Visual Analytics Decision Support Environment for Epidemic Modeling and Response Evaluation

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Problems:

• Public health officials must prepare and exercise complex plans in order to deal with potential mass casualty events like epidemic outbreaks
• Officials often rely on information and trends provided via complex modeling
• Such plans are often developed with only a few specific scenarios in mind
• Absence of decision support tools makes it difficult to analyze the future course of such events, evaluate potential mitigation strategies and find the optimal plan to deal with such catastrophic events
Our Contribution:

Developed an Interactive Decision Support Environment in which analysts can:

- Explore epidemic models and their impact
- Interactively utilize mitigative response measures and observe the impact over time under varying scenarios
- Utilize doubly linked decision history visualization and navigation tools that can link to multiple simulation runs and provide simultaneous comparison of mortality and infection rates
- Design an optimal mitigative response strategy for a given scenario
Architecture of the Decision Support Environment
Main Views of the Decision Support Environment

Spatiotemporal Model View
Showing epidemic spread at Day 214

Decision History Visualization & Navigation View
Decision History Visualization and Navigation

- Each path in the decision history view represents a simulation run.
- For each path, cumulative sum of the overall magnitude of the outbreak (in terms of lives lost etc.) is calculated.
- Baseline represents the ‘cumulative summation of lives on day t of the scenario’ in absence of any mitigative measure.
- Other paths branch off from this baseline such that the decision history views is visualizing the overall impact:

\[ P_v(t) = \sum_{i=0}^{t} P_b(t) - \sum_{i=0}^{t} P_0(t) \]

Overall Impact

Original decision path

Current decision path

Decision Path originates from x-axis
Path Highlighting
Path ends below the x-axis
Two Paths fall below x-axis but end up above x-axis
Best Decision Path

VACCINE
Case Study – Rift Valley Fever

Description:
Epidemiological spread model that utilizes a differential equation model and simulates the spread of rift valley fever through a simulated mosquito (Aedes & Culex) and cattle population in Texas²

Mitigative Response Measures:
1) Pesticides (kill Aedes and Culex Mosquito population)
2) Quarantine (Block transport of cattle into or out of the selected region)

Case Study – Rift Valley Fever

Spatiotemporal view showing effects of utilizing both the quarantine and pesticides (mitigative measures) at Day 90

Both Quarantine and Pesticides applied at Day 90

Spread Situation at Day 153

Spread Situation at Day 229
Case Study – Rift Valley Fever

Best Decision Path D3 is Identified

<table>
<thead>
<tr>
<th></th>
<th>Pesticides Aedes</th>
<th>Pesticides Culex</th>
<th>Quarantine</th>
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<tbody>
<tr>
<td>D1</td>
<td>140,260</td>
<td>260</td>
<td>80</td>
</tr>
<tr>
<td>D2</td>
<td>200</td>
<td>120,200</td>
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<tr>
<td>D3</td>
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<tr>
<td>D5</td>
<td>240,290,305</td>
<td>240,290,305</td>
<td>-</td>
</tr>
</tbody>
</table>

Summary of Decision Paths
Conclusion and Future Work

- Decision History Visualization and Navigational support helps users analyze and compare multiple simulation paths and identify optimal combination of mitigative response measures.

- Architecture of the system supports easy integration with other epidemiological models.

- In future, we will explore the inclusion of economic model into the system that might help visualize the impacts of epidemic spread on local economy.
Acknowledgement

• This work has been supported by the U.S. Department of Homeland Security’s VACCINE Center under award number 2009-ST-061-Cl001.
Q & A

THANK YOU