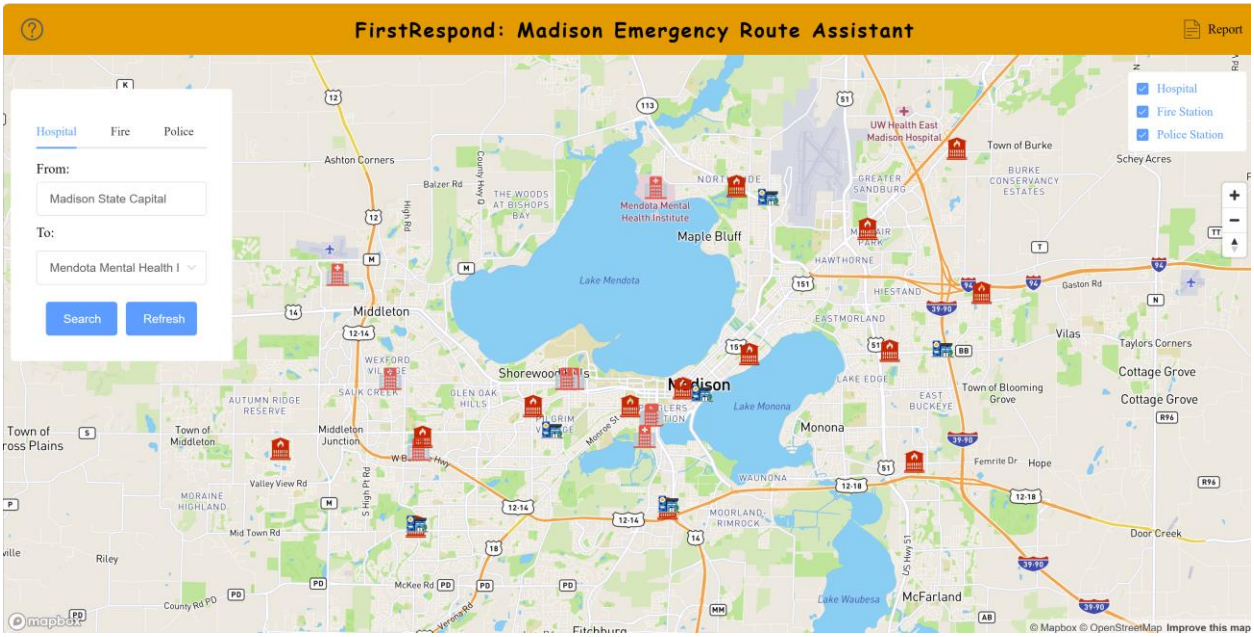
Optimizing and Evaluating Madison Emergency Response Route Report

Executive Summary



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Geography 778
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Instruction

Madison is the capital of Wisconsin, U.S., Wisconsin's second largest city. According to “Connect Great Madison 2050 Regional Transportation Plan”, the Madison is growing very fast. From 2000-2020 the Dane County population grew by 32%, That's an increase of about 135,000 people. Between 2020 and 2050, Madison's population is projected to grow by another 178,000, bringing the total population to 739,000. Undoubtedly as the population grows, so too does the inevitable increase in traffic. Therefore, it is important and necessary that Madison's roadway network be structured to accommodate the rapid growth in population and traffic. More importantly, it is important to maintain the efficiency of rapid emergency response in the face of growing population and traffic.

Intended Audience

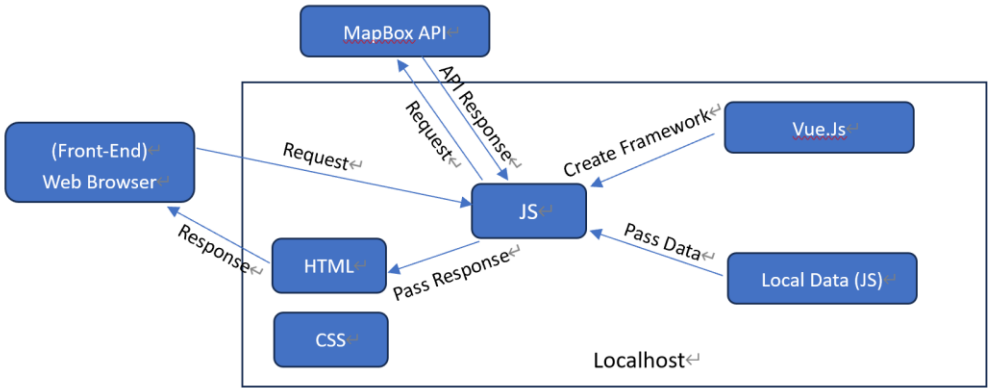
The intended audiences of this web application are Madison citizens, Police departments, and Fire departments, as well as Transportation department.

Application Overview

The purpose of the project is to enable citizens in Madison to find the fast route to go to the nearest infrastructures like hospitals, police stations, and fire stations, which means that people can get the most efficient route to the nearest accident location to save time when an accident occurs. This application source code is hosted on my Github account in the following repository: https://github.com/daniell23/Optimize-and-Evaluating-Emergency-Response-Route.

Method

The project mainly uses JavaScript, HTML, and CSS to build the website. Vue.js is used to build the website framework, and Element UI is used for page interaction design. Secondly, the project uses the MapBox API to query the map and calculate the most efficiency route and travel time from the origin to desination. The following figure is the architecture diagram of the web page:



For road network analysis, we used python packages such as OSMnx and NetworkX to construct the road network and assign values to the network, such as road speed limits and traffic flow data. Then a square area in Madison with a high level of traffic congestion (as shown in the figure) was selected to calculate the average time to the nearest hospital for each road point in the area. Thus, to compare the efficiency of emergency response in the presence or absence of traffic congestion.

Determining and assigning the effect of traffic flow on car speed and response time is a very important issue in the calculation process. We use the formula Speed = (1-Traffic_data / Traffic_data.max) * Speed_Limit. This means that the project assumes that the car travels at the speed limit of the road when there are no cars on the road. When the traffic flow is at its maximum, the speed of the car is 0 km/h. In other words, the traffic flow is used to redistribute the speed of each road. Then evaluating the efficiency of response route.

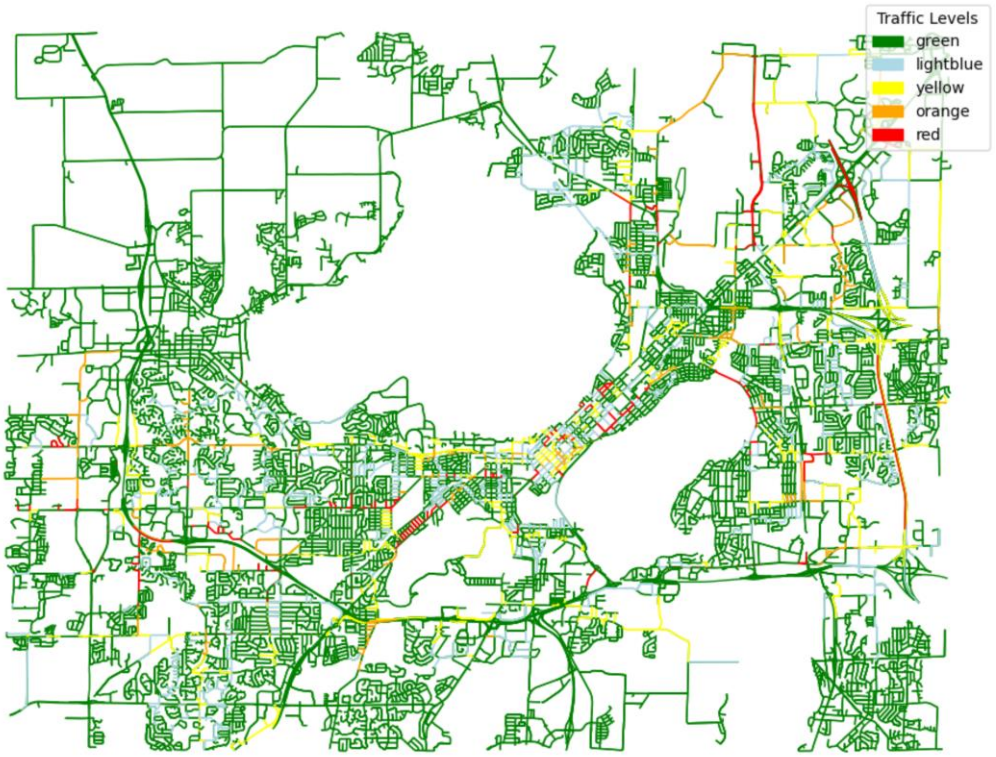


Figure 1 Traffic Flow Data Map

Results

Functionalities integrated into the web application project include:

- Pan and Zoom
- Check Boxes to show or turn off Madison hospital, police, and fire location information
- Pop-up function allows user to retrieve information about the departments
- Generate the efficiency route to the desire destination:
  - User selects the origin or destination (hospital, police, fire)
  - User inputs the address for geocoding (e.g., 550 N Park St, Madison or Science Hall, Madison)
  - User selects the department from the drop-down list
  - User clicks on the icon to retrieve the information like travel time and distance

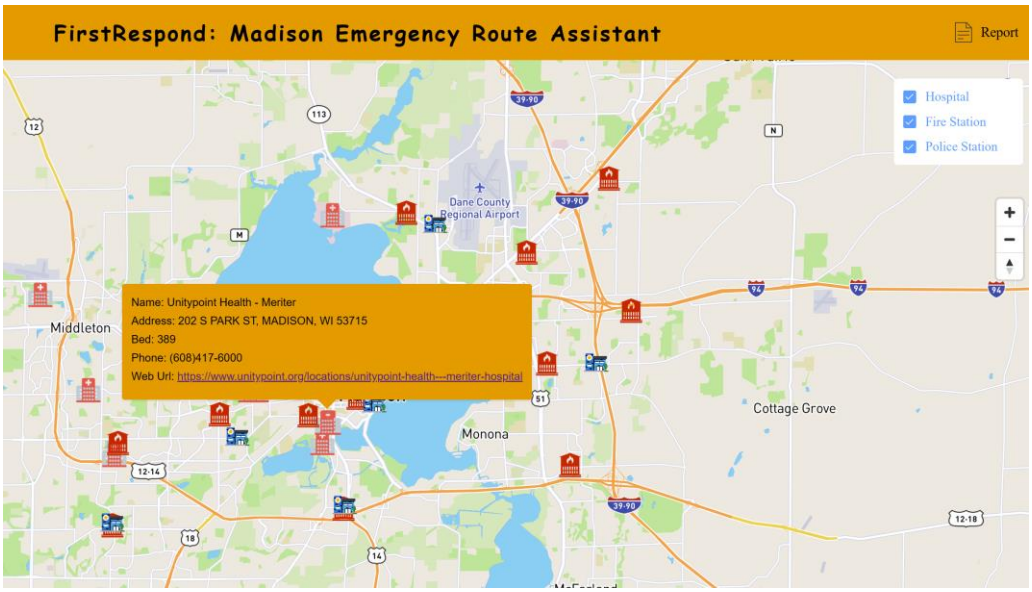


Figure 2 Infrastructures' Location and Information

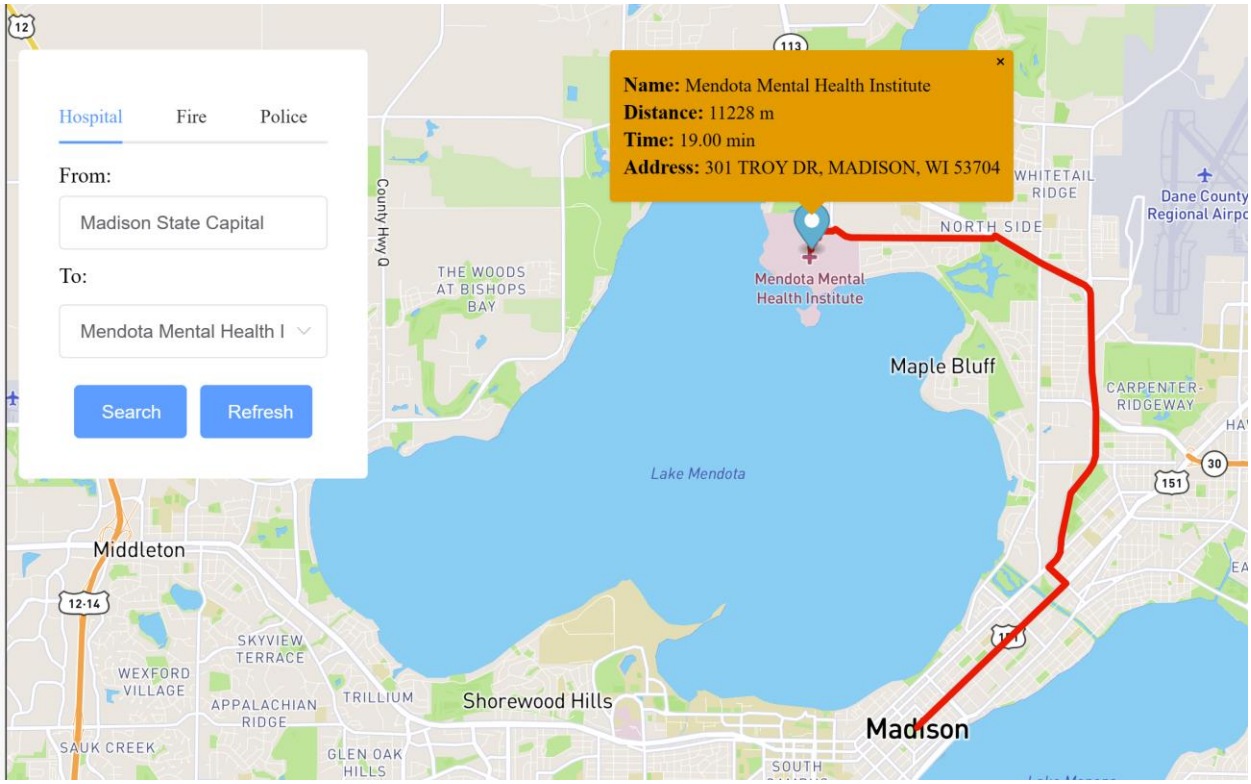


Figure 3 Route Direction Function

For Network Analysis, the project found that for a square of 1,000 meters around the state capital, the average time for the nearest hospital to arrive at the incident location was 716 seconds when considering traffic. The average time for the nearest hospital to reach the incident location without considering traffic is 670 seconds. Traffic conditions negatively impact response times by 46 seconds. For the 1,000 meters box around East Highway 151,

the average time for the nearest hospital to reach the incident location is 937 seconds when considering traffic. When traffic is not considered, the average time to reach the incident location is 886 seconds. Traffic has a negative impact on response efficiency of 51 seconds. As we can see, traffic has a negative impact on response times of roughly 1 minute. According to the policy, the optimal emergency response time is 300 seconds or 5 minutes. Therefore, 1 minute still has a large impact on emergency response time requirements.

Use Case Scenarios

Emily experiences sudden, intense abdominal pain while working from home one evening. With her condition worsening rapidly and no one around to assist her, she realizes she needs immediate medical attention. Emily turns to the "FirstRespond" web application on her laptop, then check all hospitals' information and locations in Madison. She inputs her address and selects the hospital she wants to go. It calculates the fastest route, considering current traffic conditions, and provides an estimated time of arrival. With this information, Emily calls a ride-share service, shares the route information provided by the application, and heads to the hospital.

Conclusion

By using FirstRespond Web Application, users can query the location of Madison Hospital, Fire and Police Stations and basic information of each department, such as address, phone number and website information of each department, etc. Additionally, users can use the navigation feature to navigate to their destinations. Users include not only residents, but also fire and police station staff can quickly select their work location and quickly navigate to the accident location.

In addition, if users are interested in Madison's road network, they can check the spatial road network analysis report to understand the model and general status of Madison's road network. The transportation department can also browse the report as a reference for the next improvement and upgrading of the road network.

Limitations and Future Work

1. The application is not mobile friendly, it only works on web browser. In future, can run FirstRespond on mobile and add an automatic positioning system.
2. The evaluation of emergency response time only considers the traffic data. In fact, it also needs to consider the weather.

3. The method of using traffic flow to pace roads is overly ideal and has room for improvement. In future, the project could use more realistic methods to calculate how traffic affects driving speeds.