**Topic Name: Self-Organized Systems – Opinion Consensus Dynamics**

**Outline :**

1. What is the topic? The problem?

Topic:  The dynamics of attributes of individuals or agents of a dynamically changing system.

Some examples include people’s opinions, a bird’s velocity or position (any socially interacting species), parties of people, or rendezvous points in mobile networks.  Naturally, these converging tendencies elicit the curious individual or mathematicians, in our case, to ask why and ask what factors cause this phenomena to arise.  Our talk will explore a variety of models present in the field and rigorously explore some of the conditions needed in the model for unconditional and conditional convergence.

*Interesting Quotes & Definitions*

* **“Self-organization** is a process where some form of overall [order](https://en.wikipedia.org/wiki/Order_and_disorder_(physics)) or coordination arises out of the local interactions between smaller component parts of an initially disordered system. The process of self-organization can be spontaneous, and it is not necessarily controlled by any auxiliary agent outside of the system. It is often triggered by random [fluctuations](https://en.wikipedia.org/wiki/Statistical_fluctuations) that are amplified by [positive feedback](https://en.wikipedia.org/wiki/Positive_feedback). “ https://en.wikipedia.org/wiki/Self-organization
* “A system is more than the sum of its parts.” https://en.wikipedia.org/wiki/Self-organization
* “The process of the appearance of order in a self-organized system is termed emergence.” https://en.wikipedia.org/wiki/Self-organization
* A **small**-**world network** is a type of mathematical graph in which most nodes are not neighbors of one another, but the neighbors of any given node are likely to be neighbors of each other and most nodes can be reached from every other node by a **small** number of hops or steps. https://en.wikipedia.org/wiki/Small-world\_network
* **“Dynamics** is a [branch](https://en.wikipedia.org/wiki/Branch_(academia)#Physics) of [applied mathematics](https://en.wikipedia.org/wiki/Applied_mathematics) (specifically [classical mechanics](https://en.wikipedia.org/wiki/Classical_mechanics)) concerned with the study of[forces](https://en.wikipedia.org/wiki/Force) and [torques](https://en.wikipedia.org/wiki/Torque) and their effect on [motion](https://en.wikipedia.org/wiki/Motion_(physics)), as opposed to [*kinematics*](https://en.wikipedia.org/wiki/Kinematics), which studies the motion of objects without reference to its causes. “ https://en.wikipedia.org/wiki/Dynamics\_(mechanics)
* “In biological systems, self-organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system’s components are executed using only local information, without reference to the global pattern.” <https://en.wikipedia.org/wiki/Self-organization>
* *“* Neo-classical economists hold that imposing central planning usually makes the self-organized economic system less efficient. “ <https://en.wikipedia.org/wiki/Self-organization>
* “In [philosophy](https://en.wikipedia.org/wiki/Philosophy), [systems theory](https://en.wikipedia.org/wiki/Systems_theory), [science](https://en.wikipedia.org/wiki/Science), and [art](https://en.wikipedia.org/wiki/Art), emergence is a process whereby larger entities arise through interactions among smaller or simpler entities such that the larger entities exhibit properties the smaller/simpler entities do not exhibit.” https://en.wikipedia.org/wiki/Emergence

2) Why should people care about this topic?

Because self organized systems are present in a vast array of fields and modelling them can give us information we can use to better understand how the system.

Examples of fields of study where self-organized systems are found: economics (market economy), biological systems from cellular (formation of lipid bilayer) to ecosystem level (creation of structures by social animals like beehives, flocking behavior by birds and fish), chemistry (crystallization), computer science (small world networks), sociology (human opinions)...

We are going to be focusing on dynamic self organized systems, specifically opinion consensus. This is particularly relevant right now in the context of political opinions with the upcoming election.

3) References/Resources

**Main Sources**

Baumgaertner, Bert O. Krone, Stephen M. Majmudar, Jimit. Tyson, Rebecca C. “The Voter Model and Jump Diffusion.” 2015 Cornell University Library.

\*Motsch, Sebastien. Tadmor, Eitan. “Heterophilious Dynamics Enhances Consensus.” *SIAM Review,* Vol. 56, No. 4, 2014, 577 – 621.

\*Motsch, Sebastien. Tadmor, Eitan. “A New Model for Self-Organized Dynamics and Its Flocking Behavior.” 2011. Published online by Springer Science+Business Media LLC.

*\*both of these papers relied on a similar for self-organized dynamical systems, but some explanations were more clear in “a new model,” while we relied on the mathematics in “heterophilious” for the simulation.*

**Supplementary Sources**

1. <https://arxiv.org/pdf/1004.4704v3.pdf>
2. Wikipedia page on “self-organization” https://en.wikipedia.org/wiki/Self-organization

4) State of the Field

* Brief graph theory background
  + What is a graph
  + What are vertices/edges
  + What is a graph in context of a self-organized system
* Brief historical timeline of self-organized systems in academia
* Key Characteristics of Self-Organized Systems
  + Nonlinearity (causes and effects cannot be mapped linearly ie. Small changes of causes can have large effects) (positive & negative feedback loops)
  + Multiple interactions
  + Emergence of order (ex: flocking speed of flight for birds)
  + There are many characteristics but these are the ones key to understanding our presentation
* General Framework to describe self-organized dynamical systems (based on page 579 of the “Heterophilious dynamics” paper)
  + N agents identified by position pi(t) (“position” can be opinion, velocity, actual position, etc. at a time t)
  + Agents adjust their position based on their neighbor’s position
  + Eq. 1.1 from “Heterophilous dynamics”
* Two main cases of self-organized systems
  + Global
  + Local
* Questions to focus on:
  + When and how clusters emerge out the self-interacting agents?
  + What influences emergence of clusters?
* Opinion Dynamics model
  + Eq. 1.2a and 1.2b from “Heterophilious dynamics”
  + Influence function

5) Nugget

* Conditions of consensus (convergence)/vanishing diameter proof
* Pseudocode and code demo for simulation of opinion of a local based model consensus using Runge-Kutta method of order 4 (please see github repository for code and for picture!) Its really REALLY awesome!
  + Numerically solved a first order Non-Linear ODE to show local convergence in 1d space

6) Future

* Of the field:
  + Potential challenges (briefly talk about Shalizi’s paper “Homophily and contagion are generically confounded in social network studies”)
  + Cool new applications of modelling
* For us

7) Questions/Comments