IIT Guwahati taps predictive AI to tackle traffic snarls

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India's seemingly endless traffic snarls, unpredictable vehicle movement, and mounting pressure on road infrastructure may soon have a technology-driven solution. Researchers at the Indian Institute of Technology (IIT) Guwahati have developed artificial intelligence (AI)-based models that could predict traffic behaviour, anticipate congestion, and improve road transportation efficiency.

The researchers have developed a system that combines high-resolution drone footage with mathematical modelling and machine learning (ML) to capture the complexities of Indian traffic. The findings could open up new possibilities for smarter traffic management, better road design, quicker emergency response, and more scientific assessment of road capacity.

Using high-resolution drone footage collected from a highway in North Delhi, the team tested six mathematical models and trained two ML models to predict traffic behaviour. The models account for the unpredictability of Indian roads by estimating a range of possible vehicle speeds, allowing the inherent variability of heterogeneous traffic to be represented more realistically.

Akhilesh Kumar Maurya, professor in the Department of Civil Engineering at IIT Guwahati, said the models seek to address a key limitation of conventional traffic forecasting systems, which are largely designed around relatively orderly traffic conditions and often fail to capture the unpredictable movement of vehicles on Indian roads. "Our models could mark an important step towards shifting India's traffic management systems from reacting to congestion after it occurs to predicting and preventing bottlenecks before they develop.



A drone view of vehicular traffic along an eight-lane highway in North Delhi
PHOTO: IIT GUWAHATI

How AI spots a traffic jam before it happens

- Drones track individual vehicles and map their movements
- AI analyses vehicle speeds, gaps, and traffic density to detect changing road conditions
- 6 mathematical and 2 ML models decode nearly 9 million vehicle positions
- Models forecast speed variations and emerging bottlenecks, allowing authorities to act before traffic grinds to a halt

They can be used for traffic simulation, road infrastructure planning, optimising traffic signal timings, emergency management, and developing intelligent transportation systems that respond to actual road conditions," he said.

The researchers analysed more than 36,000 vehicles and nearly 9 million vehicle positions recorded through drone-based surveillance along an eight-lane divided highway with wide paved shoulders. They used the dataset to develop mathematical and ML models that predict vehicle speeds while accounting for wide variations in traffic behaviour on Indian roads.

Unlike roads in many developed countries, Indian roads carry a heterogeneous mix of vehicles, including two-wheelers, three-wheelers, cars, and larger vehicles, often sharing road space with pedestrians. Differences in vehicle dimensions, acceleration, manoeuvrability, and driving behaviour create complex interactions influencing traffic flow.

Shekhar Singh, a research scholar, said conventional traffic models, which generally assume relatively uniform vehicle movement, may not accurately predict traffic behaviour under Indian conditions. "We need traffic data that represents the diversity and characteristics of Indian roads. Drone-based data collection allows us to observe large numbers of vehicles and their movements, monitor longer stretches of road and track individual vehicles continuously," he said.

The IIT Guwahati models seek to bridge this gap by accounting for both the relationship between vehicle speed and traffic density and the considerable variation in speeds among vehicles travelling under such traffic conditions. Turn to Page 6

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The drone study also revealed a relationship between traffic volume and road capacity. The researchers found that before congestion set in, nearly 3,000 vehicles passed a point in each lane under full traffic flow. During traffic jams, when vehicles were virtually stationary, density reached nearly 900 vehicles per kilometre of road across the entire width.

"These observations provide insights into how traffic flow evolves as roads approach capacity and how vehicle interactions change during severe congestion. Such information is particularly relevant for Indian highways and urban arterial roads, where bottlenecks can emerge from a combination of vehicle diversity, varying speeds, lane-changing behaviour, and limited road space," Maurya said.

The combination of AI and high-resolution drone data could change how traffic congestion is monitored and managed. While conventional traffic monitoring systems primarily measure traffic volume and average speeds, AI models trained on detailed vehicle trajectories can identify changing traffic patterns, anticipate congestion, and assess how traffic may respond to different road and traffic management interventions.

According to the researchers, the models could help traffic authorities forecast congestion before a traffic jam develops, identify stretches where vehicle movement is becoming unstable, and assess the likely effects of traffic diversions or changes in signal timings. In urban areas, the technology could support adaptive traffic signals that adjust green-light durations to prevailing traffic conditions rather than rely entirely on predetermined cycles.

Traffic engineers could also use the models to simulate interactions among different vehicle categories at varying traffic densities, assess the capacity of existing roads and intersections, and evaluate whether proposed road widening, junction redesign or traffic regulation measures would improve traffic flow.

"India-specific models could support more realistic traffic simulation, better road and intersection design, congestion management, capacity assessment and intelligent traffic-management systems suited to Indian conditions. As cities explore smart mobility solutions, high-resolution traffic data combined with AI-based prediction models could become an important component of urban traffic digital twins," Maurya added.