Traffic Noise & Routing of Hazardous Material Carrying Vehicles

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Abstract: Hazardous materials accidents during the process of transportation have caused enormous danger and loss to life and environment in recent years. Especially in an urban area, high population density, heavy traffic congestion and link closures face the complex and changeable situations. People who live or work near roads commonly travelled by hazmat (hazardous vehicles) trucks endure the greatest risk. Careful selection of roads used for a hazmat shipment can reduce the population at risk. On the other hand, a least time route will often consist of urban interstate, thus placing many people in harm’s way. Route selection is therefore the process of resolving the conflict between population at risk and efficiency considerations. This paper presents a methodology and case study of Guntur, which is to contribute a national action plan for hazardous material transport for Andhra sugars Ltd. This article presents a methodology for assessment of the hazardous materials transport risk and traffic noise with respect their intensity in a multi commodity, multiple origin–destination setting. The proposed risk assessment methodology was integrated with a Geographical Information System (GIS), which made large-scale implementation possible. The algorithm and general methodology is used for the routing of dangerous goods on-demand, serving individual shipments in a permitting environment by the routing was designed and also traffic noise with respected that was solved.

Keywords: Traffic Management System, Raspberry Pi 3, IoT, Automation, Geographical Information System (GIS).

I. INTRODUCTION

Each day products and materials defined as dangerous goods (DG) are shipped from one point to another within Canada. These products include: explosives, gases, flammable liquids and solid, oxidizing substances, poisonous and infectious substances, corrosive substances, and hazardous waste. As such, these products and materials require special precautions to ensure their safe transportation. The social, environmental, and monetary costs associated with DG incidents are high and every precaution has to be taken to avoid such catastrophic events. Therefore, it is essential to continually work towards minimizing the risk of incidents in the transportation of dangerous goods and their potential consequences. In industrialized countries, a significant portion of the materials transported is harmful to human health and to the environment. Materials of this nature are called dangerous goods, or hazardous materials (hazmats). They include explosives, gases, flammable liquids and solids, oxidizing substances, poisonous and infectious substances, corrosive substances, and hazardous wastes. Although rare, accidental releases of hazmats do occur during transportation, and these events often have very undesirable consequences, including fatalities. Therefore, mitigation of the associated public and environmental risk is an essential component of hazmat transportation planning.

II. PROBLEM STATEMENT

In order to compensate for uncertainties in travel time due to accidents, bad weather, traffic congestion, etc., trucks hauling time-sensitive freight build “buffer time” into their routes in order to help ensure that deliveries will be made on time. Building buffer time into routes tends to increase the likelihood of on-time delivery, an important measure of service. However, buffer time also tends to reduce measures of productivity associated with cost, such as driver and equipment idle time and the number of miles traveled per hour. One goal of this paper is to show that real-time traffic information combined with historical traffic data can be used to develop routing strategies that tend to improve both cost and service productivity measures. More specifically, motivated by situations where time-sensitive delivery is required, we examine the value of a real-time traffic information technology (IT) on vehicle routing. We present a systematic approach to aid in the implementation of transportation systems integrated with this real-time IT. To this end, we consider a stochastic shortest path problem on a road network composed of links having non-stationary travel times, where a subset of these links are observed in real-time.

III. LITERATURE SURVEY

GIS is used to develop the Recycling Education Awareness and Participation (REAP), index for New York City’s neighbourhoods (Clarke et al 2005). GIS is quickly becoming a common tool in public health and there are many examples of GIS being used to map disease.

Jennifer Evack et al (2006) presented how to improve the public health inspectors’ (PHI) efficiency using GIS optimal
routing technology. The goal of the project is to assess the value of optimum routing technology, to increase the number of inspection performed by PHIs, decrease the time spent on driving by Phis, and develop a process for using optimal routing technology.

Under the municipal GIS, MarcinKunka (2006) presented the Abu Dhabi experience, stating that, geographical information systems are very essential part of day to-day operations in many municipalities. It is important to utilize and maintain the data efficiently. Success of municipal GIS depends not only on allocated funds to finance, but also on the decisions with solutions to support. Spatial data should be better manageable and in the same time more accessible for larger groups of users. The web-based applications should support workflow of the organization and streamline all services offered to the citizens.

VivekShandas(2003) presented a GIS based water demand analysis for municipal application in Maps of India conference. Water demand indicates both current and expected water consumption in any given area over a specific time period. Due to varying requirements and spatially explicit characteristics of individual users, water demand must be determined separately for individual user groups. Multiple users of water can be differentiated according to the demand for potable water, industrial/commercial processes, as well as irrigation. The advantages of using a GIS for this analysis are that it helps initial identification of the parcels, visual cross checking with statistical data, and provides a platform for presenting the analysis to city officials for review.

IV. GENETIC ALGORITHMIC

One of the meta-heuristic algorithms used in the optimization problems is Genetic Algorithm. A large number of researchers utilized the genetic algorithm as an optimization tool, particularly in transit network design. The objective of using GA in transportation network is based on an analytical model, supplying a synthetic analysis of network performance of optimization procedures. This is for solving the network design problem by determining transit routes, associated frequencies and locating main transit centres. The basic framework of the model is established on the following three phases:

**Phase 1**: A heuristic algorithm to generate a set of feasible routes.

**Phase 2**: A genetic algorithm to find the optimal sub-set of routes with associated frequencies.

**Phase 3**: Final improvement of the network configuration.

V. POPOSED METHODOLOGY

In order to study this, we chosen the Guntur city as case study because it is the near to newly forming A.P head-quarters Amaravathi and also it’s one of the industrial hub for A.P. Guntur is one of the 9 Coastal districts of Andhra Pradesh. It is located between 15°18’ and 16°50’ North latitude and 70°10’ and 80°55’East longitude. It is bounded by Krishna & Nalgonda districts on the North, by Prakasam and Mahabubnagar districts on the West, by Prakasam district on the South and by Krishna district, and the Bay of Bengal on the East. The district has a coastline of 42 kms. The total geographical area of the district is 11328 sq kms, which forms 4.12% of the total State’s area.

VI. RISK/COST-BASED DANGEROUS GOODS ROUTING ALGORITHM (DGRA)

Routing of DG is a subject of considerable interest in the transportation community. There are two major difficulties that are associated with the routing problem. First, the problem is made up of multiple objectives (safety, security, efficiency and cost) that need to be optimized when selecting routes, making it conceptually more difficult from the perspective of the analyst as well as the decision-maker.

**Fig 1. General Characteristics of the District Location & Geographical Area.**

**Fig 2. Dangerous Goods Routing Algorithm: Conceptual Framework.**

Fig 2 shows a conceptual framework for the proposed risk/cost-based DGRA. The model contains two major components: a Dispersion Model and a GIS. The dispersion model uses site data, chemical, atmosphere and source...
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information to generate a plume footprint. Afterwards, the footprint and a number of datasets are integrated together in a GIS environment to perform the analysis. Based on the study objectives, the proposed methodology involves a set of dangerous goods routing criteria pertaining to safety, efficiency, security, and cost. These are chosen to include: incident probabilities, incident consequence, operating costs, and human health impacts.

VII. SCENARIO DEVELOPMENT

For demonstration purposes three routes connecting a pair of origin and destination (O-D) were investigated. It is assumed that only one shipment is going to traverse the O-D pair. Fig 3 depicts the study area and the three proposed routes. The three routes pass through almost the same number of intersections, albeit having variable lengths. Only route (R2) passes through Langley’s regional town centre (RTC). There are no tunnels, bridges or HOV lane present along the three routes. Route (R1) is a major highway in the lower mainland region. The highway is known as Highway (1) and begins at Horseshoe Bay ferry terminal in West Vancouver and continues for 170 (km). Route (R2) traces part of Fraser highway but passes through Langley’s town center. Route (R3) passes through a mixture of local arterials in the city of Langley.

Fig 3. Study Area and Evaluated Routes.

A. Causes of Traffic Noise
Noise comes from many sources: one of significant source is from transportation.
Noise comes from three sources
• the friction between vehicle types and road
• The engine and (exhaust).

The level of highway traffic noise depends on:
• Speed of the traffic
• Traffic volume

B. Noise Level Parameters
Unit of noise: The basic unit of noise is decibels. If the amplitude of pressure fluctuations is \( P \) the sound level in decibel is given by

\[
L = 10 \log \left[ \frac{P}{P_0} \right] \text{db}.
\]

Where \( P_0 = 2 \times 10^{-5} \text{ N/m}^2 \) (amplitude of audible pressure wave). The overall sound pressure is denoted by dB(A).

Percentile exceeded sound Level (Lx) decibel The noise level exceeded for x per cent of the time is denoted by Lx. The most common noise exceeded level used is L10 ie noise level exceeding for 10 per cent of time. It is an indication of the peak level of the intruding noise, whereas L90 level is an indicator of the background noise level. Traffic Noise Index (TNI) It is defined as

\[
TNI = 4(L10 - L90) + L90 - 30 \text{dB(A)}
\]

This index attempts to make an allowance for noise variability with respect to L10 level.

C. Road Traffic Noise & It’s Effect
Road traffic noise is the most important major source of community noise specially near an important road with high volume of traffic of any major city. In developing country like India where Roads are in bad condition, and poorly maintained and has considerable number of vehicles of outdated technology, the road traffic noise assumes much more importance. Factors effecting traffic noise. There are various factors that affect the traffic noise.

• Type of traffic flow speed, as the traffic flow increase, the noise level increases. Higher speed also causes higher noise levels. At lower speeds, the influence of engine transmission of noise is predominant on the other hand at higher speed the tyre surface interaction assumes importance. Noise level increases during acceleration.

• Tyre-road surface interaction: It is a major generator of noise Grooved cement concrete pavement is found to be source of annoying noise to neighborhood.

• Road surface condition: Smooth surface generally produce less noise. Rough surface and poorly maintained road with pot-holes produce more noise.

VIII. RESULTS

Table 1 provides a summary of the individual components of the DG routing algorithm. The results indicate that route (R1) minimizes travel time and consequently transport cost. On the other hand, route (R2) minimizes distance traveled as well as accident probability. Route (R3) is probably the worst choice since it has the highest accident probability, travel distance, travel time, and transport costs.

<table>
<thead>
<tr>
<th>Description</th>
<th>Routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Probability</td>
<td>R1</td>
</tr>
<tr>
<td>Travel Distance (km)</td>
<td>33</td>
</tr>
<tr>
<td>Travel Time (min)</td>
<td>23</td>
</tr>
<tr>
<td>Transport Cost ($)</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 2 summarizes population exposure numbers using the dispersion model to determine the impact zone. The results indicate that route (R2) minimizes population exposure at the three levels of concentrations during evening. However, during day route (R3) minimizes population exposure at highest concentration zone as well as the number of overall evacuees.

Table 2. Exposed Population by Time of Day.

<table>
<thead>
<tr>
<th>Description</th>
<th>Routes</th>
<th>20 (ppm)</th>
<th>2 (ppm)</th>
<th>0.5 (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evening Exposed Pop.</td>
<td>R1</td>
<td>41,163</td>
<td>19,912</td>
<td>9,503</td>
</tr>
<tr>
<td></td>
<td>R2</td>
<td>41,230</td>
<td>16,206</td>
<td>4,538</td>
</tr>
<tr>
<td></td>
<td>R3</td>
<td>41,289</td>
<td>21,085</td>
<td>14,339</td>
</tr>
<tr>
<td>Evacuated</td>
<td>R1</td>
<td>89,870</td>
<td>80,942</td>
<td>90,315</td>
</tr>
<tr>
<td></td>
<td>R2</td>
<td>80,471</td>
<td>61,194</td>
<td>25,203</td>
</tr>
<tr>
<td></td>
<td>R3</td>
<td>82,667</td>
<td>63,503</td>
<td>25,937</td>
</tr>
</tbody>
</table>

Table 3 summarizes the number of emergency and special facilities along the three routes. Route (R2) has the highest number of emergency response facilities among the three routes at 20(ppm). This is very important since having several emergency response facilities along the route will result in a more responsive reaction to the incident and facilitate isolation and protection procedures. It is also important to note that exposure to chlorine at this concentration level is expected to have a very severe impact on human health.

Table 3. Number of Special & Emergency Facilities alongside each Route.

<table>
<thead>
<tr>
<th>Concentration Level</th>
<th>Facility Type</th>
<th>No. of facilities on each route</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ppm</td>
<td>Sensitive</td>
<td>R1 11 R2 9 R3 9</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>R1 3 R2 2 R3 2</td>
</tr>
<tr>
<td>2 ppm</td>
<td>Sensitive</td>
<td>R1 20 R2 21 R3 18</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>R1 4 R2 5 R3 5</td>
</tr>
<tr>
<td>0.5 ppm</td>
<td>Sensitive</td>
<td>R1 25 R2 24 R3 30</td>
</tr>
<tr>
<td></td>
<td>Emergency</td>
<td>R1 7 R2 8 R3 7</td>
</tr>
</tbody>
</table>

Furthermore, routes (R2) and (R3) pass by the least number of schools and hospitals within the highest concentration zone. As the concentration level drops to 0.5 (ppm) route (R2) still has the least number of exposed special facilities. This is important since it minimizes the number evacuees in such sensitive facilities. On the other hand, route (R3) exposes 30 special facilities to probable danger. Should an incident occur during the transportation process this route places some school-aged children and potential ill individuals at the risk of being exposed to harmful materials. Table 4 summarizes the costs associated with routing DG based on evening- and day population exposure. For evening and day-time exposure, route (R2) minimizes the total costs. However, it could be argued that route selection should consider not only the costs but also the number of emergency and sensitive facilities on-route. In contrast, route R3 has the highest cost because: (i) it exposes a large number of individuals to risk; and (ii) it has the highest operating cost.

Table 4. Costs Associated with routing DG during Evening

<table>
<thead>
<tr>
<th>Description</th>
<th>Routes</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk (20 ppm)</td>
<td></td>
<td>16,858</td>
<td>14,311</td>
<td>24,259</td>
</tr>
<tr>
<td>Costs ($2)</td>
<td></td>
<td>4,002</td>
<td>2,301</td>
<td>6,194</td>
</tr>
<tr>
<td>Incident Probability</td>
<td></td>
<td>389</td>
<td>17%</td>
<td>642</td>
</tr>
<tr>
<td>Evacuated</td>
<td></td>
<td>7,607</td>
<td>6,934</td>
<td>10,613</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>28,936</td>
<td>24,045</td>
<td>38,053</td>
</tr>
<tr>
<td>Operating Costs ($)</td>
<td></td>
<td>21</td>
<td>24</td>
<td>38</td>
</tr>
<tr>
<td>Total Cost ($)</td>
<td></td>
<td>29,957</td>
<td>24,108</td>
<td>41,947</td>
</tr>
</tbody>
</table>

IX. DISCUSSION

Table 5 provides a summary of the “best route” by the different DGRA components. The table is going to be referenced throughout this section to compare and differentiate between the findings of each routing criteria. The results in Table 5 indicate that route (R2) minimized travel distance but did not minimize travel time. The difference in the results is explained by examining the speed profiles on both routes. The difference in speed profiles between routes (R1) and (R2) is explained by the fact the route (R1) is a major highway in the lower mainland region. The highway is known as Highway (1). As a result of having a higher speed, route (R1) minimized travel time. In contrast, route (R2) passes through the city of Langley’s town centre where lower speeds are enforced. There is an apparent similarity between the travel time and transport cost criteria. These similarities can be explained by recognizing that transport cost is a function of travel time and operating costs. Therefore, it is expected that both measures would identify the same route. As expected incident probability and travel distance criteria identified the same route since both measures are based on road segment length.

Table 6: Percentage Increase from the base Value

<table>
<thead>
<tr>
<th>Description</th>
<th>Routes</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Distance (km)</td>
<td></td>
<td>22%</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>Travel Time (min)</td>
<td></td>
<td>Base</td>
<td>9%</td>
<td>78%</td>
</tr>
<tr>
<td>Transport Cost ($)</td>
<td></td>
<td>Base</td>
<td>4%</td>
<td>49%</td>
</tr>
<tr>
<td>Incident Probability (per million)</td>
<td>Evening</td>
<td>20%</td>
<td>Base</td>
<td>74%</td>
</tr>
<tr>
<td>Total Cost ($)</td>
<td></td>
<td></td>
<td>10%</td>
<td>21%</td>
</tr>
</tbody>
</table>
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(R1) and (R3) over route (R2) the decision-maker is increasing the distance traveled by 22% and 52%, respectively. These percentages show that for this specific criterion, a significant difference in the results is apparent between the three alternative routes. Routing by travel time or cost increases the percentage by 9% and 78% for routes (R2) and (R3), respectively, relative to route (R1). This indicates that routes (R1) and (R2) could be considered as surrogate routes since the results are not significantly different under both criteria. Similarly, the incident probability criterion shows no significant difference between routes (R1) and (R2). Route (R3) is probably the worst choice since it has the largest distance, longest time, highest cost and incident probability while showing a significant increase in all criteria when compared to the best alternative.

X. CONCLUSION AND FUTURE ENHANCEMENT

In this study a risk/cost-based DGRA was developed. The algorithm had four major components. First, a chemical release was simulated using a dispersion model to determine the impact zone(IZ). The generated IZ is based on time of day, weather conditions and type/amount of chemical released. Second, the DGRA was formulated to include a set of routing criteria including: incident probability, population exposure, travel distance travel time and health cost. Third, all the above information was integrated into a GIS database. Lastly, the GIS database utilized an optimal routing algorithm to allow for the evaluation of a specific truck route or alternative truck routes between a particular origin and destination. The applicability of the algorithm was demonstrated using B.C. calibrated datasets representing the Metro Vancouver area.

There are many other uses of GIS models as DG incident management tools to identify evacuation plans, emergency responsiveness, re-routing of existing traffic, etc. The current study could be extended to include additional datasets. For example, locations of farms, crops, watersheds and other environmental locations can be used to determine the effects on the environment. The number of students enrolled in schools can be obtained to determine the exact number of evacuees; with a similar count for hospitals. Moreover, information on bus-stops, shared bicycle or bus lanes, transit stations, etc., can be factored into the analysis. Other topics include determining adequate release probabilities, obtaining accurate and recent truck accident.

XI. REFERENCES


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