Title: Intruder Chaser

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1 Project Goal

In this project, we aim to design, model and analyze a cat-and-mouse game[1] between robots. In this game there exist multiple chasers, the *guards*, and a single escaper, the *intruder*. The intricacies of this game, such as sensor-fusion and proximity-based interaction, find their application in automated security, context-aware computing, and the Internet of Things.

A key challenge in these types of applications and their dynamically evolving infrastructure infrastructure is that the distinction between "design time" and "run time" becomes blurred. Ensuring that different components and subsystems can be dynamically recombined yet still function properly requires, highly advanced development methodologies, models, and tools [3]. We will leverage one of these, namely accessors [2], which allow simulated components to be replaced by their real-world counterparts in composition with other components that continue to be simulated

2 Project Approach

We plan to develop this project on a strong mathematical foundation and a representative model of the environment and the robots. The research component of the project is in indoor localization. We plan to use the Machine Learning toolkit in Ptolemy II, developed by Ilge Akkaya and others, to improve the relative positioning data obtained from Bluetooth Modules installed on the robots using a particle filter. The distribution of the noise on the distance measures will be obtained experimentally and the particle filter will be tuned accordingly.

The model of the system and environment will be developed in Ptolemy II. If time permits, we plan to explore different models of the robot with incrementally increasing expressiveness or freedom:

- Freedom to move only in predefined trajectory;
- Freedom to move anywhere in the environment but with constant speed;
- Freedom to move anywhere in the environment but with variable speed.

We aim to start with a simple environment, which may be an empty space, to more interesting ones represented as a grid with obstacles.

We may also experiment with different variants of the game. In one game the prime objective for the guards may be to protect and asset or critical section from entry by the intruder, whereas in another game the goal may be to chase and capture the intruder. We plan to demonstrate the experiment on the iRobots available in the National Instruments Lab, Berkeley. We intend to show a demo that features five centrally coordinated, concurrently operating robots.

3 Resources

We plan to use the iRobot along with the BeagleBone platform, augmented with a WiFi and Bluetooth module. On the BeagleBone Black we have an ensemble of sensors to our disposal, including an accelerometer and a compass. On the robots we have bump- and IR-sensors to detect obstacles. For communication between the robots we use Bluetooth, and we expose a sensing and control interface through a Web service accessible through WiFi. This service will be wrapped in an accessor to expose an actor interface that is importable in Ptolemy II. On the software side we will work a standard Web-stack (including node.js) on the BeagleBone boards, and with Ptolemy II to build our controller. If time permits, we might use verification tools like SpaceEx, CybOrg to prove timing properties of the robots.

[1]A contrived action involving constant pursuit, near captures, and repeated escapes.

4 Timeline

The project covers a span of 7 weeks (4th week of October - 2nd week of December). An estimated timeline for the project would be as follows:

Timeframe	Work Plan
October 21:	Project charter
October 28:	Literature survey on particle filters, SLAM techniques, Bluetooth signal characterizations, and experimental setup design.
November 4:	Ptolemy model, first experimentation with simulation of iRobot.
November 11:	Installed software for deployment of iRobot: drivers for WiFi and Bluetooth, web interface for actuation and control through accessor.
November 18:	Mini project update: demonstrate Ptolemy model and in-the-loop simulation with accessors.
November 25:	Assess location and proximity accuracy, modify simulation model.
December 2:	Deploy multiple iRobots, experiment with different strategies.
December 9:	Evaluate the soundness and fidelity of our model, improve where possible.
December 16:	Demonstration video made, presentation prepared.
December 17:	Final presentation and demo.
December 19:	Project report and video turned in.

5 Risk and Feasibility

This project depends on several hardware components such as the sensors on the iRobot and BeagleBone and external Bluetooth and Wireless adapters, all of which may malfunction or behave unreliably in unexpected ways. In our previous experiences with this kind of hardware, the first major hurdle is to establish proper hardware support through the appropriate device drivers. After that, issues are likely to arise with interfacing the iRobot and the Beaglebone, collection of RSSI measurements between our Bluetooth devices, and closing the feedback loop between our control logic over a wireless network that may suffer from arbitrary network delays. Such network problems, along with computational delays suffered from using the particle filter, are likely to pose an upper bound on the operation speed of our robots in order for them to behave reliably. In our model we may have to resort to aspect-oriented modeling to account for network latency in pre-deployment stage [1]. In general, it will be a major challenge to model the environment in the simulator, because of which we often see a marked difference between the simulator and the physical world.

References

[1] I. Akkaya, P. Derler, and E. A. Lee. Aspect-oriented fault modeling and anomaly detection in ptolemy ii, November 2013. Presented at the ¡a href=”http://ptolemy.org/conferences/13” ¿10th Biennial Ptolemy Miniconference¡/a¿, Berkeley.

[2] E. Latronico, E. A. Lee, M. Lohstroh, C. Shaver, A. Wasicek, and M. Weber. A vision of swarmlets. *TBD: A Suitable Magazine, Journal, or Conference*, 2014.

[3] E. A. Lee, J. D. Kubiatowicz, J. M. Rabaey, A. L. Sangiovanni-Vincentelli, S. A. Seshia, J. Wawrzynek, D. Blaauw, P. Dutta, K. Fu, C. Guestrin, R. Jafari, D. Jones, V. Kumar, R. Murray, G. Pappas, A. Rowe, C. M. Sechen, T. S. Rosing, B. Taskar, and D. Wessel. The terraswarm research center (tsrc) (a white paper). Technical Report UCB/EECS-2012-207, EECS Department, University of California, Berkeley, Nov 2012.