Exploring individual interactive mechanism of pigeon flocks

——following leaders or neighbors?

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- Collective Motions in Nature
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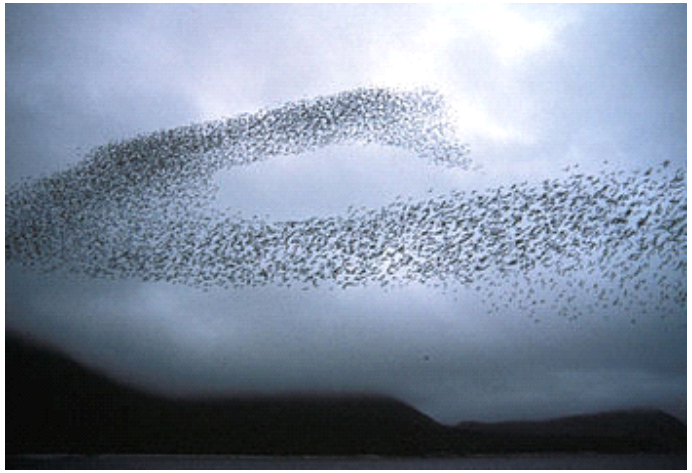
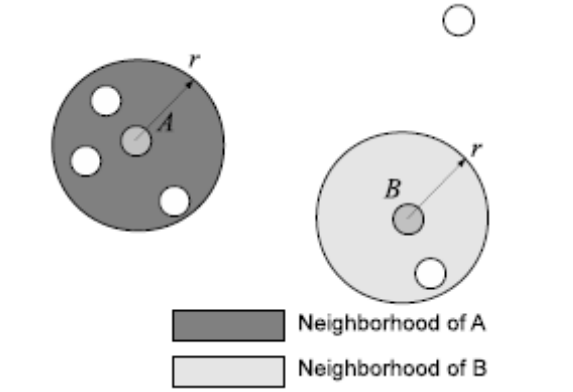
Collective Motions in Nature

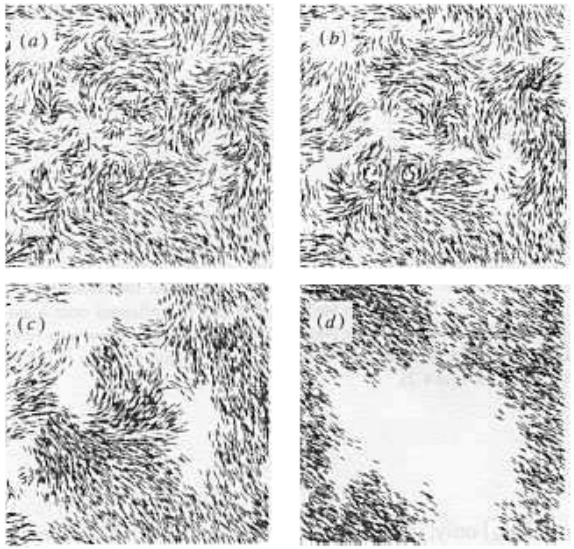


T. Vicsek, A. Zafiris, Phys. Rep. 2012

Neighborhood-Dominating Mechanism

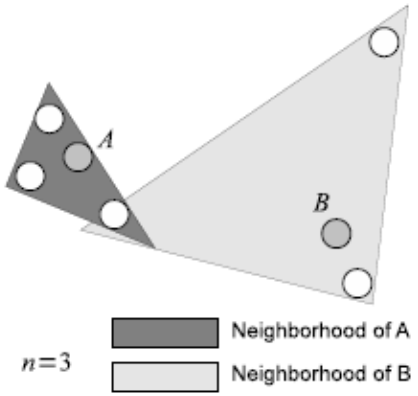
- Fixed Neighboring Region (FNR, Geometry)

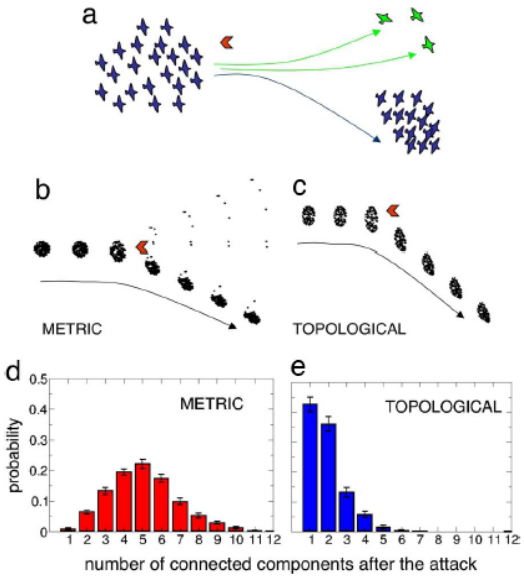




T. Vicsek,et al., PRL 1995

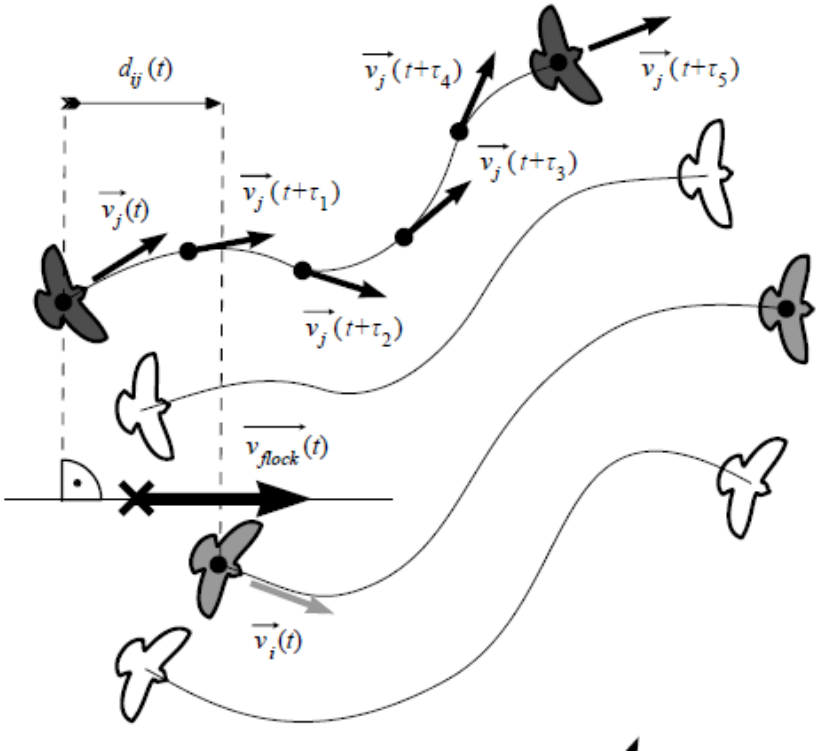
- Fixed Number of Neighbors (FNN, Topology)



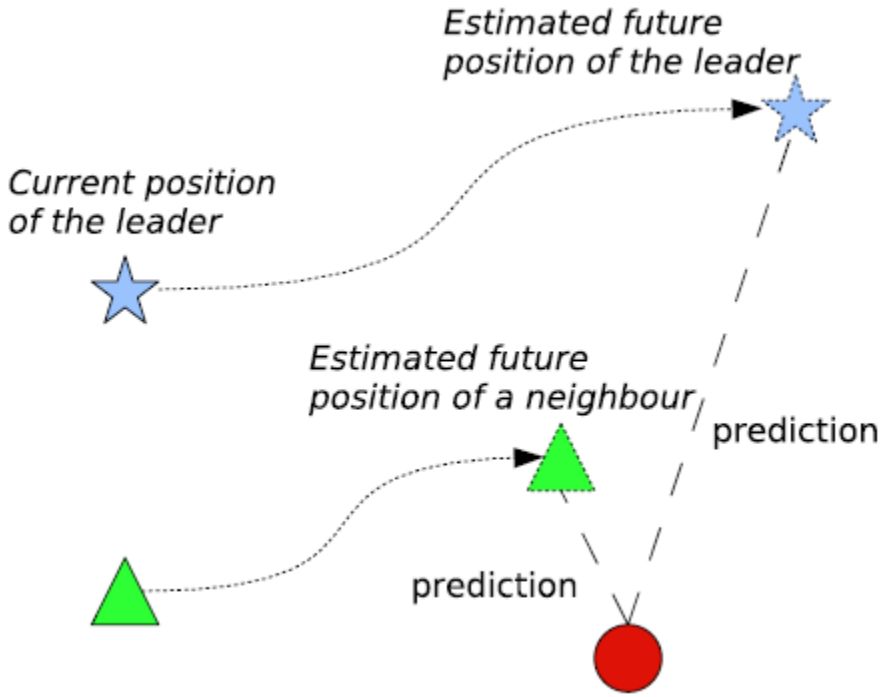


M. Ballerini,et al., PNAS 2008

Leadership-Dominating Mechanism



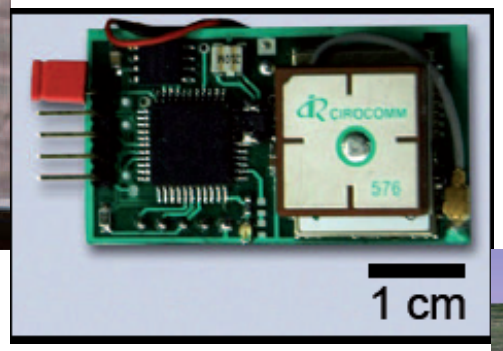
M. Nagy,et al., Nature 2010



H.-T. Zhang, et al., IEEE CAS Magazine 2008
H.-T. Zhang, et al., EPL 2008
H.-T. Zhang, et al., PRE 2009

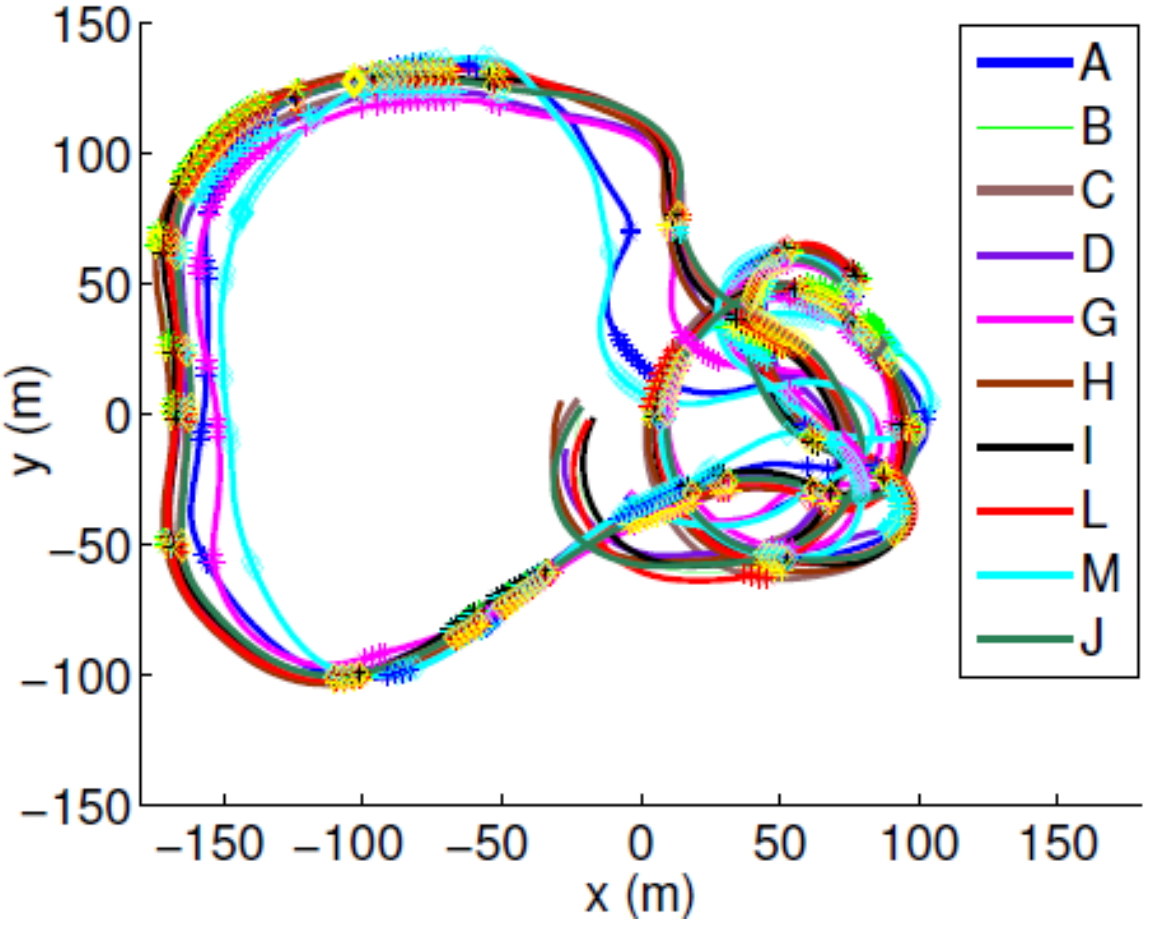
Experimental Data

10 pigeons, 14.8km, 11 flights and on average 12 minutes,
32h of flight time and 580,000 data points for every 0.2s.

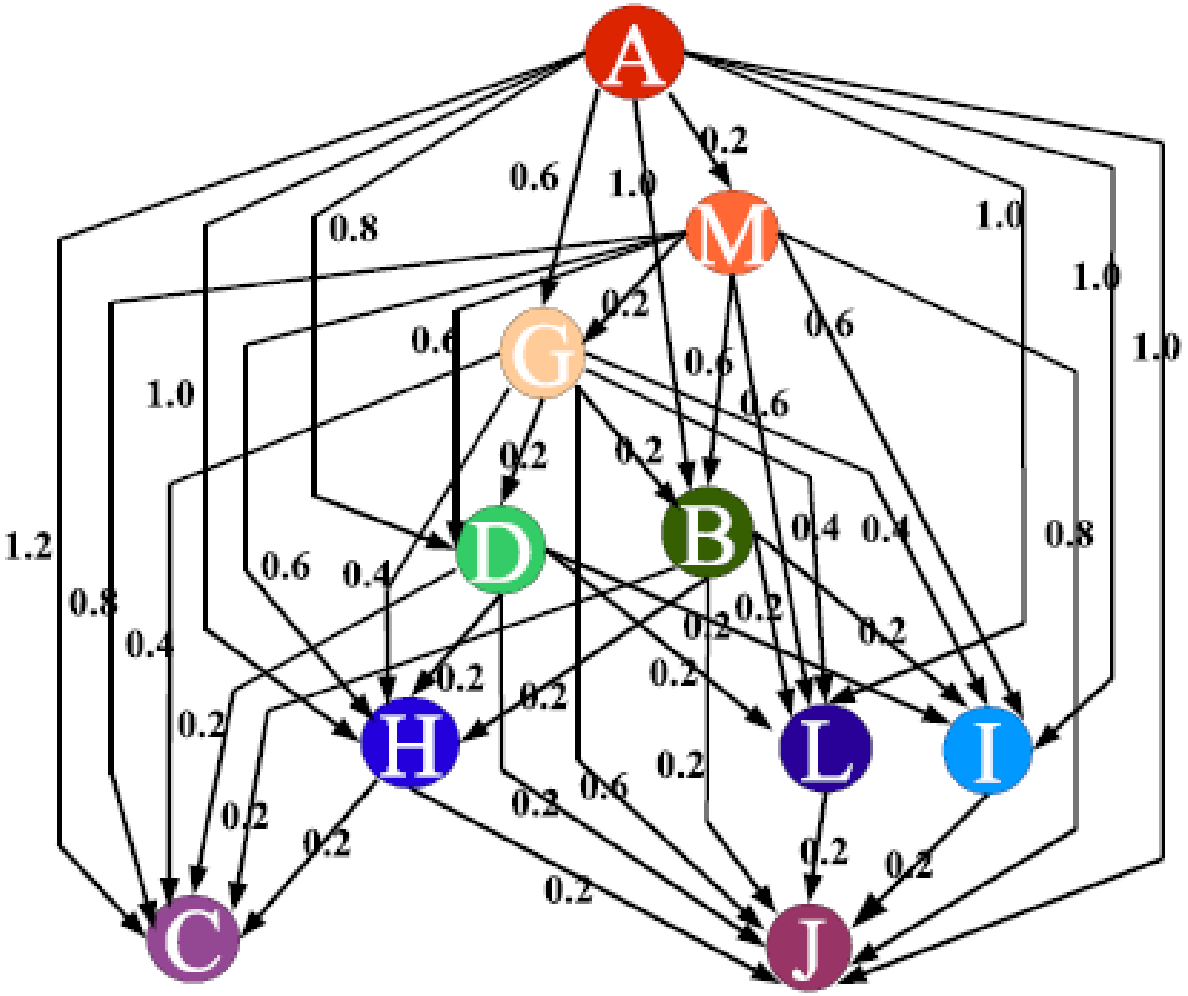


M. Nagy,et al., Nature 2010

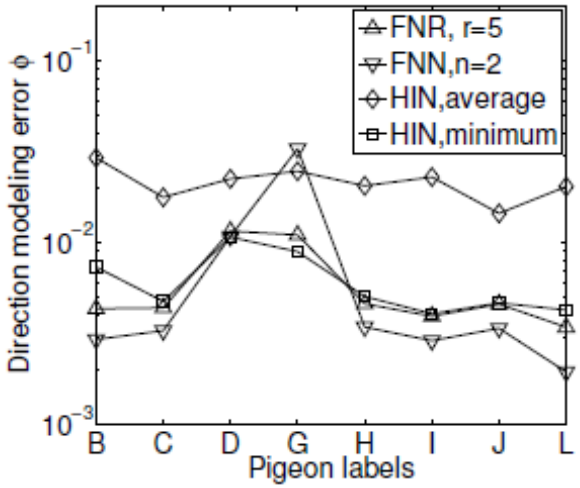
Trajectories



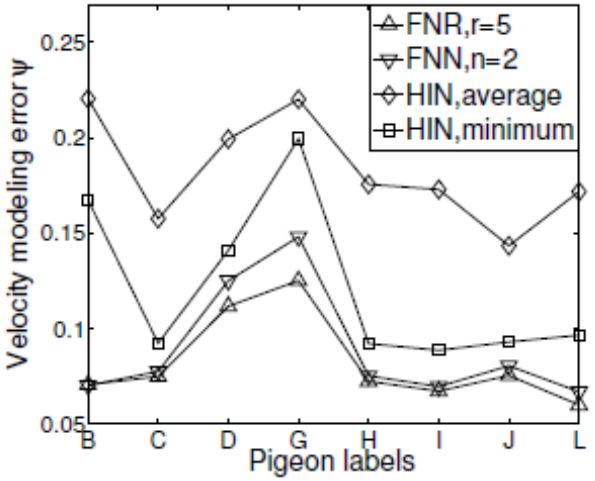
Hierarchical leadership network



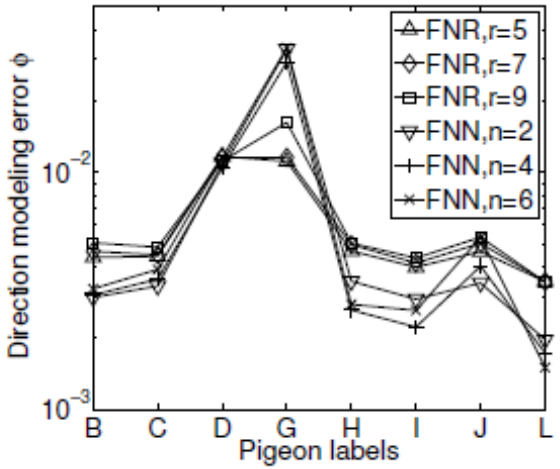
Modeling Errors

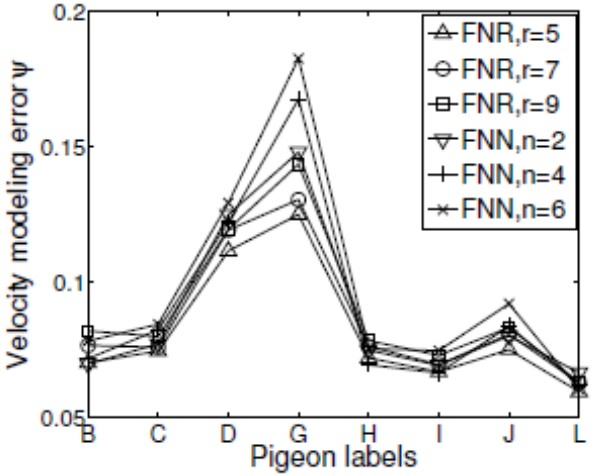


(a)

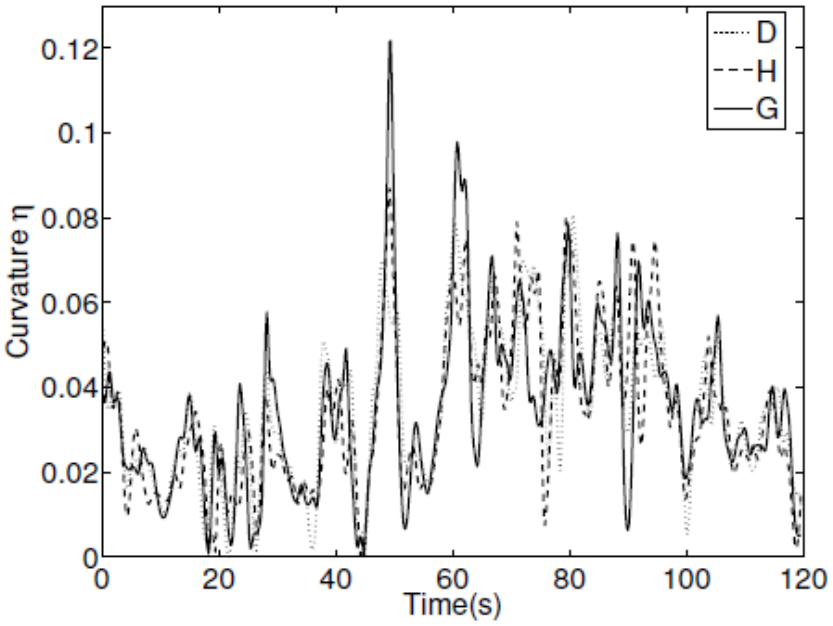


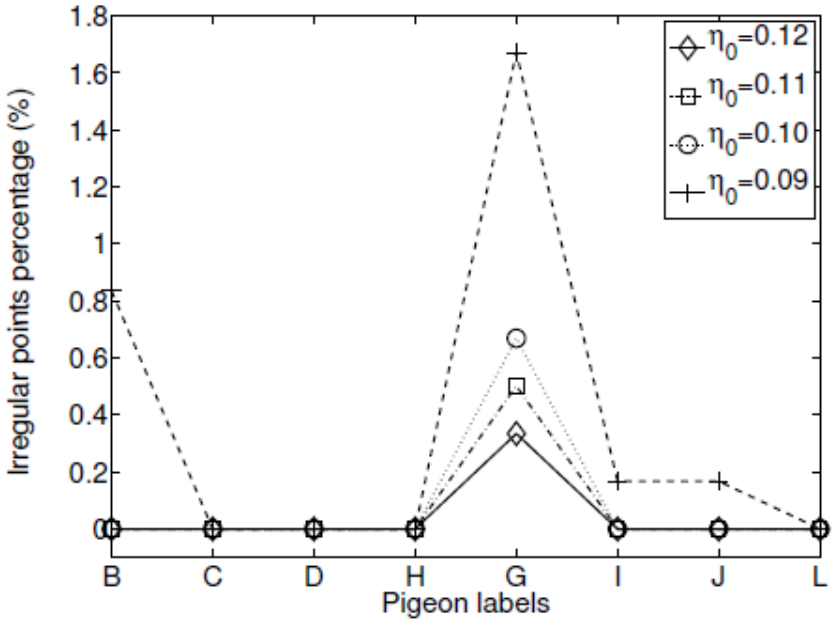
(b)



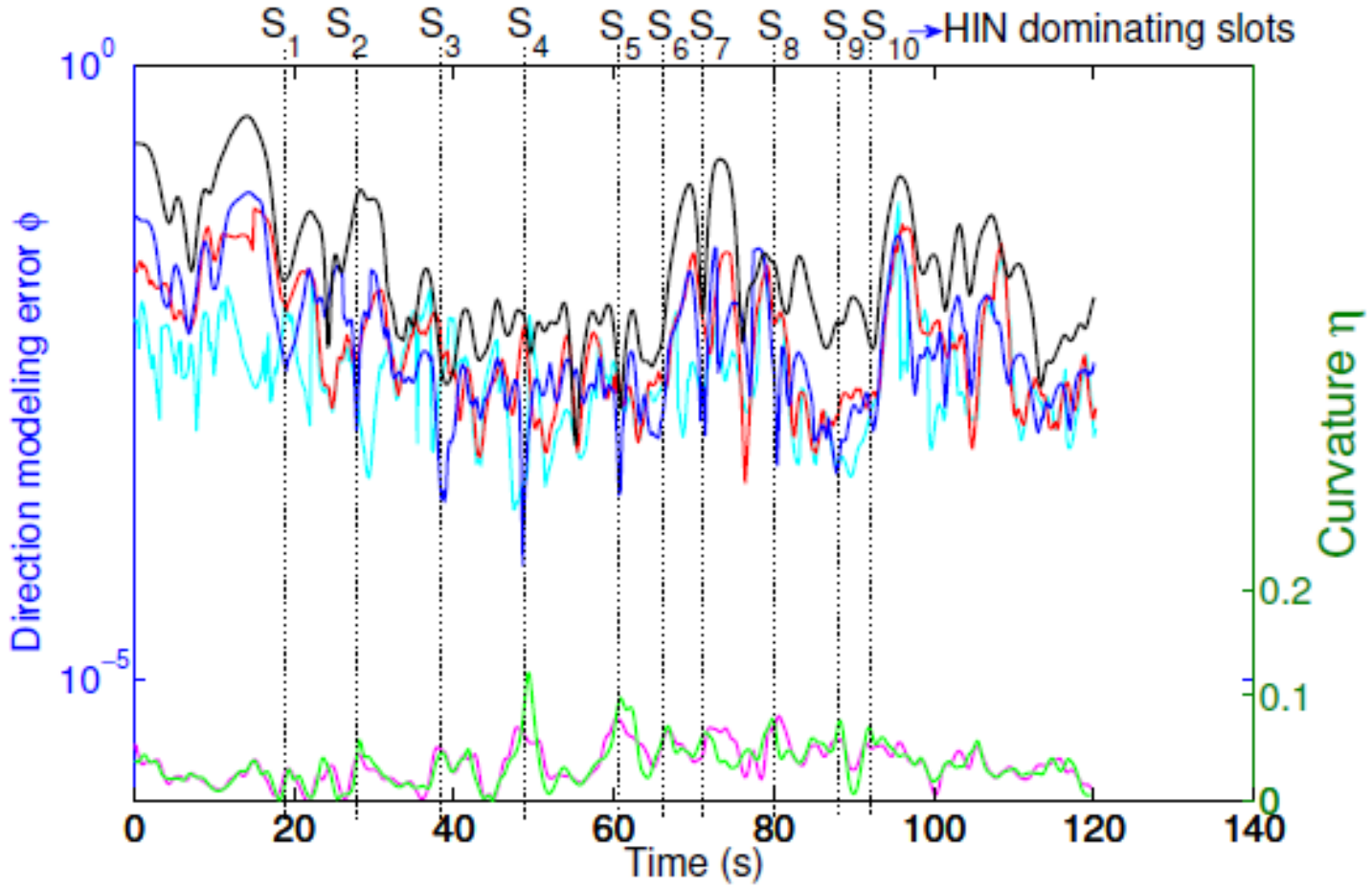


Why G is different?



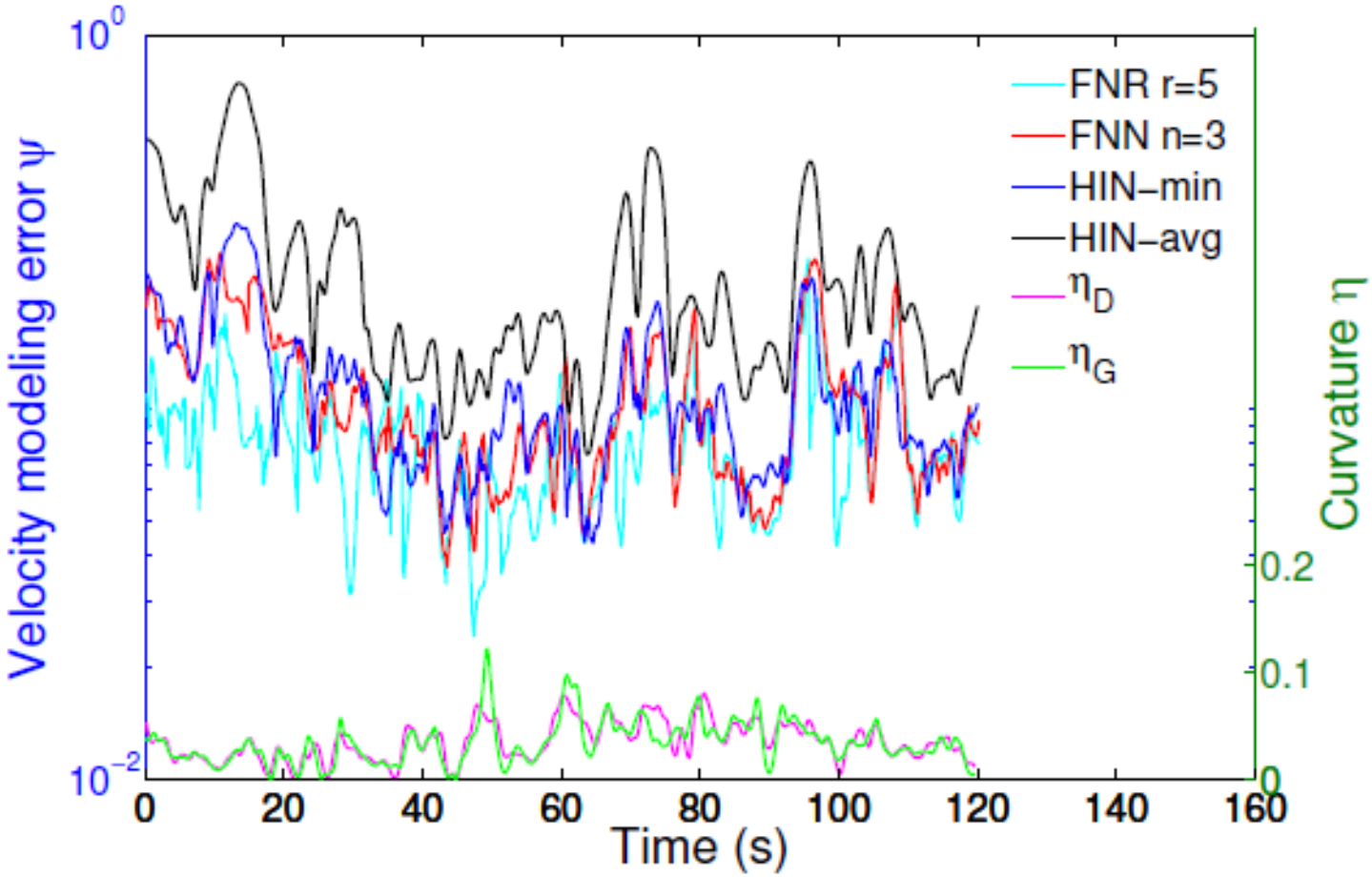


Comparing Two Mechanisms



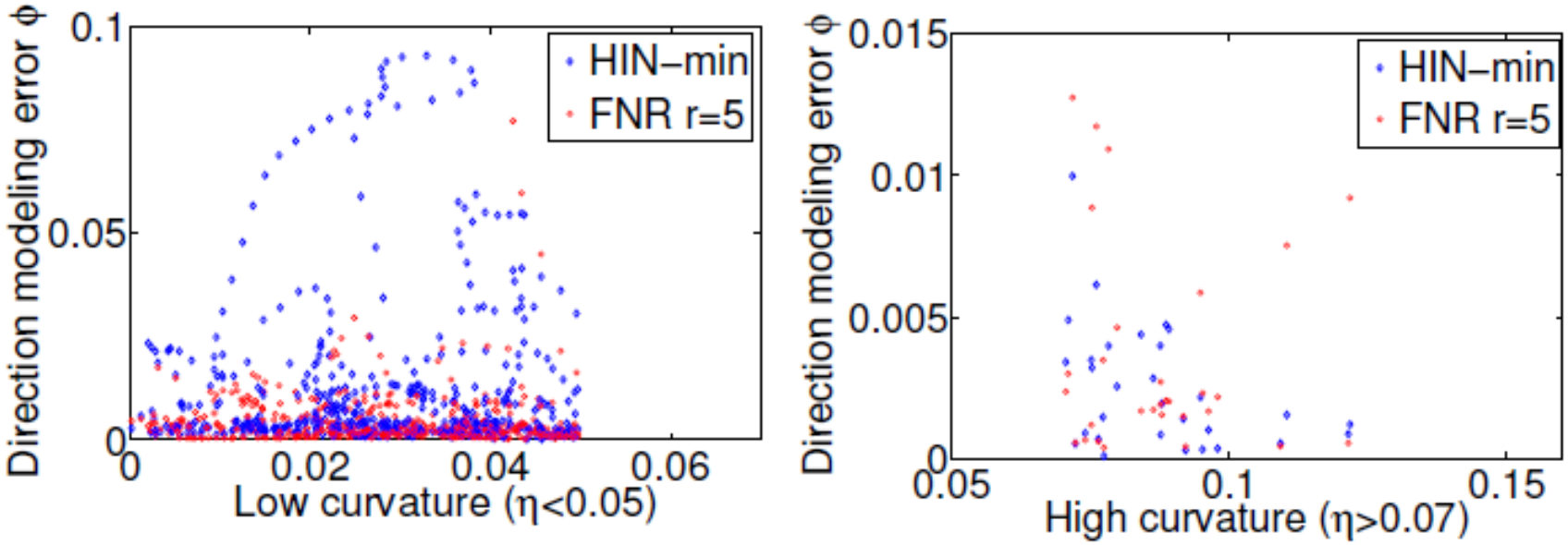
For direction

Comparing Two Mechanisms

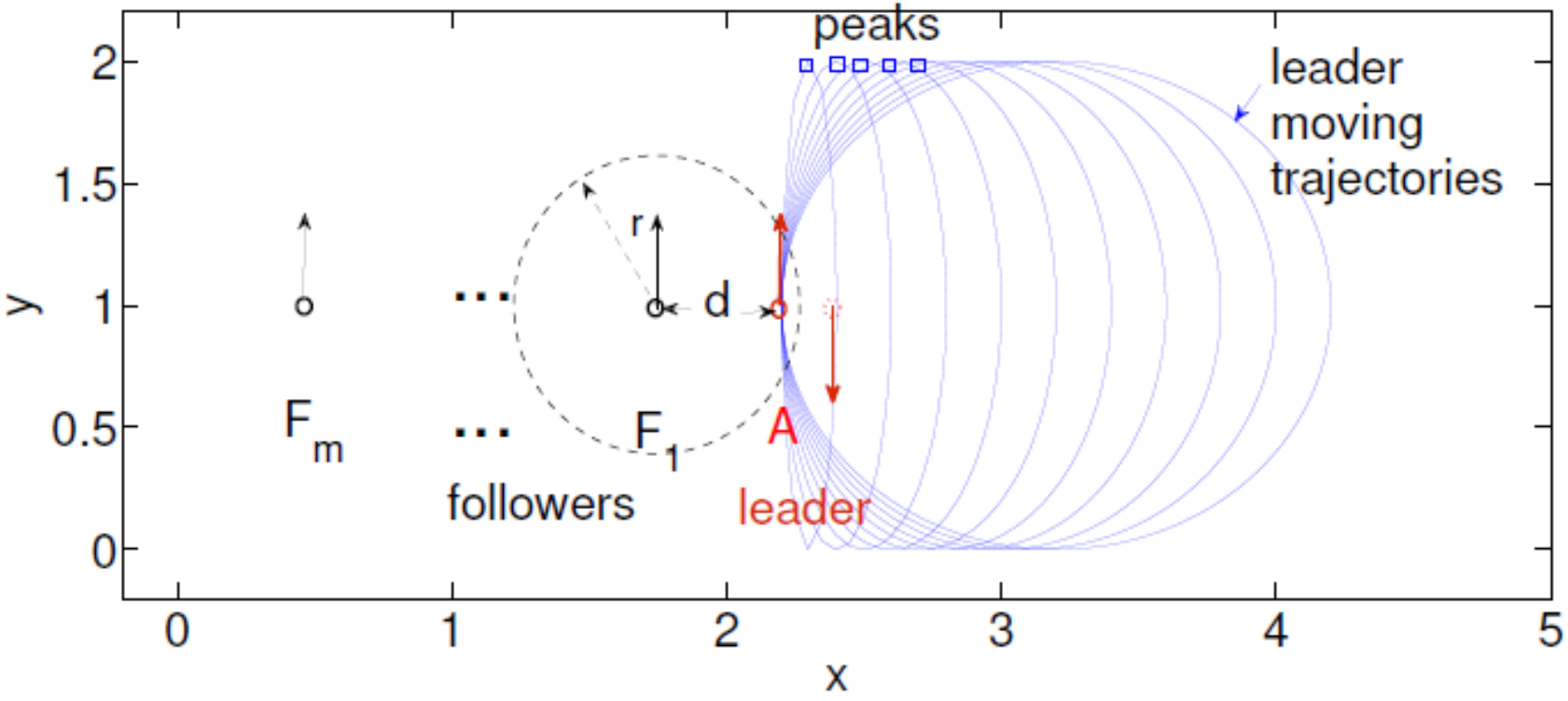


For Speed

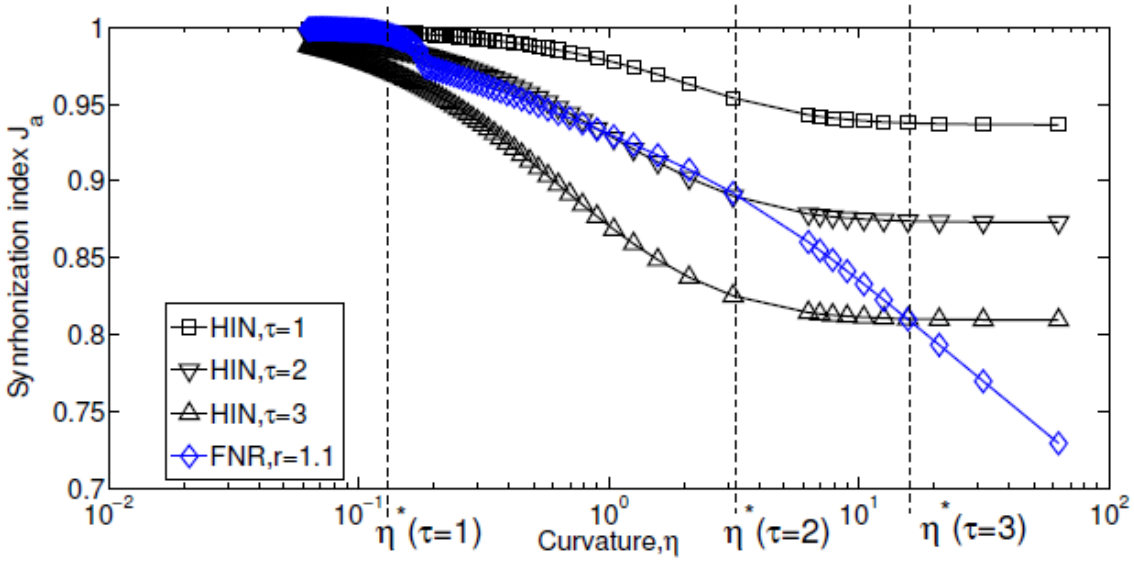
A Mixture Picture

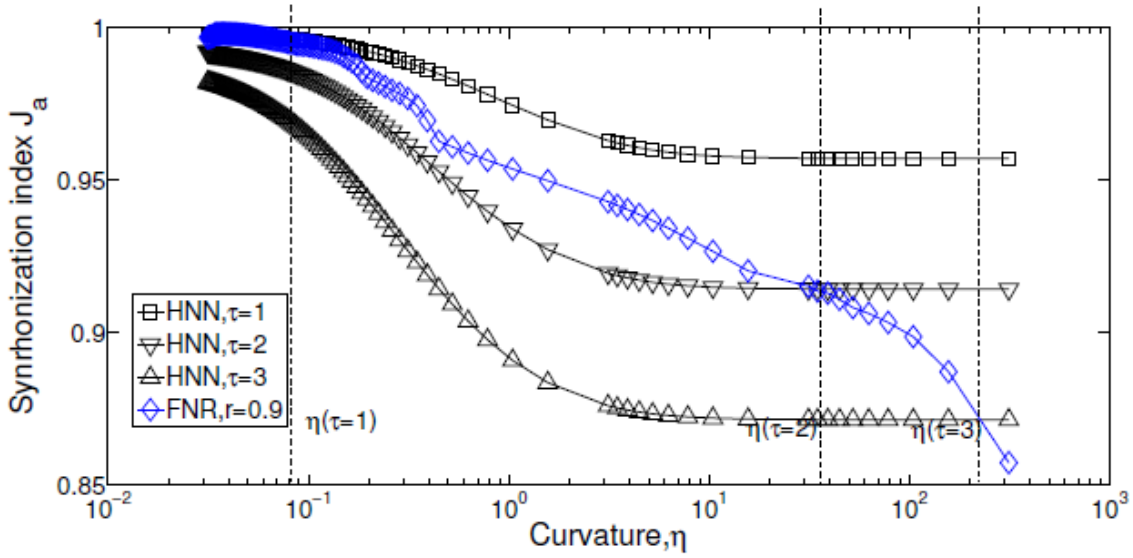


Theoretical Model



Results


Synrhonization index J_a
1
0.95
0.9
0.85
0.8
0.75
0.7
HIN,τ=1
HIN,τ=2
HIN,τ=3
FNR,r=1.1
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
$\eta^*(\tau=1)$
$\eta^*(\tau=2)$
$\eta^*(\tau=3)$
Curvature,η


Synrhonization index J_a
1
0.95
0.9
0.85
HNN,τ=1
HNN,τ=2
HNN,τ=3
FNR,r=0.9
η(τ=1)
η(τ=2)
η(τ=3)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Curvature,η

Conclusion

The flock actually adopts a mixture of the two aforementioned interacting patterns: each pigeon synthesizes the velocity of its neighbors and adopts the average direction of its neighbors when moving along a regular trajectory, while switches to follow the leader(s) at irregular points in its trajectory.

Thank you