Joint Transportation Research Program

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Dynamic Real-Time Routing for Evacuation Response Planning and Execution

Introduction

Strategic planning for emergency response is critical for effective response to natural or deliberate disasters. Response vehicle routing and evacuation of the affected people are part of emergency response operations under disasters. The response vehicle routing seeks to rescue the distressed population and deliver relief support to the affected locations in minimum time, while the evacuation component aims to quickly relocate the affected people to safe locations. The difference between these activities is that they are typically conducted in opposite spatial directions, that is, to and from the affected area, respectively. This characteristic of emergency response operations presents challenges in terms of routing, in addition to time constraints. Moreover, the road network state under a disaster can be time-dependent, since the link (or node) capacity/availability is known only after the disaster occurs (or spreads), and as information is received or updated over time.

This study addresses the problem of dynamic routing operations in the emergency response context, primarily in terms of the routing of response vehicles and evacuees. The study focuses on identifying the paths used for routing response vehicles and the evacuees in disaster situations. In this context, two application modules are developed: a module for K-shortest paths routing and a module for multiple-stop routing. The K-shortest paths module allows more flexible options for routing response vehicles under the dynamic network conditions due to a disaster. It provides multiple routes for evacuation and response operations. The multiple-stop routing module enables the delivery of relief resources to several locations using a single response vehicle. It has the ability to impose time window constraints for relief operations and reorder the routing to the delivery locations—capabilities that are critical to disaster operations.

Findings

- Some links may not be functional after a disaster. To provide flexible routing options for the emergency responders and evacuees, there is a need to generate multiple routes (such as the shortest, 2nd shortest, 3rd shortest, etc.) so that if a route is not available or is congested, the next best route can be provided. This can be done by using a K-shortest path algorithm to generate multiple routes.

- The paths obtained from the K-shortest path algorithm should not overlap each other significantly so as to avoid redundancy in routing. Significant overlap may result in limited usefulness during response operations, should link failures or congestion occur.

- In response operations, there is a need to deliver relief resources (e.g. food, medicine etc.) to several locations by each response vehicle in a trip. This introduces the problem of multiple-stop routing. Further, the deliveries to some stops may be subject to time window constraints, whereby the stops should be ordered in a certain manner such that the resources can be delivered within the pre-specified time limits.

- The K-shortest paths module provides the functionality to generate K-shortest paths based on the dynamic network conditions such that the generated paths are mostly distinct. That is, the generated paths do not share a significant proportion of common links.

- The multiple-stop routing module can be used in situations where relief resources need to be delivered to several locations (stops) using one or a limited number of response vehicles. This module supports the shortest path routing across multiple stops. This is critical in disasters when there is a priority associated with the stops to be visited, or there are time constraints for the delivery of relief resources at some stops.

- In the multiple-stop routing module, any violations of time windows are indicated so that the operators can further re-arrange the fleet. If no priority of deliveries to the stops is imposed, the module can support re-ordering to achieve the shortest travel time.

Implementation Recommendations

Two modules, the K-shortest paths and multiple-stop routing modules, are developed on a Geographic Information System (GIS) platform used by the Indiana Department of Transportation (INDOT) and Indiana Department of Homeland Security (IDHS). Based on dynamic field conditions, color-coded flags on the GIS map are used to characterize links in terms of their availability and functionality in the context of the response operations. The link characteristics are dynamically updated as new information on the network conditions becomes available over time. The two modules will be integrated into the current web-based traffic information system called TrafficWise supported by INDOT and disaster management system Web Emergency Operation Center (WebEOC) supported by IDHS for seamless practical implementation. A step by step manual has been provided for the implementation of the modules.

References

Peeta, S., Sharma, S., & Hsu, Y. T. *Dynamic Real-Time Routing for Evacuation Response Planning and Execution*. FHWA/IN/JTRP-2011/08. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011. DOI: 10.5703/1288284314621.