Title: Embedding Swarm on Bluetooth-enabled Bipedal Robots with Multiple Modalities

Authors: Tarek A. El Doker, Ian J. Rich, Josh T. King, Brian H. Adams, and James E. Holmes, Machine Perception Laboratory, Northern Arizona University
Tarek.ElDoker@nau.edu

Abstract:

The design and implementation of a bipedal robotic swarm, based on the Robosapien platform is described. Every robot acts as an agent in a swarm, with a number of embedded subsystems on-board the robot incorporating both software and hardware modules. The agent state machine is comprised of various discrete states that are quite simple, relative to the complexity of the design itself. Discrete states include: navigate, seek, identify doors, identify fires, exit from room, etc... This is in keeping with tenants of agent-based modeling and design, namely to maintain less complex agent decision-making, while still allowing for emergent behavior.

Hardware modules include:

- Bluetooth (B/T) dongle
- TI OMAP 5912 chip
- Camera module Omnivision VGA CMOS camera
- SONAR module Devantech SRF-08
- Optical navigational module ADNS-2051 (web camera with a modified focal length)
- IR hack module

Software modules include:

- B/T communication module
- Autonomous navigation module
- Streaming video module
- Optical analysis module

Information is comprised of a proximity map, developed through a SONAR sweep combined with video analysis, and optical positional tracking. Decisions are made based upon the fusion of knowledge from these various modalities, per the robot state machine.

As an application, this robotic swarm is used to fight fires in a mock-up urban environment. Fires are emulated by candles being lit in various rooms. Robots have to navigate through a mock-up city block, identify and open doors, and then successfully detect and classify a fire. Fires can be classified, according to their size, into three main categories: category one, two and three. The last two categories require robots to swarm together, collaboratively extinguishing the fire. Results show that a robotic swarm system can be very efficient in such attempts, especially that robots inherit inter-agent information and can successfully collaborate on problem solving. More importantly, this work illustrates how multi-modal data fusion (camera, sonar, optical navigation) allows for better swarming, and a more efficient, simpler state space, given the constraints of the problem in an agent-based setting.