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A Topology-Based Dynamic Repair Strategy for Enhancing Urban Road Network Resilience under Flooding

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Abstract : As global climate change intensifies, extreme weather events such as floods increasingly threaten urban infrastructure, making the vulnerability of urban road networks a pressing issue. Existing static repair strategies fail to adapt to the rapid changes in road network conditions during flood events, leading to inefficient resource allocation and suboptimal recovery. The main research gap lies in the lack of repair strategies that consider both the dynamic characteristics of networks and the progression of flood propagation. This paper proposes a topology-based dynamic repair strategy that adjusts repair priorities based on real-time changes in flood propagation and traffic demand. Specifically, a novel method is developed to assess and enhance the resilience of urban road networks during flood events. The method combines road network topological analysis, flood propagation modelling, and traffic flow simulation, introducing a local importance metric to dynamically evaluate the significance of road segments across different spatial and temporal scales. Using London's road network and rainfall data as a case study, the effectiveness of this dynamic strategy is compared to traditional and Transport for London (TFL) strategies. The most significant highlight of the research is that the dynamic strategy substantially reduced the number of stranded vehicles across different traffic demand periods, improving efficiency by up to 35.2%. The advantage of this method lies in its ability to adapt in real-time to changes in network conditions, enabling more precise resource allocation and more efficient repair processes. This dynamic strategy offers significant value to urban planners, traffic management departments, and emergency response teams, helping them better respond to extreme weather events like floods, enhance overall urban resilience, and reduce economic losses and social impacts.

Keywords : Urban resilience, road networks, flood response, dynamic repair strategy, topological analysis
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