MONASH University
Department of Electrical and Computer Systems Engineering

ECE4045 Project B Semester 2, 2012

Graph Theory Based Formation Control

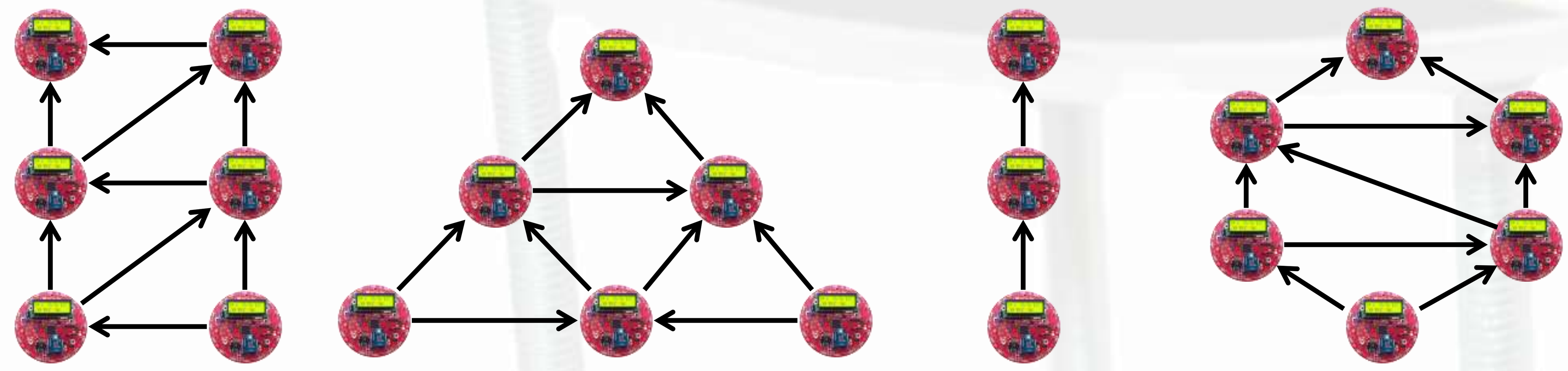
Whye Leon SENG
Dr. Jan Carlo Barca & Dr. Ahmet Sekercioglu

In this project a novel adaptive formation control algorithm for wireless mobile robot networks has been created. The algorithm allows a robot network to preserve its formation in the presence of obstacles. Performance of the algorithm has been tested on WSRNLab's eBug-II system[1][2].

PURPOSE

The increasing awareness of safety, coupled with technological advancement, have pushed for the development of automated multi robot systems to replace humans in critical missions such as reconnaissance and search & rescue, where human lives can be at stake.

IMPLEMENTATION



Rectangle Formation | Triangle Formation | Line Formation | Circle Formation

The formation control algorithm is based on a local leader-follower approach[3]. Application of graph theory in forming minimally rigid formations (i.e. the formations are no longer rigid with the loss of any edge) helps minimizing inter-robot communications.

Followers are each assigned to a formation position, along with the corresponding angle and distance constraints from the local leaders. These constraints are utilized by the control system to maintain the formation without the use of global information.

Obstacle avoidance involves 3 stages:

Potential field based obstacle avoidance

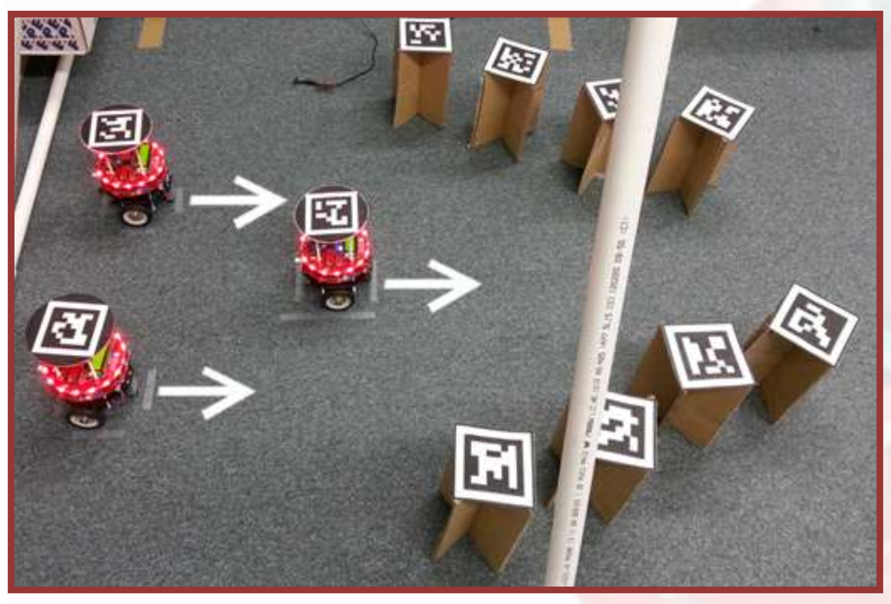
Repulsive forces generated by potential fields push the eBugs away from obstacles.

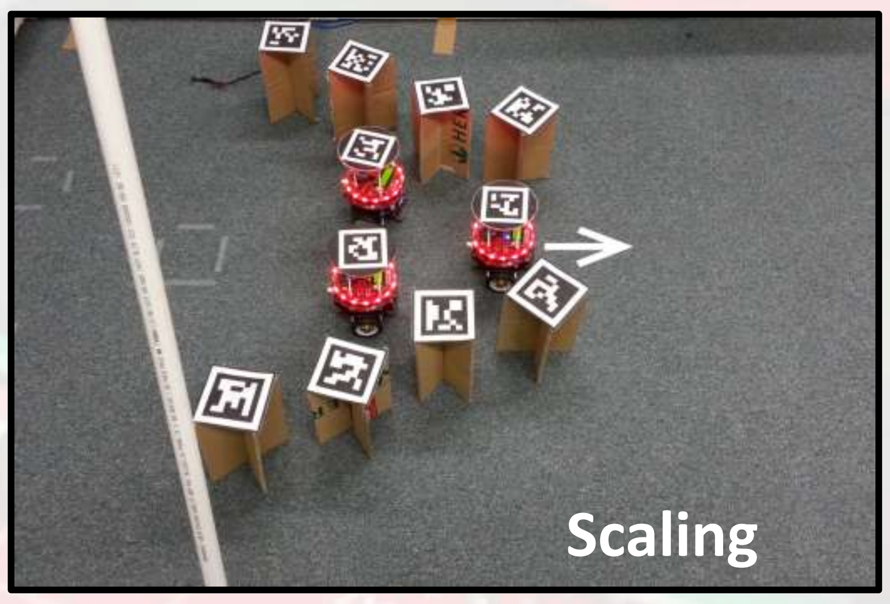
Formation Scaling

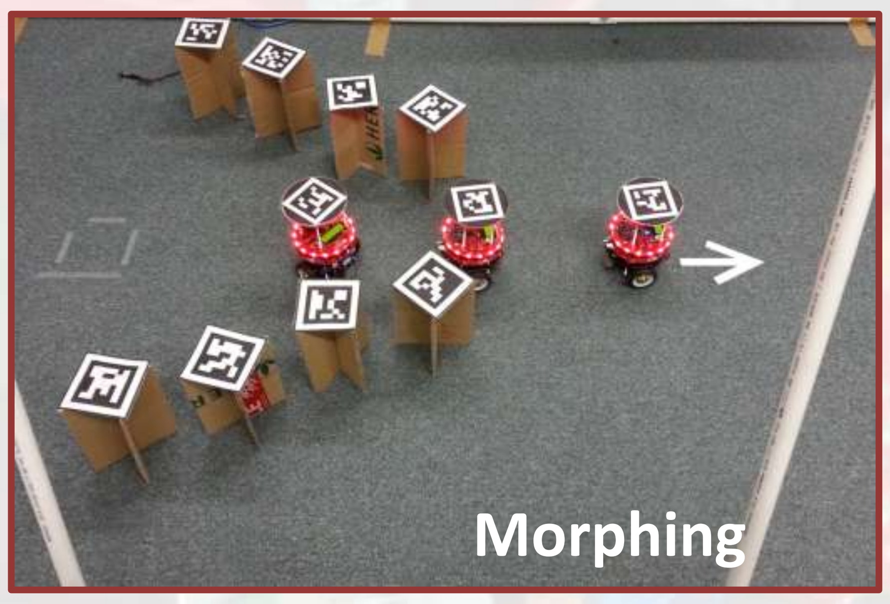
Formation scales down in size whenever obstacles are detected.

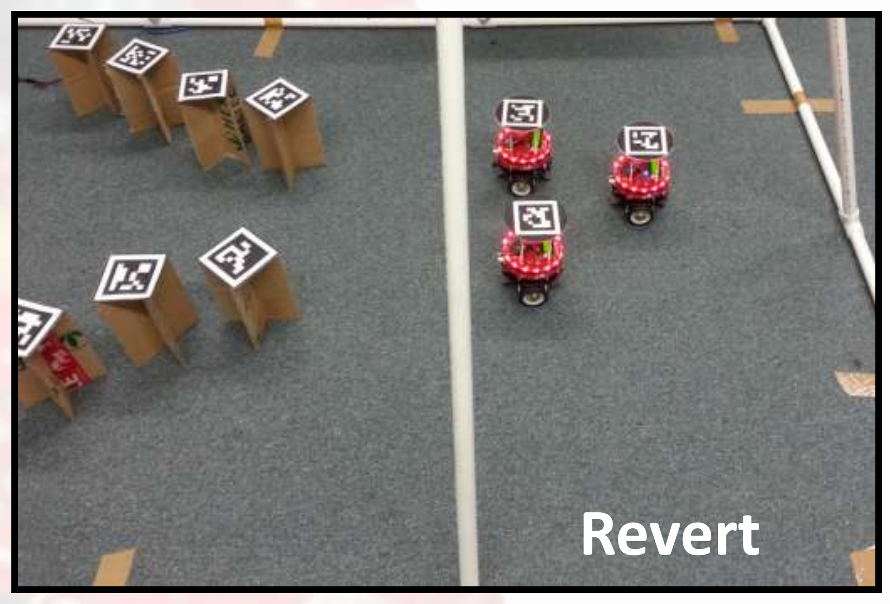
Formation Morphing

When the original formation no longer takes shape, a new formation will be chosen based on the current positions of the eBugs.

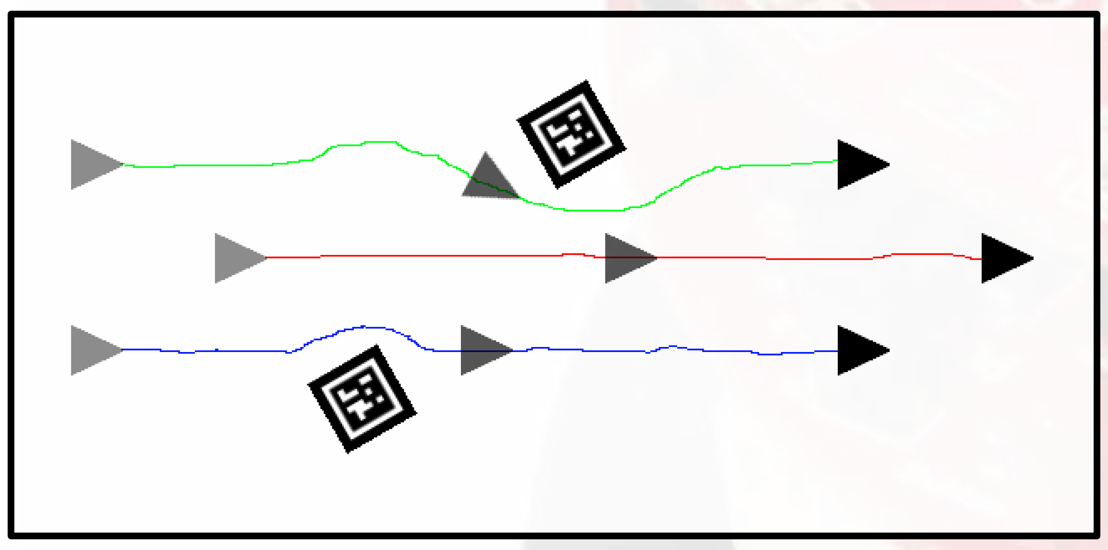


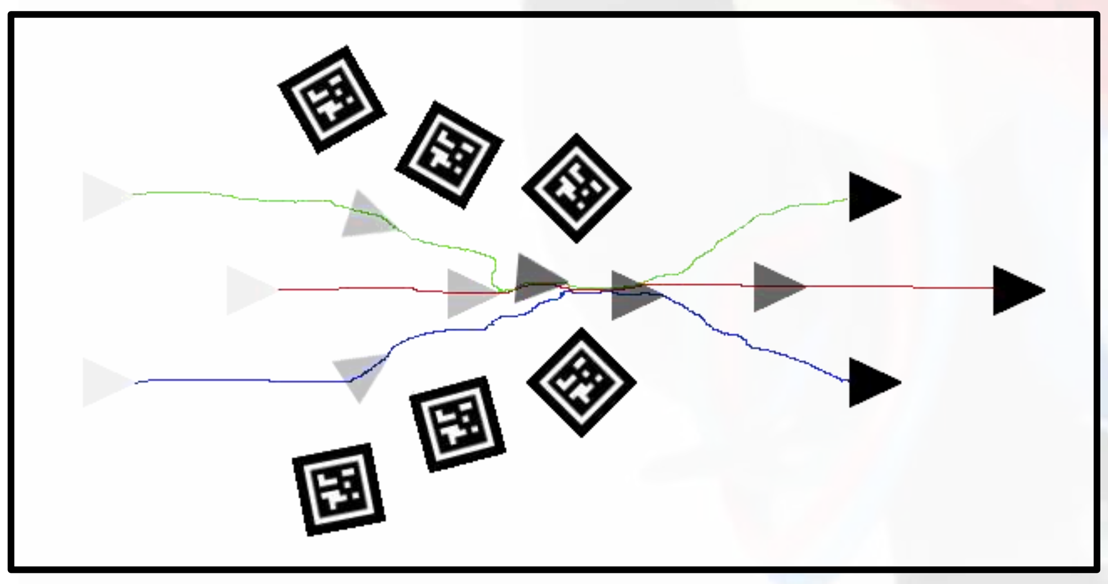


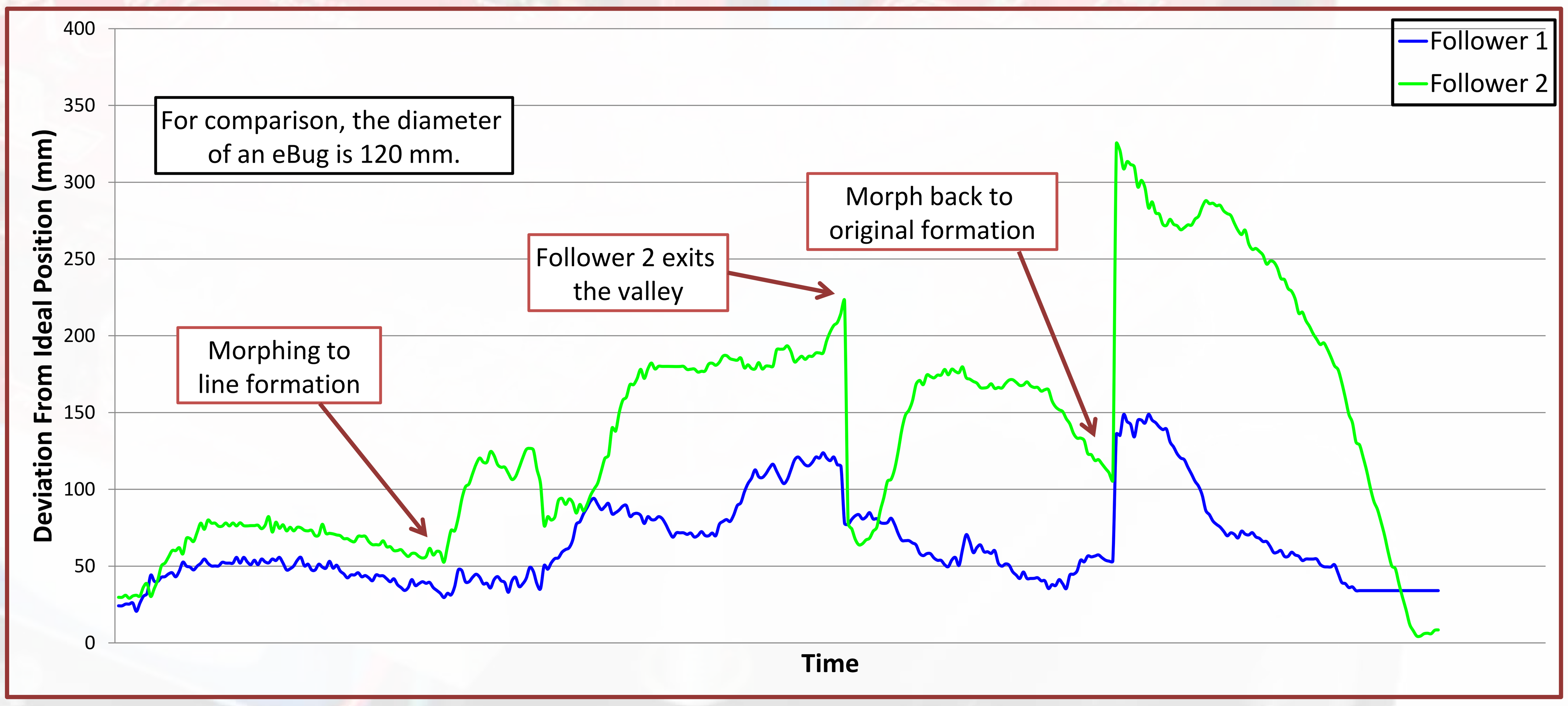




OPERATION AND RESULTS







Results show that the followers are on average 101 mm away from the ideal position, which is less than the diameter of an eBug. It also demonstrates that the eBugs are able to navigate through environments with obstacles without any collisions.

FUTURE WORK

Implementation of morphogenesis based formation generation[4][5] will increase the scalability of the system, as the constraints for every formation position do not need to be determined manually. The algorithm will also be implemented onto another multi robot system with capabilities to perform self localization instead of relying on the overhead camera as in the eBug system.

REFERENCES

[1] http://wsrnlab.ecse.monash.edu.au/
[2] N. D'Ademo, W. L. D. Lui, W. H. Li, Y. A. Sekercioglu and T. Drummond, "eBug - An Open Robotics Platform for Teaching and Research", Australasian Conference on Robotics and Automation (ACRA 2011), Melbourne, Australia, December 2011.
[3] J. C. Barca, Y. A. Sekercioglu and A. Ford, "Controlling Formations of Robots with Graph Theory", The 12th International Conference on Intelligent Autonomous Systems (IAS'12), Jeju Island, Korea, June 2012.
[4] J. C. Barca, E. E. Lee and A. Sekercioglu, "Flexible Morphogenesis based Formation Control for Multi-Robot Systems", to appear in: International Journal of Robotics and Automation (IJRA), March 2013.
[5] Y. Jin, and Y. Meng, "Morphogenetic Robotics: An Emerging New Field in Developmental Robotics," IEEE Trans. on Systems, Man and Cybernetics, Part C: Applications and Reviews, vol. 41(2), pp. 145-160, 2010.