergency response times, reduced congestion, and optimized traffic flow, *LaneMorph* significantly enhances urban transportation efficiency.Overall, the project contributes to the advancement of intelligent traffic management solutions, paving the way for smart city integration and future-ready transportation networks.

REFERENCES

1. Khanke, P., & Kulkarni, P. S. (2014). A technique on road traffic analysis using image processing. *International Journal of Engineering Research, 3*(2).
2. Sundar, R., Hebbar, S., & Golla, V. (2014). Implementing intelligent traffic control system for congestion control, ambulance clearance, and stolen vehicle detection. *IEEE Sensors Journal, 15*(2), 1109–1113. https://doi.org/10.1109/JSEN.2014.2360288
3. Nagaraj, U., Rathod, J., Patil, P., Thakur, S., & Sharma, U. (2013). Traffic jam detection using image processing. *International Journal of Engineering Research and Applications, 3*(2), 1087–1091.
4. Bhusari, S., Patil, S., & Kalbhor, M. (2015). Traffic control system using Raspberry Pi. *Global Journal of Advanced Engineering Technologies, 4*(4), 413–415.
5. Lavanya, N. L., Bhat, A., Bhanuranjan, S. B., & Narayan, K. L. (2023). Enhancing the capabilities of remotely piloted aerial systems through object detection, face tracking, digital mapping, and gesture control. *International Journal of Human Computations & Intelligence, 2*(3), 147–158.
6. Ahmed, S. T., Kumar, V. V., & Kim, J. (2023). AITel: eHealth augmented-intelligence-based telemedicine resource recommendation framework for IoT devices in smart cities. *IEEE Internet of Things Journal*, *10*(21), 18461-18468.
7. Kawle, A., Shah, D., Doshi, K., Bakhtiani, M., Gajja, Y., & Singh, P. (2017). Movable traffic divider: A congestion release strategy. *International Journal of Recent Advances in Engineering & Technology (IJRAET).*
8. Agrawal, S., & Maheshwari, P. (2021, January). Controlling of smart movable road divider and clearance ambulance path using IoT cloud. *2021 International Conference on Computer Communication and Informatics (ICCCI)* (pp. 1–4). IEEE. https://doi.org/10.1109/ICCCI50826.2021.9402443
9. Dalmia, H., Damini, K., & Nakka, A. G. (2018, September). Implementation of movable road divider using Internet of Things (IoT). *2018 International Conference on Computing, Power and Communication Technologies (GUCON)* (pp. 968–971). IEEE. https://doi.org/10.1109/GUCON.2018.8674942
10. Sun, Z., Bebis, G., & Miller, R. (2006). On-road vehicle detection: A review. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 28*(5), 694–711. https://doi.org/10.1109/TPAMI.2006.104
11. Kumar, S. S., Ahmed, S. T., Xin, Q., Sandeep, S., Madheswaran, M., & Basha, S. M. (2022). Unstructured Oncological Image Cluster Identification Using Improved Unsupervised Clustering Techniques. *Computers, Materials & Continua*, *72*(1).
12. Temkar, R., Asrani, V., & Kannan, P. (2015). IoT: Smart vehicle management system for effective traffic control and collision avoidance. *International Journal of Science and Research (IJSR), 4*(05).
13. Lokesh, S., & Reddy, T. P. (2014). An adaptive traffic control system using Raspberry Pi. *International Journal of Engineering Sciences & Research Technology, 3*(6), 831–835.
14. Ahmed, S. T., & Basha, S. M. (2022). *Information and communication theory-source coding techniques-part II*. MileStone Research Publications.
15. Vijayananda, N., Lavanya, N. L., Sattigeri, N. N., Nisarga, R. K., & Pooja, N. M. (2023). Abnormal event detection and signaling in multiple video surveillance scenes using CNN. *International Journal of Human Computations & Intelligence, 2*(3), 106–116.