



# BIEN 2011

## **Synthetic Flocking and Bioinspiration**

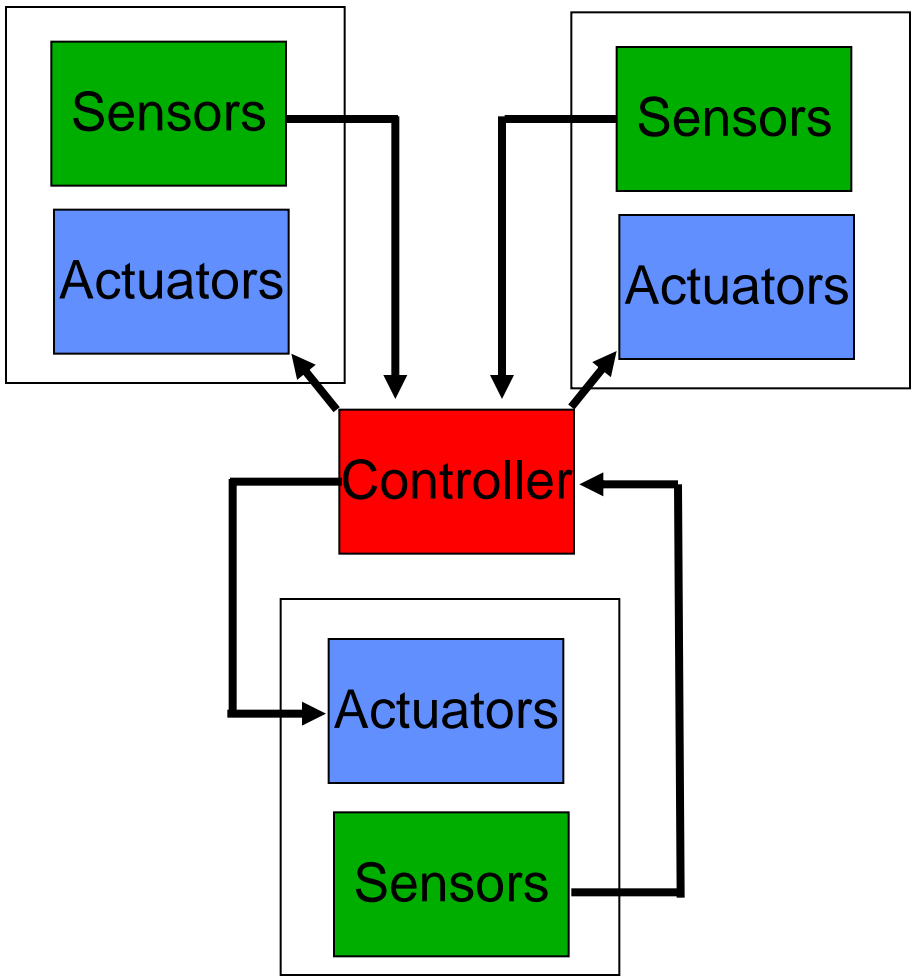
Benjamin D. Flom

Mentors: Biswadip Dey, Kevin S. Galloway

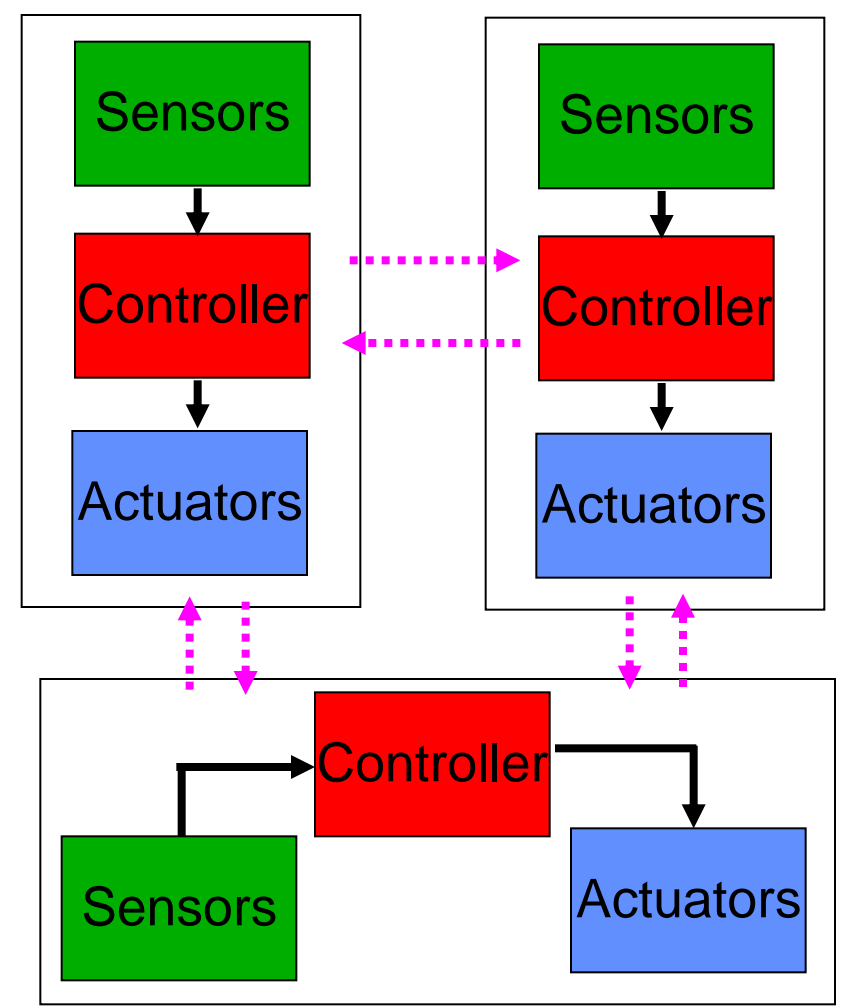
Prof. P.S. Krishnaprasad

Intelligent Servosystems Lab

# Central vs. Distributed Control



**Central Control**



**Distributed Control**



# Engineering Applications

- Multi-agent Systems
  - Search and Rescue
  - Self-assembly
  - Intelligence
  - Space Colonization?



<http://www.outerspaceuniverse.org/ice-water-discovered-moon-lcross-successful.html>



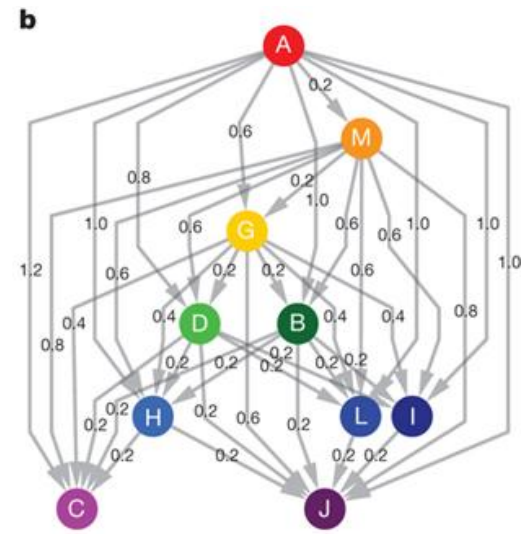
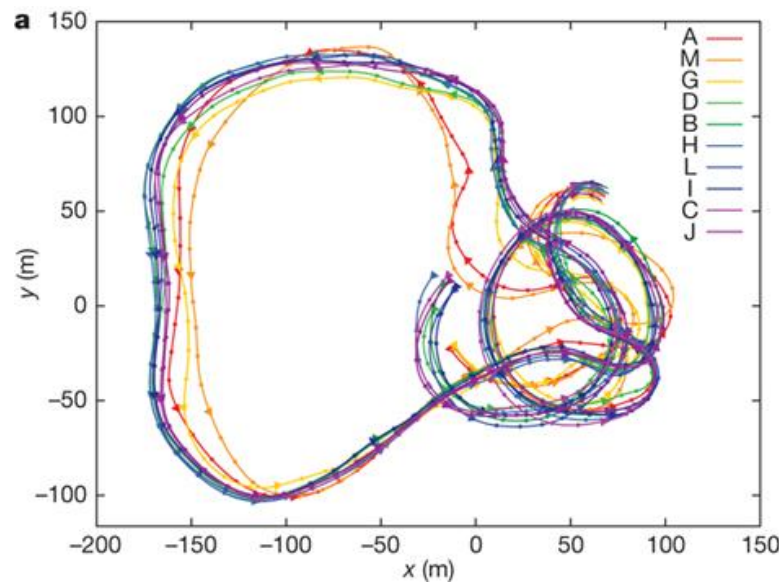
<http://aquariumprosmn.com/2010/01/460/>



<http://www.pbs.org/wgbh/nova/sciencenow/3410/03-ever-01.html>

# Pigeon Flock Experiment

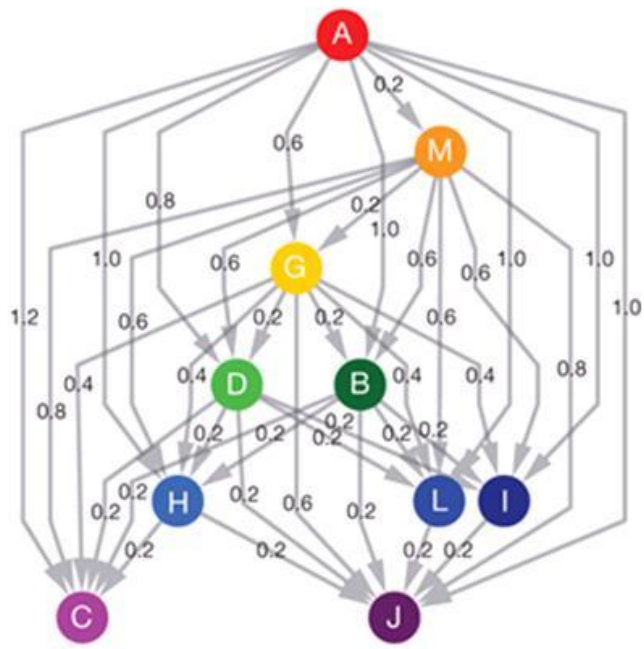
- 10 Pigeons
- GPS Sensors
- Evidence of Hierarchy



Nagy M, Ákos Z, Biro D, Vicsek T: Hierarchical group dynamics in pigeon flocks, *Nature* **464**, 890-893 (2010).

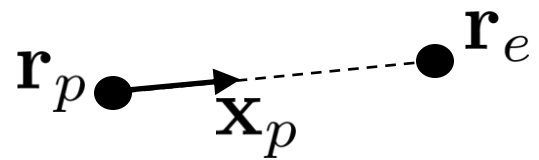
# Project Objectives

- Understand how state of a follower evolves as a function of the state of its leader(s)
- What **pursuit strategy** governs the individual behavior which leads to collective flocking

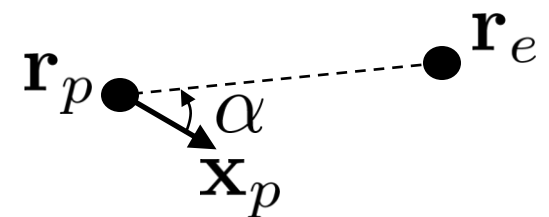


# Pursuit Strategies

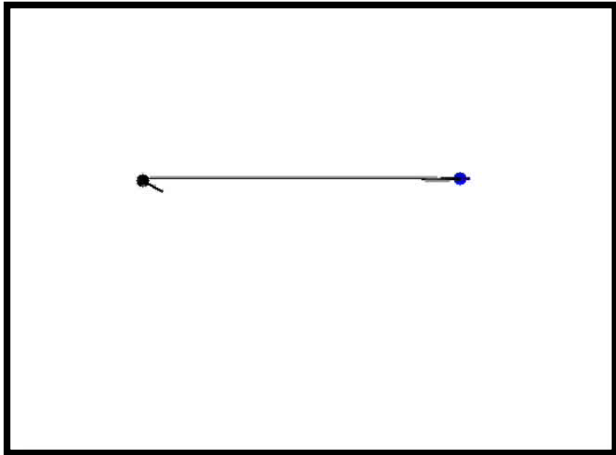
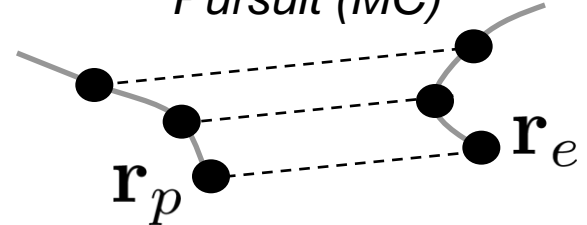
Classical Pursuit (CP)



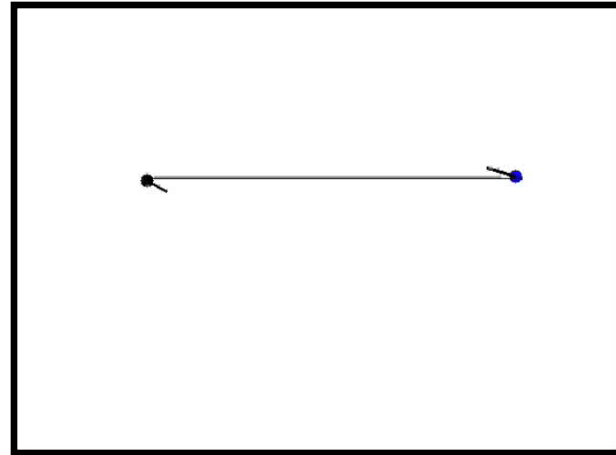
Constant Bearing Pursuit (CB)



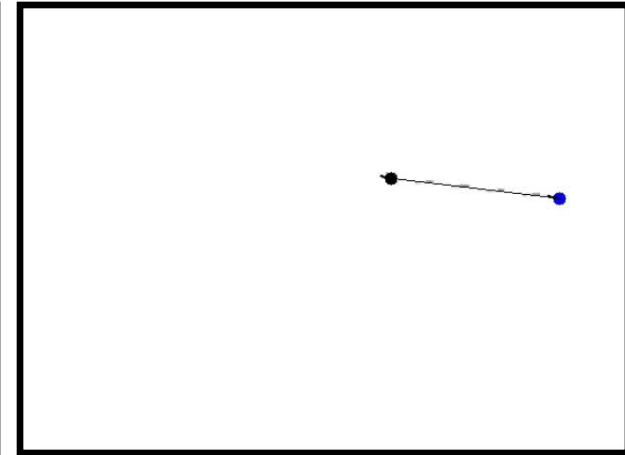
Motion Camouflage Pursuit (MC)



E.g. pair of bats (*Eptesicus fuscus* Beauvois) chasing the same prey [1]

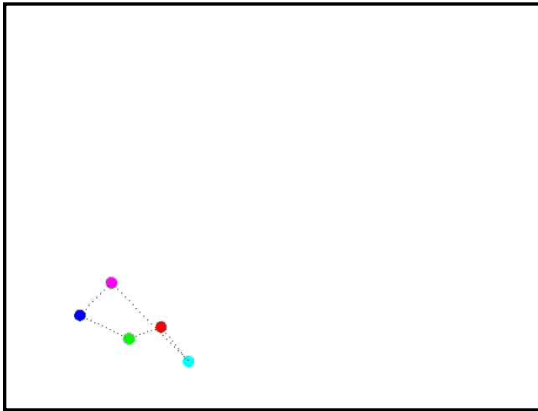


E.g. falcons (*Falco peregrinus*) intercepting prey [2]

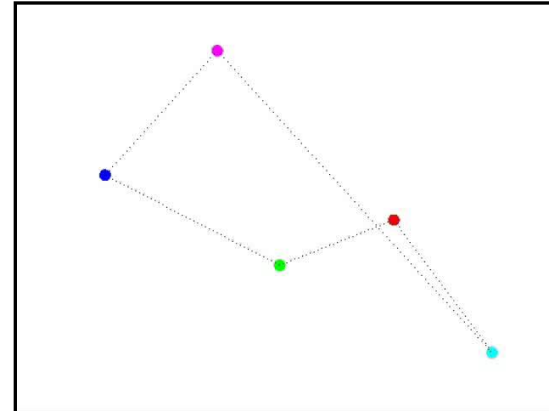


E.g. bats intercepting prey [3]

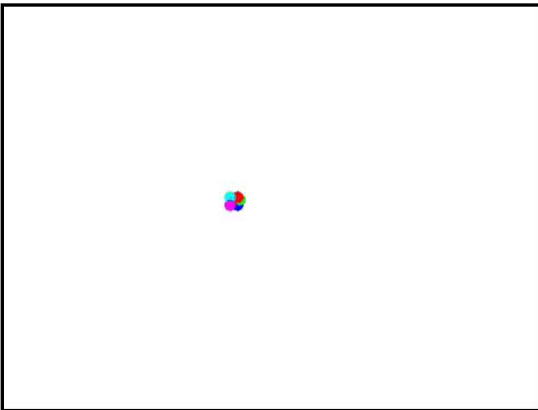
# CB-Pursuit Driven Collectives



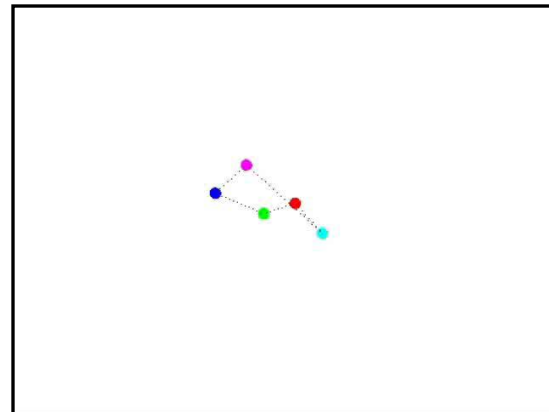
Rectilinear



Circling



Expansion



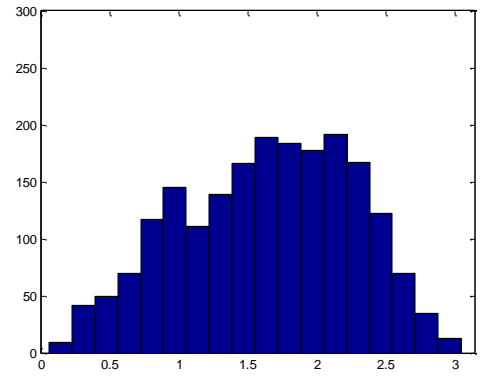
Shape-preserving spiral



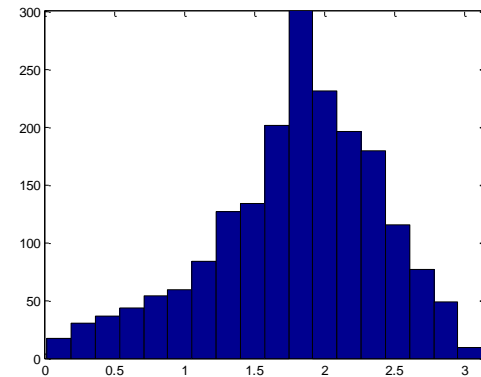
# Preliminary Results

M pursuing A

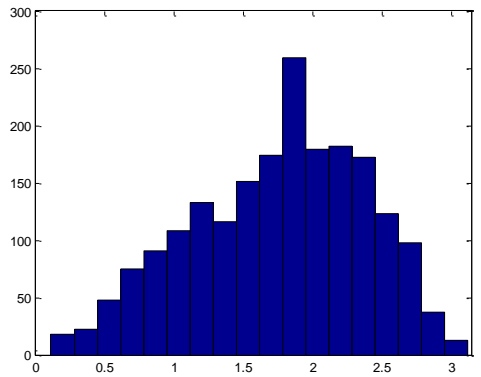
Number of samples in bin



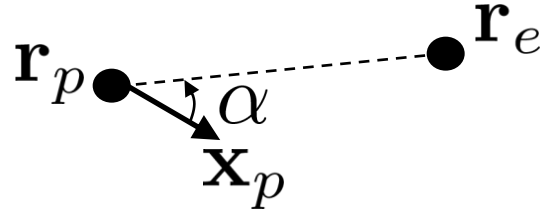
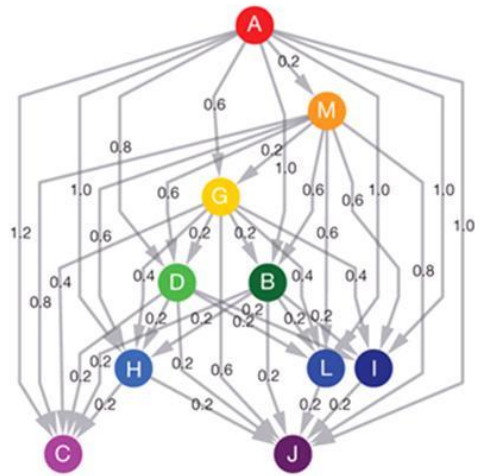
M pursuing I



M pursuing G



Bearing angle



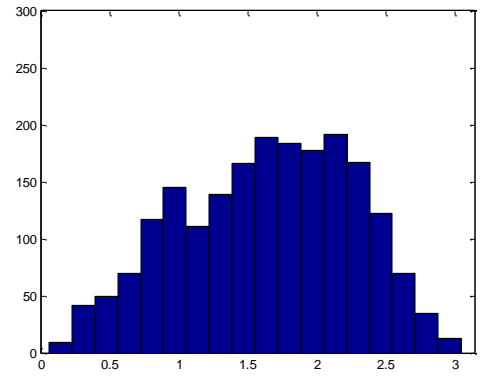
- Evidence supporting CB pursuit consistent with Nagy hierarchy not strong
- Suggests possible alternative hierarchy, where followers do not have unique leader



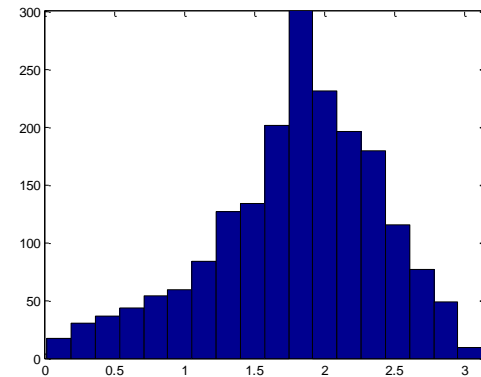
# Preliminary Results (cont.)

## M pursuing A

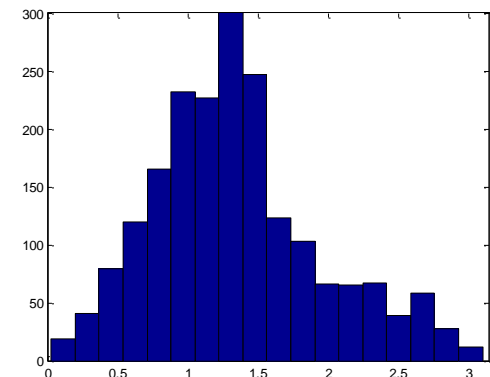
Number of samples in bin



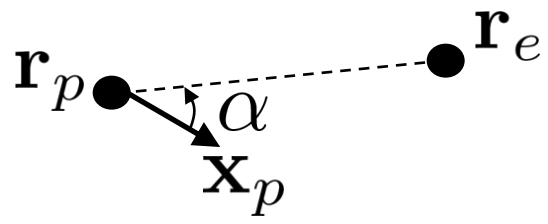
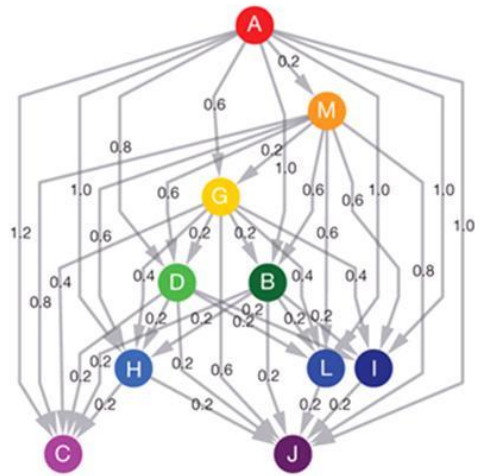
## M pursuing I



## I pursuing M



Bearing angle



- Suggests possible role-switching between leader and follower
- Reduce drag? Such as bicyclists in competition?



# Conclusion

- Preliminary results suggest that CB pursuit hierarchy not necessarily consistent with Nagy et al. hierarchy.
- Follower might not follow same leader for entire flight.
- Leader-follower roles may switch during flight.

## Acknowledgments

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- Unofficial mentors: Matteo Mischiati, Prof. Abshire
- BIEN Colleagues



# References

- [1] C. Chiu, P. V. Reddy, W. Xian, P. S. Krishnaprasad, and Cynthia F. Moss (2010). Effects of competitive prey capture on flight behavior and sonar beam pattern in paired big brown bats, *Eptesicus fuscus*, *The Journal of Experimental Biology*, Vol. 213, Issue 19, 3348-3356.
- [2] V. A. Tucker, A. E. Tucker, K. Akers, and J. H. Enderson, “Curved flight paths and sideways vision in peregrine falcons (*Falco peregrinus*),” *J. Exp. Biol.*, Vol. 203, pp. 3755-3763, 2000.
- [3] K. Ghose, T. K. Horiuchi, P. S. Krishnaprasad and C. F. Moss (2006). Echolocating bats use a nearly time-optimal strategy to intercept prey. *PLoS Biol.* 4, 865-87.