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Spatial Data Considerations for a Trauma Transport Spatial Decision Support System

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Abstract

With the recent proliferation of sensing and tracking technologies in medical settings, hospitals have the ability to integrate real-time spatial and aspatial data to make important logistical decisions. One area in need of this is trauma transportation, where patient outcomes are sensitive to the mode of transportation and the time it takes to receive care. This research presents a spatial decision support system that uses real-time information to guide medical personnel responsible for making complicated transportation choices with a diverse set of dynamic and static spatial and aspatial variables.

1. Introduction

The use of real-time spatial information coupled with relevant health data to drive decisions during emergency medical scenarios is, in practice, uncommon (Raghupathi and Raghupathi 2014). This is especially true in the context of trauma transportation, where the decision process for selecting the mode of transportation (i.e. helicopter or ambulance) to an appropriate trauma centre in an acceptable amount of time, is relatively unsophisticated and results in questionable choices (Widener et al. 2015). It is important to note that in many severe trauma cases, patients may be many miles away from care, providing for a complex geographic context that includes a range of rural and urban environments. Additionally, trauma patient outcomes are sensitive to transport mode (Brown et al. 2012). Given the quickening pace of adoption of sensing and tracking technologies in the medical community (Raghupathi and Raghupathi 2014; Xu et al. 2014), there is an opportunity to further integrate geographic data to address these inherently spatial problems to maximize the survival of patients and minimize the resource burden on the health care system. While there has been some research using GISystems and Science to analyze trauma transport in the past (Widener et al. 2015), and older examples of GISystems guiding emergency medical services (Peters and Hall 1999), research considering the relationships between modern spatial data feeds relevant to transporting trauma patients has not been thoroughly developed.

This short paper presents a spatial decision support system (SDSS) that considers the various streams of spatial and aspatial data required to generate informed responses to trauma incidents. Special attention is paid to links and feedbacks between dynamically changing and static spatial datasets, the order of processing these data, and, finally, how decisions are computed, visualized, and communicated via GISystems. With this SDSS, there is a framework that guides hospitals and emergency medical responders to optimal decisions for a diverse array of trauma scenarios, and takes advantage of the increasing number of hospital resources providing real-time information. Additionally, we will demonstrate the utility of the SDSS through testing a variety of trauma transport scenarios using historical and simulated data. However, because the data on trauma incidents were just acquired, only the SDSS and select preliminary results are presented below. Scenario tests are anticipated to be completed by July 2016.

2. Data

While the decision framework developed through this research project can be applied in most North American contexts, the data used to demonstrate the SDSS will be from Maryland, USA, where the helicopter emergency medical services (HEMS) system is publicly funded with a standardized protocol for deploying more expensive helicopter transportation.

A variety of data are used to inform the development of, and test, the SDSS. Table 1 outlines the static and dynamic variables considered in the SDSS, where "static" describes variables considered time-independent and "dynamic" describes variables considered time-dependent. The first static variable that will be considered is the locations of all trauma centres, accounting for their capacities, described by the American College of Surgeons. Other static variables considered are helicopter and ambulance base locations. Suitable helicopter landing sites are determined by calculating the slope of sufficiently large cleared patches of land (preliminary sites are seen in Figure 1). Additionally, the road network is used to calculate optimal routes for ground ambulances.

Table 1. Variables relevant to the SDSS.

Static Variables	Dynamic Variables
Hospital locations	Patient condition
Helicopter landing sites	Traffic conditions
Helicopter bases	Weather conditions
Ambulance bases	Ambulance positions
Road network	Hospital capacity

Important dynamic variables relevant to trauma transport decisions are patient condition, traffic conditions, weather, ambulance positions, and hospital capacity. After data are processed and incorporated, various dynamic values for these variables will be simulated within the GIS to explore the SDSS's output.

3. Spatial Decision Support System Map

Current protocol for trauma patient transport begins after ground emergency medical services (GEMS), has arrived at the site. Upon evaluation of the patient, the GEMS crew determines whether the patient should be driven to a trauma centre or flown via HEMS. However, the process for determining the appropriate mode of transport can be somewhat arbitrary. Widener et al. (2015) show a significant proportion of patients were flown to the trauma centre despite the

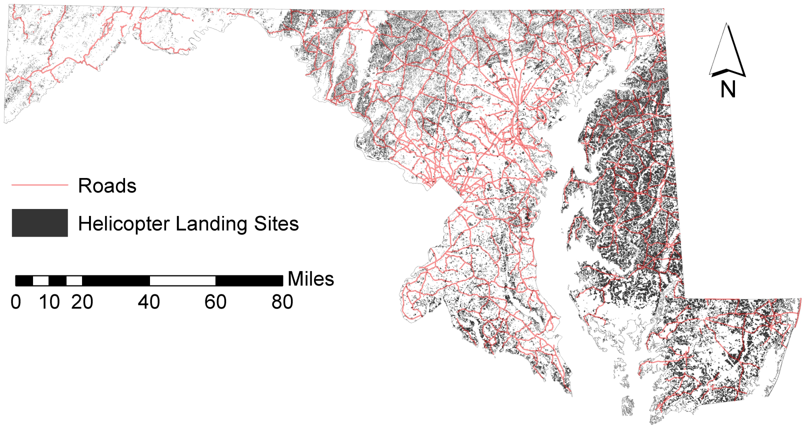

Figure 1. Potential helicopter landing sites with major roads.

travel cost via GEMS being lower. Given that trauma patient outcomes improve if they arrive at a trauma centre within one hour (known as the golden hour (Newgard et al. 2010)) it is critical that a standardized, but flexible, system for decision-making be developed.

The SDSS (Figure 2) is initiated via a user through a Graphical User Interface (GUI) that takes information on the patient's location, condition, and the time the incident was reported.

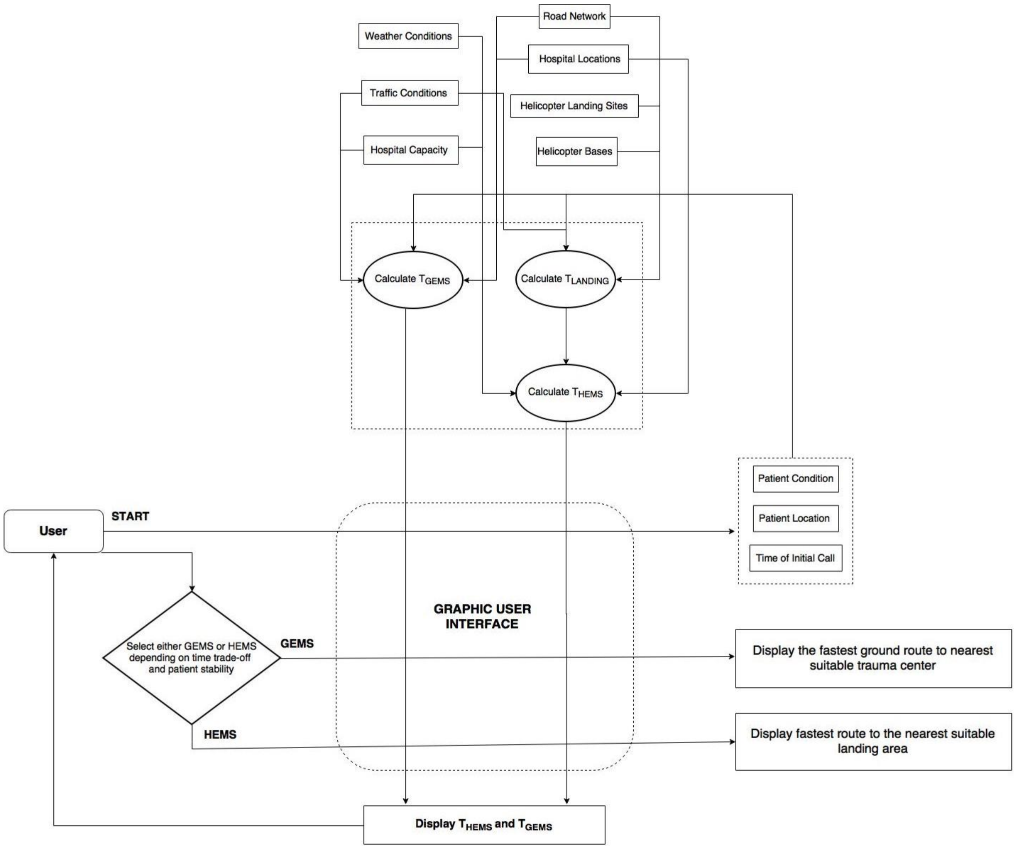

Figure 2. Model of the Trauma Transport Mode Selection SDSS.

With this information, T_{GEMS} and T_{HEMS} are both computed. Prior to computing T_{HEMS}, the travel cost of the time needed to transport the patient from the incident location to a suitable helicopter landing site, $T_{LANDING}$, is also calculated and considered.

Given that every trauma case is unique, the SDSS displays the computed GEMS and HEMS travel times to the EMS crew via the GUI and allows the EMS crew to select a mode depending on the patient's estimated stability and how valuable the EMS crew believes a time-tradeoff between the two modes might be. In this way, the SDSS handles all of the sophisticated aspatial and spatial data behind the scenes and produces a result that the EMS crew can easily combine with their expertise. When the EMS crew decides on a mode and communicates that decision to the SDSS via the GUI, the SDSS outputs one of two displays depending on the EMS crew's decision - if the EMS crew selects GEMS, then the output is a display of the fastest route to the nearest suitable trauma center. If the EMS crew selects HEMS, then the output is a display of the fastest route to the nearest suitable helicopter landing site.

This SDSS explicitly addresses the role of new streams of data and how this information can be processed into a meaningful product useful to an EMS crew. It effectively integrates complex real-time traffic and weather data (acquired through esri's World Traffic Service and the US National Oceanic and Atmospheric Administration), simulated real-time patient data, and static spatial datasets to demonstrate the need for such a decision support system, and delivers a prototype that will guide EMS crews in making complex and time-sensitive medical decisions. It provides for a flexible system that is modifiable for each unique trauma case, and is capable of communicating with EMS crews and hospitals about transportation logistics given current on-the-ground conditions and in-person assessments of the situation. Ultimately, this research demonstrates the utility of carefully handling and processing spatial data, in combination with aspatial information, to generate objective decisions in a variety of geographic and time-sensitive trauma scenarios.

References

Brown, Brandon S, Korby A Pogue, Emily Williams, Jesse Hatfield, Matthew Thomas, Annette Arthur, and Stephen H Thomas. 2012. Helicopter EMS transport outcomes literature: annotated review of articles published 2007–2011. *Emergency Medicine International* 2012.

Newgard, Craig D, Robert H Schmicker, Jerris R Hedges, John P Trickett, Daniel P Davis, Eileen M Bulger, Tom P Aufderheide, Joseph P Minei, J Steven Hata, and K Dean Gubler. 2010. Emergency medical services intervals and survival in trauma: assessment of the "golden hour" in a North American prospective cohort. *Annals of Emergency Medicine* 55 (3):235-246. e4.

Peters, Jeremy, and G Brent Hall. 1999. Assessment of ambulance response performance using a geographic information system. *Social Science & Medicine* 49 (11):1551-1566.

Raghupathi, Wullianallur, and Viju Raghupathi. 2014. Big data analytics in healthcare: promise and potential. *Health Information Science and Systems* 2 (1):3.

Widener, Michael J, Zac Ginsberg, Daniel Schleith, Douglas J Floccare, Jon Mark Hirshon, and Samuel Galvagno. 2015. Ground and helicopter emergency medical services time tradeoffs assessed with geographic information. *Aerospace Medicine and Human Performance* 86 (7):620-627.

Xu, Boyi, Li Da Xu, Hongming Cai, Cheng Xie, Jingyuan Hu, and Fenglin Bu. 2014. Ubiquitous data accessing method in IoT-based information system for emergency medical services. *Industrial Informatics, IEEE Transactions on* 10 (2):1578-1586.