Development of an Agent Based Model to Optimize Restoration Strategies and a Case Study of "Future" Hurricane Sandy

Tara Walsh[1], Thomas Layton[2], David Wanik[3], Diego Cerrai[1], Peter Watson[1], Jonathan Mellor[1], Emmanouil Anagnostou[1]
[1]University of Connecticut, Storrs; [2]United Illuminating; [3]University of Connecticut, Stamford

Introduction

In August 2011 and October 2012 Hurricanes Irene and Sandy caused $13.5 billion and $65 billion of damage in the United States. The restoration times for these storms were 10 and 11 days, respectively for Connecticut. It remains a question whether different restoration strategies or more resources could have improved the restoration process.

Methods

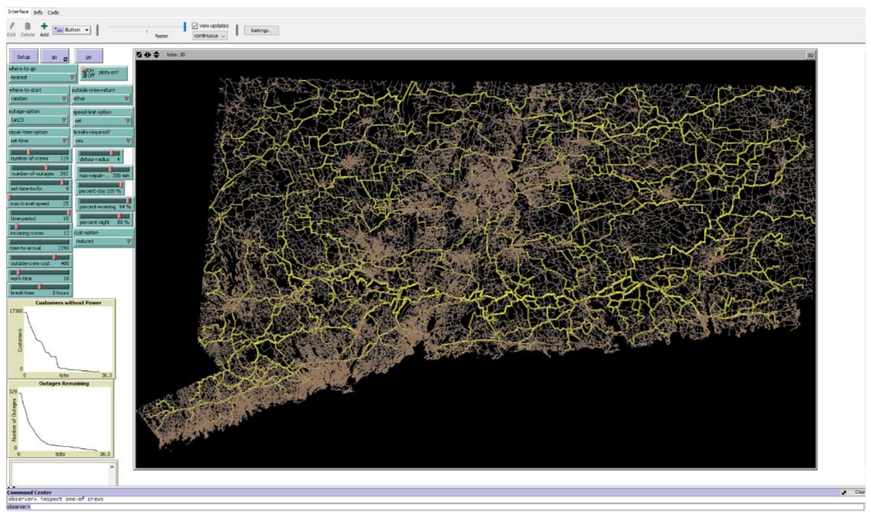

Figure 1: Interface of ABM.

An agent based model (ABM) is a computer modeling technique comprised of agents who are given certain behavioral rules and operate in a given environment. ABMs allow the user to simulate complex systems by varying user-defined parameters to study emergent, unpredicted behavior. This model could be used to justify decisions made in a restoration process or to see if increased resources can improve the estimated restoration time.

Input Data

Eversource provided the number of crews working, storm restoration curves, power line and area work center locations. The road network of Connecticut was obtained from the UConn Map and Geographic Information Center. Dijkstra's search algorithm calculates the optimum path to the next outage along the road system.

Processes

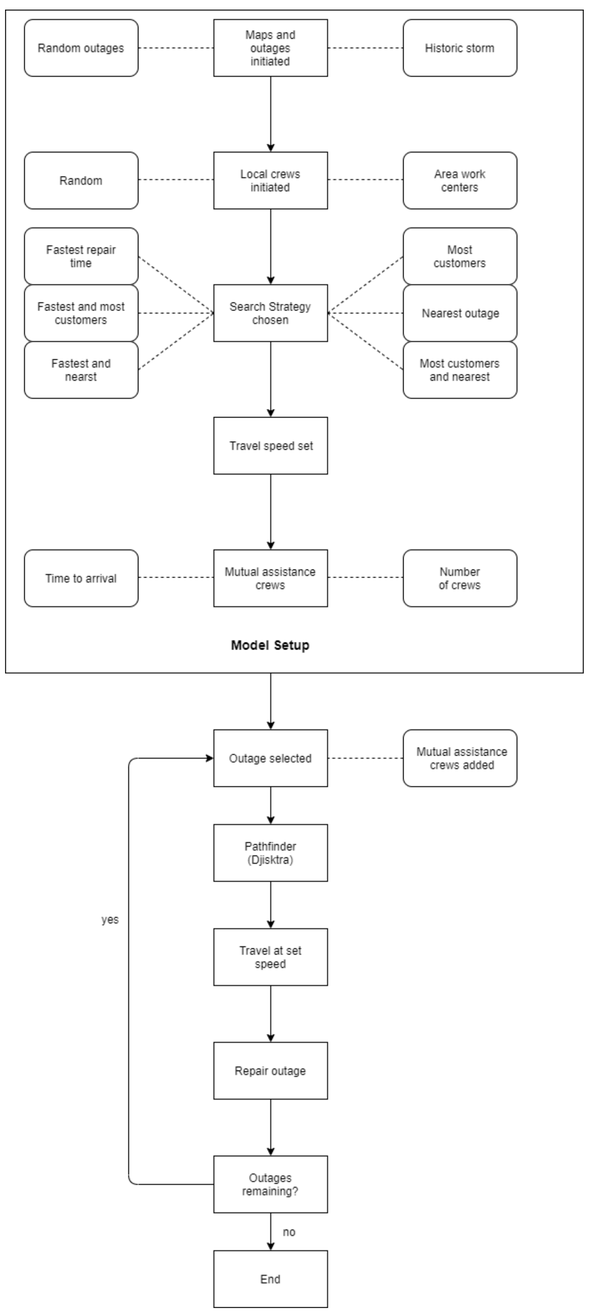

Figure 2: User set-up decisions and agent (utility crew) behavior rules.

Validation

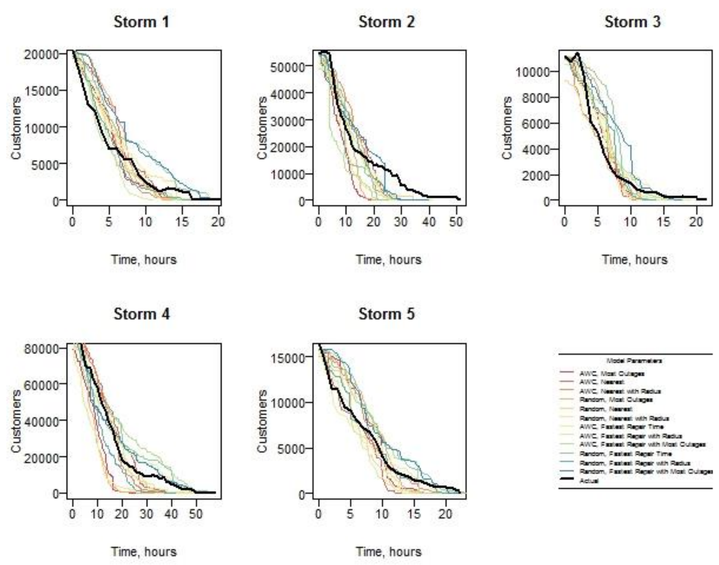

Figure 3: Storms used in the model validation and run with different model search strategies and crew starting locations.

Time to System Recovery (h)	17	51	50	22	20	–
Repair Time Range (h)	1–7	1–13	1–9	1–13	1–11	1–10
% Crews Working Night	100	72	31	29	100	66
% Crews Working Evening	100	93	100	100	100	99
% Crews Working Day	100	64	100	88	73	85
Crews	201	365	212	392	190	272
Peak Customers	20,377	54,431	11,207	88,341	15,840	38,186
Outages	657	1399	495	2056	661	1220
Weather	Snow, Wind	Snow, Wind	Wind	Wind	Wind	–
Month	April	February	February	January	February	–
Storm	1	2	3	4	5	Average

Table 1: Validation storm information for Storms 1-5 in Figure 3.

Application and Case Study

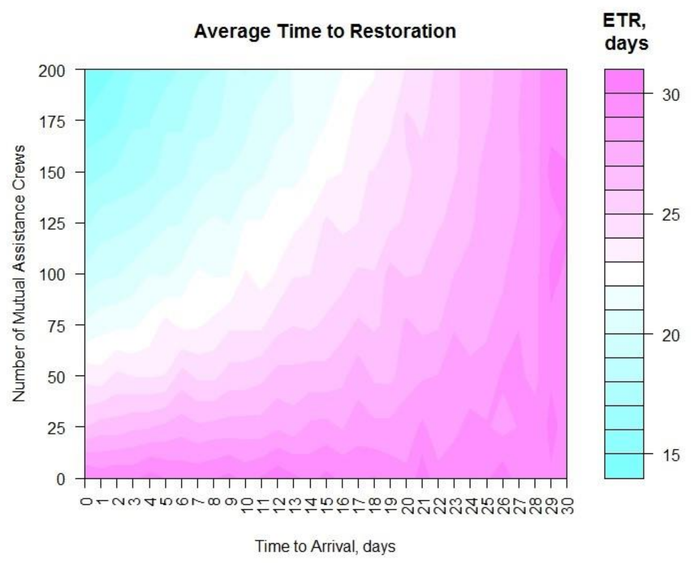

Figure 4: The ABM can be used to determine mutual assistance crew effectiveness by varying the number of mutual assistance crews and their time to arrival..

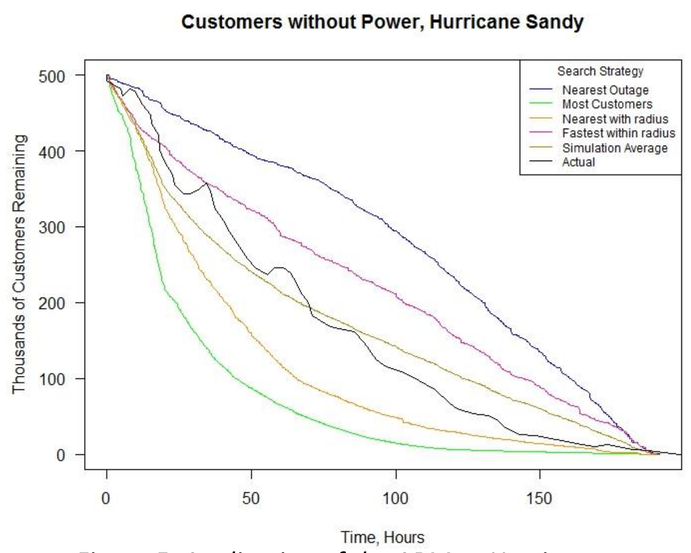

Figure 5: Application of the ABM to Hurricane Sandy. Outage location and utility crew assignments match the historic restoration.

Future Work

We are working on combining the ABM with the outage predictions from the Wanik et al. 2018 paper titled "A Case Study on Power Outage Impacts from Future Hurricane Sandy Scenarios" to study how climate change can impact the restoration time of storms, and therefore the resources needed for reasonable restoration.

Acknowledgements

Special thanks to the Eversource Energy Center, Michael Zappone and William Burley for supporting this work.