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Human-Robot Trust Relationships for Search and Rescue

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Motivation

- Any disaster, whether man-made or natural, has the following characteristics
  - Confusion about the extent of the damage and the number and location of victims
  - Potentially hazardous conditions at the disaster site
  - A limited number of first responders
  - An exponentially decreasing survival rate
- To address these issues, one proposal is to use autonomous robots for mapping the current state of the disaster site and locating victims and hazards in the disaster area


BBC News


UNESCO

USGS

Problem

- As stated by Robin Murphy, humans don't trust robots operating in challenging environments

"One impact of the human side is that rescue workers today refuse to consider fully autonomous systems designed to act as 'yes/no there's something down there' search devices." [1]

Trust and Coalitions

- *Trust* represents an agent's estimate of how likely another agent is to fulfill its cooperative commitments
- The risk of whether to cooperate, and with whom, may be determined by, among other things, the degree of trust
- As agents interact they can infer trust values based on their experience and, over time, improve their models of trustworthiness[2]

Trust and Coalitions

- A *coalition* is a group of agents that collaborate to perform a task that is generated as a response to an event that has occurred in the environment
- A *dynamic coalition* is one that is formed in response to an event and dissolved when that event no longer exists or when the tasks required to respond to that event are completed
- A coalition is necessary when an agent cannot respond to an event by itself due to lack of information, knowledge, functional capabilities, or other resources [3]

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Modeling Human-Robot Trust

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- To model the human-robot trust relationship, a model was created using the agent modeling language *NetLogo* [4]
- The model simulates an environment with random grass fires that need to be extinguished
- There are both human and robotic firefighters in the model
- The humans have a user-selectable initial trust level, that will change as the human agents call on the robotic rescuers and the robots succeed or fail in assisting the human firefighters
- The objective is to identify the factors (workload, fatigue, robot reliability, etc.) that assist humans in trusting robots

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Demo

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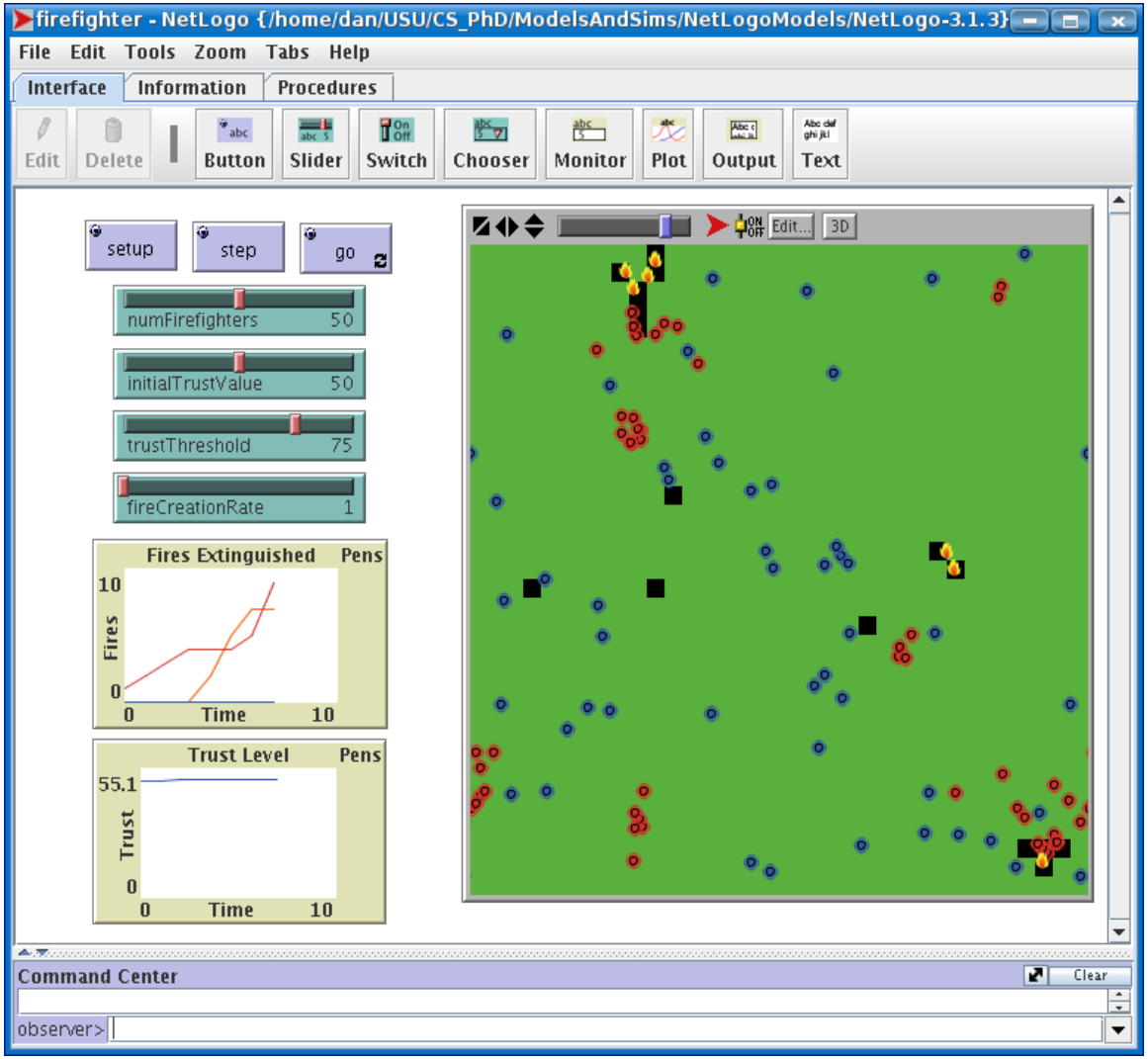

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Results

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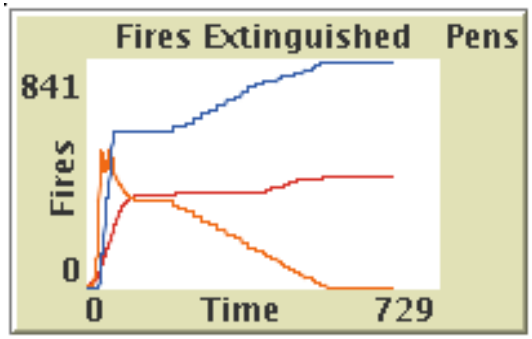
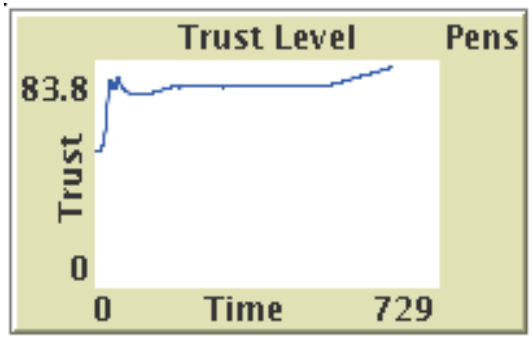
- These plots show the results of a typical simulation run
  - The top plot shows that the human firefighters (red) called on the robots (blue) when there were too many fires (orange) for them to handle; however, once the fires were under control, the humans didn't call on the robots again until the humans became fatigued
  - The bottom plot shows the corresponding fluctuations in the trust level
    - 50% was the initial trust level
    - 75% was the threshold for using robots





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The Next Step

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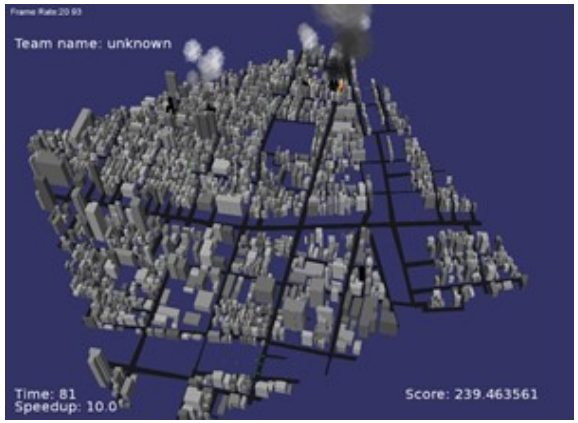
- NetLogo is a good tool for quickly generating a model, but a tool that supports a more complex scenario could improve the fidelity of the simulation results
- Toward this end, the next step after the NetLogo model is to model the trust relationship and coalition formation in the RoboCupRescue Simulation [5]



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Conclusion

- This project is still in progress and the results are still very preliminary
  - More work needs to be done, especially in investigating the various factors that affect the human-robot trust level
- It is hoped that this modeling will help with an understanding of the human-robot trust relationship and lead to better utilization of robots in hazardous environments in the future

Questions?

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References

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[1] R. Murphy (2004). "Rescue Robotics for Homeland Security," *Communications of the ACM*, special issue on Homeland Security, vol. 27, no. 3, March 2004, pp. 66-69.

[2] N. Griffiths and M. Luck (2003). “Coalition Formation Through Motivation and Trust,” in *Proceedings of the 2nd International Conference on Autonomous Agents and Multi-agent Systems (AAMAS 2003)*, Melbourne, Australia, pp. 17-24, ACM Press, July 2003.

[3] L.-K. Soh, C. Tsatsoulis, and H. Sevay (2003). “A Satisficing, Learning, and Negotiated Coalition Formation Architecture,” in *Distributed Sensor Networks: A Multiagent Perspective*, V. Lesser, M. Tambe and C. Ortiz (eds.), Kluwer Publishing, Chapter 7, pp.109-138.

[4] U. Wilensky (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL.

[5] RoboCupRescue Simulation. http://www.robocuprescue.org/rescuesimulation. html

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