Applying Line Graphs to Resource Allocation During Extreme Events

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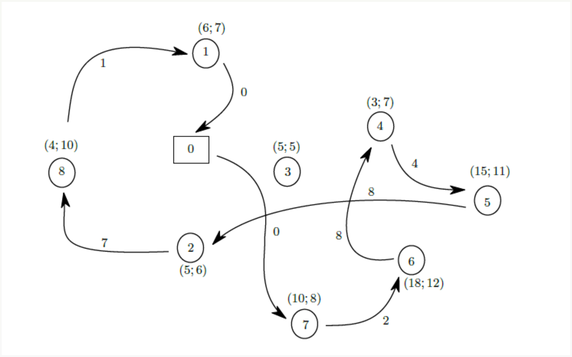
Abstract

Over the past half century the magnitude and cost of natural disasters has generally increased in the United States. As the number of these natural disasters continues to rise, it has become imperative to develop a system that efficiently allocates resources to affected areas and effectively distributes services during the emergency event. Our objective is to use line graphs combined with principles of graph theory to develop a solution capable of optimizing resource allocation. We will also be using a self-service bike sharing system as a model to develop the solution.

Bike Sharing Model

The bike sharing system consists of publicly owned bikes located at several locations within a city that are available for the public to use (usually for a fee). People pick up the bikes at one location and deposit it at another location. On the return trip the process is repeated.

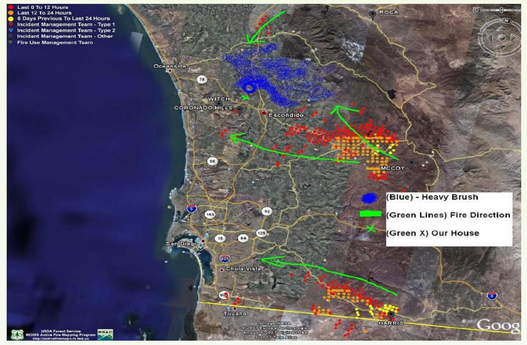


Example of possible truck route

Bike Sharing Model

Because people do not always return the bike to the same location a surplus of bikes forms at certain locations and a shortage of bikes is created at other locations. A system of trucks regulates the amount of bikes available at each station by redistributing all of the bikes overnight to match the demand.

Emergency Application Example



Map of wildfires affecting San Diego

In October 2007 , Southern California experienced a series of wildfires that destroyed over 1,500 homes and burned over 500,000 acres of land. In this example, a line graph with weighted edges could be used to model the fire. The weight of the edges would be dependent on the factors affecting the transmission of the fire. The bike model would be used to find the greenest path available for firefighting resources. This path would take into considerations obstacles that arise such as blocked paths, which could be modeled as cut-vertices.

Emergency Application Example

Map of Evacuation Zones for Hurricane Sandy

In the case of Hurricane Sandy, line graphs could help establish alternatives evacuations routes and methods to minimize the amount of traffic gridlock. Supplies such as food and water could be correctly allocated to areas of need, possibly by the use of tree diagrams.

Graph Theory Definitions

- A graph G is bipartite if vertex set V(G) is the union of two disjoint independent sets (partite sets) of G
- A path is a simple graph whose vertices can be ordered so that two vertices are adjacent if and only if they are consecutive on the list.
- A graph H is a subgraph of graph G such that $V(H) \subseteq V(G) and E(H) \subseteq E(G)$ and the assignment of endpoints to edges in H is the same as in G
- The line graph L(G) of an undirected graph G is another graph L(G) that represents the adjacencies between edges of G.
- A digraph consists of a vertex set V(G), an edge set E(G), and a function assigning each edge an ordered pair of vertices.

Graph Theory Definitions

- The outdegree $d^+(v)$ is the number of edges with tail v. The indegree $d^-(v)$ is the number of edges with head v.
- In a digraph G, $\Sigma_{v \in V(G)} d^+(v) = e(G) = \Sigma_{v \in V(G)} d^-(v)$

Research Questions

• Which type of resource will we be working with?

• For each resource what are some possible limiting factors and exceptions?

• What defines the shortest path in certain situations?

• How should obstacles be defined in specific situations?

Research Questions

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References

1.D. B. West, Introduction to Graph Theory (Edition 2), Pearson (2000)

2.D. Chemla, F. Meunier and R. W. Calvo, “Bike Sharing System: Solving the Statistical Rebalancing Problem,” *Vous Consultez L’Archive HAL* ,30 Aug (2013)