Collectives in a Test-bed

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Background and Motivation
- **Pursuit** and collective behavior are ubiquitous in nature (e.g. dragonfly contest, fish schools, bird flocks)
- In the search for **mechanisms** that give rise to collective motion, various **mathematical models** have been proposed
- It is of interest to investigate the performance of these models in a laboratory environment

**Attention Graph**
- Node: Agent (real/virtual)
- Link: Attention

**Strategy & Control Law**
- Agent Dynamics:
  - $\dot{x} = \nu x$
  - $\dot{y} = \nu y$
  - $\dot{y} = -\nu ax$

**Collective Motion**

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**Experimental Set-up**

**Reference:**

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**Beacon Referenced Cyclic Pursuit**
- **Attention Graph:** Cycle with a spoke (“$i$”-th agent pays attention to the beacon and the “$i+1$”-th agent)
- **Strategy:** Constant bearing pursuit
- **Control Law:**
  - $u_i = (1 - \lambda) \begin{pmatrix} -\nu_i \left( R(y_i, y_{i+1}) \cdot \frac{r_{i+1}}{|r_{i+1}|} \right) \\ \nu_i \left( R(x_i, x_{i+1}) \cdot \frac{r_{i+1}}{|r_{i+1}|} \right) \end{pmatrix} - \frac{1}{2\nu_i} \left( \frac{r_{i+1}}{|r_{i+1}|} \cdot R(\pi/2, r_{i+1}) \right)$

**Topological Velocity Alignment**
- **Attention Graph:** Each agent pays attention to its $k$-nearest neighbors, i.e. the attention graph is time varying.
- **Strategy:** Each agent attempts to align its velocity parallel to the direction of motion of its neighborhood center of mass.
- **Control Law:**
  - $u_i = \begin{pmatrix} \nu_i \sum_j y_j / \sum_j y_j \\ \nu_i \sum_j x_j / \sum_j x_j \end{pmatrix}$ where $\nu_i = \frac{v_{x, i}}{v_{x, i} + v_{y, i}}$ and $v_{x, i} = \frac{1}{|x_i|} \sum_j y_j / x_j$

Extension to three dimensional case is straightforward.
The control law becomes undefined if the velocity of the neighborhood center of mass vanishes. However, this is handled in implementation by neighborhood extension.