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MODELING AND EVALUATING THE IMPACT OF ROAD CONSTRUCTION ON URBAN TRAFFIC

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Abstract. *Road construction is a critical contributor to intermittent traffic congestion in urban road networks. This study investigates a model that includes lane change rules (turning and overtaking), vehicle priority at intersections, and semi-closed or fully closed construction scenarios. Simulations reveal that increased lane closures significantly reduce network speed beyond a critical density threshold. Additionally, road construction impacts a consistent spatial range of adjacent roads, while optimizing vehicle bypass proportions during semi-closed construction enhances overall network efficiency. These findings provide actionable insights for mitigating congestion in urban infrastructure projects.*

Key words: *transportation engineering, road construction, traffic simulation, urban congestion, safety, vehicles follow, intelligent transport systems.*

Introduction.

Urban traffic congestion, exacerbated by road construction, poses significant challenges to mobility and economic efficiency. Traditional traffic models often focus on one-way systems, limiting their applicability to real-world urban networks characterized by two-way-multi-lane roads and complex intersections. Cellular automaton (CA) models, renowned for their simplicity and flexibility, offer a robust framework for simulating such scenarios. This study advances prior research by developing a CA model tailored to two-way-six-lane networks with roundabouts, explicitly addressing the interplay between construction zones and traffic flow [1].

The proposed model integrates realistic driver behaviors, including lane-changing and intersection navigation, while prioritizing safety through conflict-avoidance rules [2]. By simulating diverse construction scenarios, this work identifies strategies to minimize congestion and improve traffic management during urban infrastructure projects [3].

The structure of the CA model allows for spatial and temporal updates of vehicle positions, integrating rules for lane-changing maneuvers and conflict resolution in intersections. Vehicles follow optimized routes computed using Dijkstra's algorithm, considering additional "costs" for turning movements. This ensures simulation realism and better mirrors actual urban driving patterns [4].

Main text.

Simulation experiments were performed under varying conditions of lane closure (one-lane, two-lane, and full closure) and vehicle density. The results highlight a threshold phenomenon: at low densities, traffic is resilient to lane closures. However, as density crosses a critical point, network performance deteriorates rapidly. Interestingly, beyond this threshold, further increases in density dilute the marginal impact of additional closures due to the system already being in a congested state.

Furthermore, spatial analysis of traffic speed reveals that road construction impacts are not uniformly distributed. The disruption radiates to a consistent subset of adjacent roads, regardless of traffic conditions, defining a predictable "influence zone." This insight supports better traffic management and planning, as efforts to alleviate congestion can focus on these critical surrounding routes [5].

Another important finding involves the optimization of vehicle rerouting during partial lane closures. By allowing a controlled proportion of traffic to bypass the construction area, overall network efficiency improves. Yet, there is an optimal bypass threshold: insufficient diversion leads to congestion near the work zone, while excessive diversion overloads alternate routes, again reducing efficiency. This non-linear response highlights the need for balanced traffic distribution strategies [6].

In conclusion, the proposed CA-based model offers a robust framework for simulating urban traffic dynamics under construction constraints. It provides valuable insights into traffic behavior, congestion zones, and effective mitigation strategies such as strategic bypassing. This work lays the foundation for future extensions incorporating signal control, incident prevention, and intelligent transport systems to further optimize urban traffic flow in construction-heavy environments [7].

Summary and conclusions.

This study demonstrates that lane closures during urban road construction significantly degrade traffic flow, particularly at moderate to high densities. A fixed spatial impact range and optimal bypass ratios provide actionable guidelines for planners. Future work will integrate real-time congestion controls, such as adaptive signal timing, route guidance, and driver assistance systems, to enhance the model's practical utility.

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