2.4. Basics of foraging: See Section 5 of the attached paper. For context, the paper is a so called "Review", which is a meta-study summarizing what research efforts already exist in a particular field. A review often lists different approaches. You don't have to mention every single approach in Section 5 but pick what you find interesting and talk a bit about it.

5.3 Models inspired by animal behav- ioral patterns

Insects:

* Mormon crickets and Desert locusts tend to exhibit cannibalistic behavior when nutritional resources become depleted.
* Motivated by these observations, individuals with escape and pursuit behavior patterns (which can be correlated with cannibalism) exhibit collective motion.
* The escape reaction is triggered in an individual if it is approached from behind by another one, leading the escaping animal to increase its velocity to prevent being attacked from behind.
* In contrast, if an insect perceives one of its mates moving away, it increases its velocity in the direction of the escaping one, known as pursuit behavior.
* These interactions of escape and pursuit, at moderate noise intensity and high particle density, result in global collective motion regardless of specific model parameters.
* Pursuit behavior leads to density inhomogeneities, such as the appearance of clusters, while escape behavior promotes homogenization.
* In the case of locusts, sudden and coherent switches in the direction of motion have been observed. It has been suggested that these switches result from small errors that insects make when trying to align their motion with that of their neighbors.
* These errors usually cancel each other out, but over exponentially long time periods, they can accumulate and result in a switch.

5.3.2 Moving in three dimensions

fish and birds:

* The goal of early models was to simulate realistic-looking collective motion in birds and fish.
* System-specific models were developed to consider various parameters and characteristics of biological systems.
* Different aspects were studied, including line versus cluster formation in bird flocks, correlation between fish size and spatial characteristics of fish schools, effect of social connections on collective motion, cohort departure of bird flocks, ecological context, and the effect of perceived threat.
* Biologists incorporated specific biological details into their models, such as stochastic differential equations with multiple parameters and realistic representation of body size and shape.
* The agent-based approach, which links individual behavior to emergent properties of the group, was commonly used in simulations.
* Basic rules for individuals included maintaining distance, attraction towards mates, and alignment with neighbors.
* The perception zone was divided into three regions: zone of repulsion, zone of orientation, and zone of attraction.
* Global properties like the order parameter (alignment) and group angular momentum (rotation) were calculated to analyze system behavior.
* Different parameter setups led to different types of collective motion, such as swarm, torus, dynamic parallel group, and highly parallel group.
* Individual-based modeling had limitations, as different combinations of rules and parameters could produce similar collective behaviors.
* Models had weak predictive power in capturing various aspects of collective motion.
* Ongoing research focuses on understanding the complexity of three-dimensional animal group behavior.

5.4 The role of leadership in consen- sus finding

* Animals traveling together need to make collective decisions about various aspects of their behavior.
* Modifying existing models, informed individuals are given a preferred direction while the rest of the group remains naive.
* Informed individuals balance social alignment and preferred direction using a weighting factor.
* The accuracy of the group's movement increases as the proportion of informed individuals increases.
* If informed individuals have different preferred directions, the group's direction depends on the differences between those preferences.
* A social importance factor can be included to describe the influence of individuals on group movement.
* Even simpler models, such as the severe quorum rule, can lead to accurate group decisions.
* Leadership can emerge from the differences in the level of information possessed by group members.
* Leadership can be transient and transferable as information changes among group members.
* Different models and approaches exist in the field of collective motion, and further research is ongoing.

2.5. Mention task allocation: Section 11. What is it in general and why is it important to foraging

* Task allocation or division of labor in a swarm robotics system refers to the ability to dynamically change the task executed by each robot based on local perception of the environment.
* Task allocation allows robotic systems to exhibit efficient work dynamics by adapting the ratio of robots engaged in a given task based on the current demand or expected gain from task execution.
* Threshold-based methods are commonly used for task allocation, where robots switch activities when an observed quantity exceeds a threshold value.
* Observed quantities can be local (perceived in the robot's neighborhood) or global (measured by all robots), and thresholds can be fixed or variable.
* Task allocation methods in foraging scenarios often use observed quantities related to the energy stored in the nest or the time spent on previous searches to determine when robots should start or stop searching for items.
* Probabilistic methods for task allocation involve random decisions by robots to switch activities based on dynamically changing probability values.
* Probability values can be calculated from previous experience or environment observations, and stimuli or effort levels can influence the probability of engaging in a specific task.
* Task allocation algorithms have been widely applied in foraging scenarios, where they determine when robots should engage in foraging or rest based on expected success or stimulus.
* Different principles such as impatience, acquiescence, and adaptive thresholds have been used to regulate robot activity in foraging tasks.
* Distributed task allocation techniques have also been implemented in scenarios other than foraging, such as item collection and clustering tasks.
* Metrics used to assess the performance of task allocation methods include energy consumption, net energy income, completion ratio, resource usage, and task completion efficiency.
* Analytical models and equations have been developed to understand and optimize the task allocation process in swarm robotics systems.

1.4. Basics of flocking (Section 2.1), simple self-propelled particle model (Section 4.1 and Figure 31)

* Phase transitions involve a system transitioning from one phase to another based on external parameters.
* Order parameters, specific system variables, change during phase transitions, indicating a change in system symmetry.
* Collective motion uses the average normalized velocity as the order parameter.
* First-order transitions involve discontinuous changes in the order parameter, while second-order transitions involve continuous changes with discontinuous derivatives.
* Phase transitions involve spontaneous symmetry breaking as the system passes the critical value of the control parameter.
* Phase transitions can occur in both equilibrium and non-equilibrium systems, but collective motion is more closely associated with equilibrium phase transitions.
* The language and formalism of equilibrium phase transitions are suitable for interpreting many phenomena in collective motion.
* Collective motion typically involves a smaller number of units compared to equilibrium systems, but mesoscopic-scale transitions can still occur.
* The observed states and transitions in collective motion can be associated with phenomena at the mesoscopic scale.
* Flocking behavior has been modeled using the simplest self-propelled particle (SPP) models.
* The first widely-known flocking simulation was developed by Reynolds, who introduced the concept of "boids" to represent bird-like objects.
* Reynolds' model included three types of interactions: collision avoidance, alignment with neighbors, and cohesion towards the center of mass of the flock.
* Aoki also proposed a similar simulation for the collective motion of fish, highlighting that collective motion can occur without a leader or global information about the group's movement.
* Vicsek et al. introduced the Vicsek Model (VM) or Standard Vicsek Model (SVM), a statistical physics approach to flocking.
* The SVM incorporated perturbations as a natural consequence of stochastic and deterministic factors affecting flocking organisms.
* The SVM used a cellular-automaton-like approach with self-propelled particles moving with a fixed velocity and assuming the average direction of others within a given distance.
* Perturbations were added by introducing a random angle to the average direction of motion within the particle's neighborhood.
* The SVM exhibited a second-order phase transition from a disordered to an ordered state as the level of perturbations decreased.
* Simulations using SPP models revealed a rich variety of collective motion patterns, such as marching groups, mills, rotating chains, and bands.
* Factors like noise, density, type of interaction, and boundary conditions played important roles in the formation of specific patterns.
* SPP models provided a simple yet effective way to simulate and understand flocking behavior and collective motion phenomena.

