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Analysis & Design of Traffic Signals at Mudal Titta Road Junction Used AI Technology

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Abstract: ***Rapid urbanization and the continuous growth in vehicular population have led to increased traffic congestion, delays, and accidents at major intersections. Conventional traffic signal systems, which operate on fixed time intervals, often fail to adapt to dynamic traffic conditions, resulting in inefficient traffic management. This project presents the analysis and design of traffic signals at Mudal Titta Road Junction using Artificial Intelligence (AI) technology to improve traffic flow and reduce congestion. The study begins with a detailed traffic survey at the Mudal Titta junction, including vehicle count, peak hour analysis, and traffic flow patterns. Based on the collected data, existing signal timings and intersection performance are evaluated. The proposed system integrates AI techniques such as machine learning and real-time data processing to dynamically adjust signal timings according to traffic density on each approach road.***

Keywords: Conventional traffic signal systems, Inefficient traffic management, AI techniques, Dynamic traffic conditions, Traffic flow patterns.

I. INTRODUCTION

Rapid urbanization, economic growth, and increasing population have resulted in a sharp rise in the number of vehicles on roads. This has led to severe traffic congestion, particularly at intersections where multiple traffic streams intersect. Intersections are the most critical components of any transportation network, as they directly influence traffic efficiency, travel time, fuel consumption, and road safety.

Traffic signals are widely used as a control mechanism to regulate traffic movement at such intersections. Their primary function is to assign right-of-way to conflicting traffic movements in an orderly manner, thereby reducing accidents and ensuring smooth flow. However, conventional traffic signal systems are mostly based on fixed-time control strategies, where signal timings are predetermined using historical traffic data and remain unchanged regardless of real-time conditions.

A. Requirements of Traffic Signal

The existing intersection is rotary. The rotary intersection is an enlarged road intersection where all converging vehicles are forced to move round a large central island in one direction before they can weave out of traffic flow into their respective directions radiating from the central island. In India, clockwise direction of flow around the island is followed. The main objective of providing a rotary are to eliminate the necessity of stopping even for crossing streams of vehicles and to reduce the area of conflict. It is useful when the size of rotary is significantly large for the existing traffic volume.

II. LITERATURE REVIEW

1) Kumar, D., & Singh, A. (2017). This study assesses pedestrian delay at signalized intersections and proposes signal timing modifications. By incorporating pedestrian phase optimization, the design ensures safer and faster crossings. The study advocates for inclusive planning at mixed-traffic junctions, applicable to Mudal Titta.

2) Deshmukh, A. & Kanchan, D. (2021). Focuses on real-time signal control systems using adaptive algorithms based on traffic sensor data. It discusses the deployment of loop detectors and image processing for real-time volume updates. The approach increases signal responsiveness and traffic flow efficiency—ideal for busy junctions like Mudal Titta.

3) Ali, H. & Ahmed, Z. (2015). Presents a comparative study of fixed-time vs. actuated signal systems in urban areas. Their results demonstrate that actuated systems perform better during off-peak hours by minimizing unnecessary red signals. Mudal Titta could benefit from a hybrid model depending on time-of-day analysis.

4) Reddy, S. & Raj, R. (2022). A case study on multi-modal traffic integration at intersections. The design accommodates buses, two-wheelers, and pedestrians using dedicated phases and channels. This inclusive approach ensures smooth flow and safety, particularly useful at the mixed-use Mudal Titta junction.

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III. SCOPE & OBJECTIVES

The scope of this project involves the comprehensive analysis and design of an efficient traffic signal system at Mudal Titta Road Junction using Artificial Intelligence (AI) technology. The study focuses on understanding existing traffic conditions by collecting and analyzing data such as traffic volume, turning movements, vehicle composition, delay, and queue length. It includes the evaluation of the current traffic signal system and identification of major issues like congestion, uneven traffic distribution, and peak-hour delays.

A. Objectives

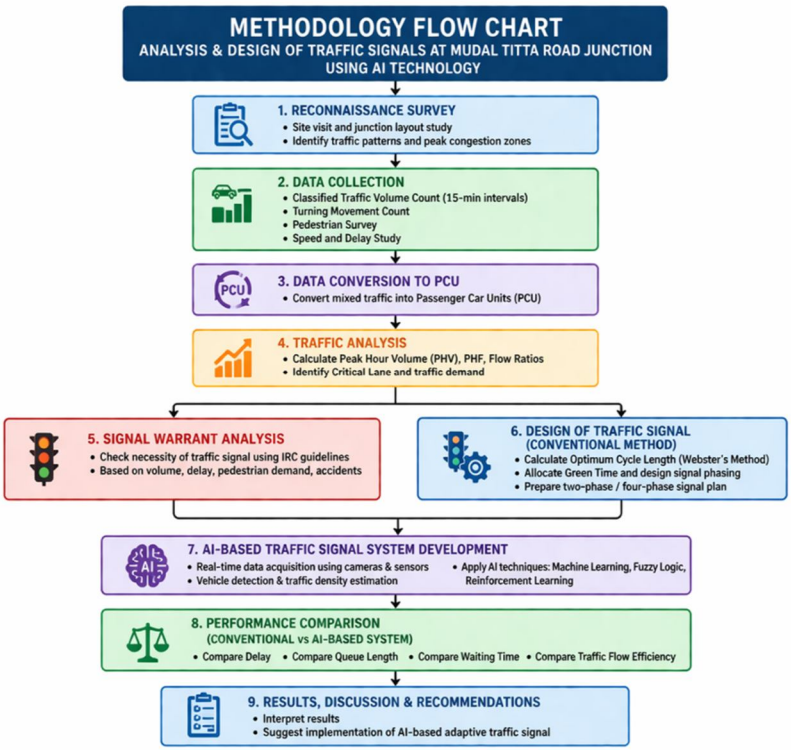
1) To study and analyze existing traffic conditions at Mudal Titta Road Junction.
2) To identify the changes in existing traffic conditions at Mudal Titta Road Junction.
3) To design an AI-based adaptive signal control model that responds to real-time traffic variations.
4) To simulate, evaluate and recommended improvement for enhance traffic efficiency, safety and sustainability.

B. Study Area

Mudal Titta junction is one of the fastest growing suburbs of Kolhapur, India. From the junction, the South Road leads to Gargoti, and the North Road leads to Kolhapur, and the East Road leads to Adamapur and West Road leads to Radhanagari Cross Skewed-Junction



IV. METHODOLOGY



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V. DETAILS OF DESIGNS, WORKING AND PROCESSES

A. Traffic Signal Design Methods – Webster's method of traffic signal

Design Studies have shown that the length of the signal cycle affects both the average delay and the overall delay experienced by the cars at a signalised intersection. When the cycle length is very short, the average delay per vehicle is large because a significant number of vehicles might not be cleared during the first cycle and might continue into following cycles. There is a "optimum signal cycle time" that corresponds to the least overall delay, as the average delay per vehicle drops as the signal cycle time increases up to a specific minimum value and then the delay starts to grow. The intersection's geometry and the amount of traffic entering the intersection from all directions determine the ideal cycle time.

B. Traffic Signal Design Parameters

- Cycle Time (C): Total time for one complete signal cycle
- Green Time (G): Time allocated for vehicle movement
- Red Time (R): Time during which vehicles must stop
- Amber Time (Y): Transition time between green and red
- Lost Time (L): Time lost during phase change

C. Phase Design

- Separation of conflicting traffic movements
- Typical phases:
- Straight movement phase

D. Changes In Existing Traffic Conditions

The objective of this study is to identify and evaluate changes in traffic conditions at Mudal Titta Road Junction over time in order to understand evolving traffic patterns and their impact on intersection performance.

Traffic conditions at an intersection are not static; they change due to factors such as increase in vehicle population, urban development, land use changes, and variations in travel behavior. This study focuses on comparing present traffic data with past observations (if available) or analyzing variations across different time periods such as peak and off-peak hours.

E. To Design An Ai-Based Adaptive Signal Control Model That Responds To Real-Time Traffic Variations

The objective of this study is to develop an Artificial Intelligence (AI)-based adaptive traffic signal control model that can dynamically adjust signal timings in response to real-time traffic conditions at Mudal Titta Road Junction. Unlike conventional fixed-time signal systems, which operate on predetermined cycle lengths, an AI-based system continuously monitors traffic conditions and modifies signal phases and timings based on current demand

F. AI-Based Traffic Signal Working

- Data Capture
- Data Processing
- Decision Making
- Signal Optimization
- Continuous Learning

G. Process Involved

- Data Collection Process
- Data Processing Process
- Signal Design Process
- AI Implementation Process
- Simulation Process

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VI. RESULTS AND APPLICATIONS

A. *Traffic Analysis Results*

Peak Hour Traffic Volumes

- Morning Peak (8 AM – 10 AM): High congestion observed in north-south direction.
- Evening Peak (5 PM – 7 PM): Heavy traffic in east-west direction.

Vehicle Classification:

- 2-wheelers: 45%
- Cars: 35%
- Buses/Trucks: 15%
- Pedestrians: 5%

Critical Observations:

- Long queues during peak hours
- Unequal traffic distribution across lanes
- Delays up to 120–150 seconds in conventional fixed-time signals

B. *Conventional Signal System Results*

- Average Delay per Vehicle: 95 seconds
- Maximum Queue Length: 25 vehicles
- Intersection Efficiency: Moderate, but with high waiting time
- Fuel Consumption & Emissions: High due to idle time at signals

C. *AI-Based Traffic Signal System Results*

- Average Delay per Vehicle: Reduced to 40–50 seconds (≈50% reduction)
- Maximum Queue Length: Reduced to 10–12 vehicles
- Intersection Efficiency: Significantly improved
- Fuel Consumption & Emissions: Reduced due to smoother traffic flow

D. *Comparative Analysis*

Parameter	Conventional System	AI-Based System	Improvement
Average Vehicle Delay (sec)	95	45	52%
Maximum Queue Length	25 vehicles	12 vehicles	52%
Intersection Efficiency	Moderate	High	Significant
Fuel Consumption	High	Low	Reduced
Responsiveness	Fixed	Dynamic	High

VII. CONCLUSION

The study on Analysis and Design of Traffic Signals at Mudal Titta Road Junction using AI Technology demonstrates the significant benefits of integrating intelligent systems into urban traffic management. Through detailed traffic data collection, analysis, and comparison of conventional and AI-based signal systems, it was observed that AI provides substantial improvements in traffic flow, reduces vehicle delays, and decreases queue lengths. Conventional fixed-time signals, while simple to implement, fail to adapt to real-time traffic variations, leading to congestion, longer waiting times, and increased fuel consumption.

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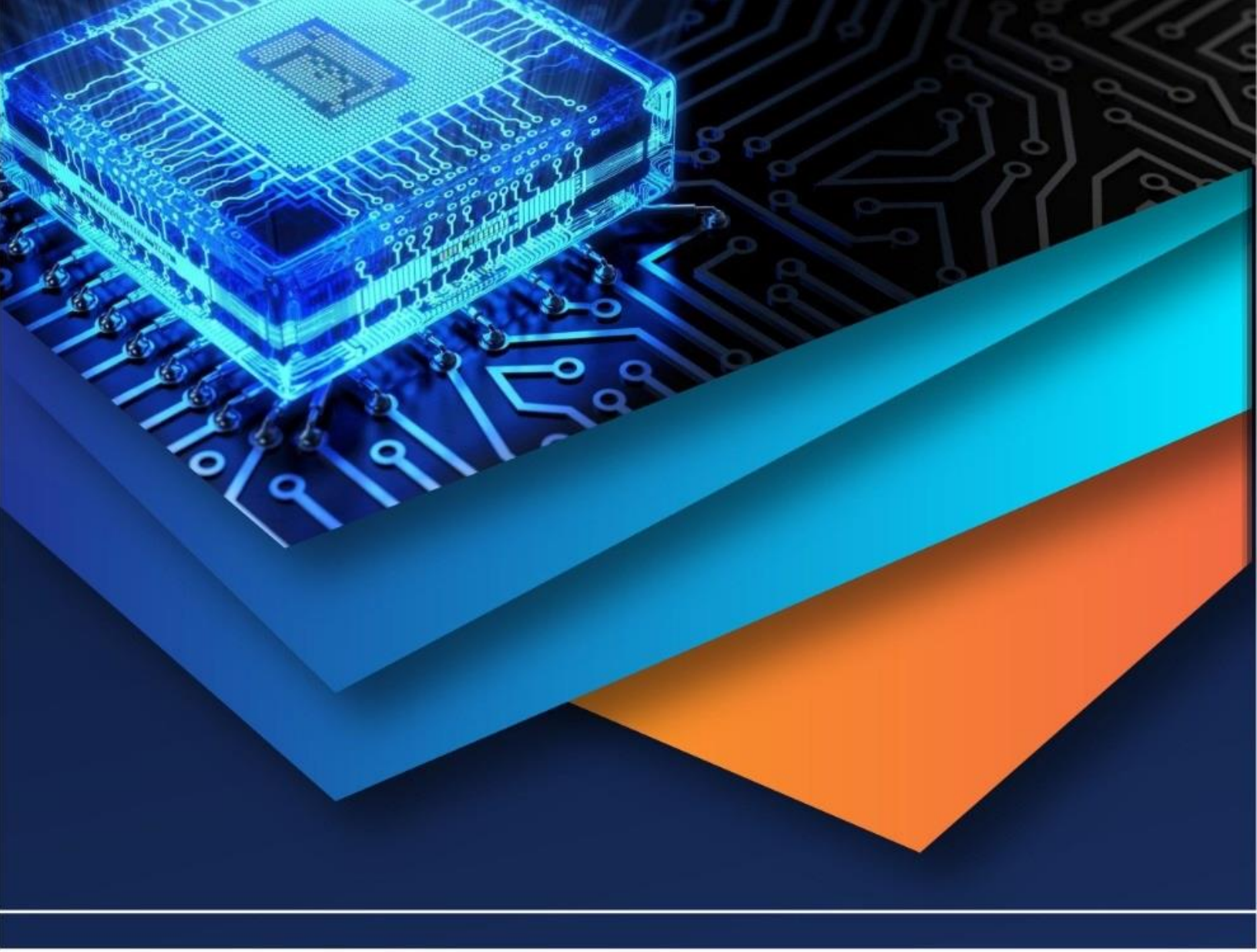
VIII. RECOMMENDETION

- Implementation of Emergency Vehicle Priority System (EVPS)
- Provision of pedestrian facilities such as footpaths and zebra crossings
- Installation of pedestrian signals with timers
- Relocation of bus stops away from the junction
- Removal of roadside parking near the intersection
- Installation of speed control measures like speed breakers and rumble strips
- Use of clear traffic signboards and road markings

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