A Formal Approach to Circle Formation in Multi-Agent Systems

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A Multi-Agent System (MAS) is a distributed system where the agents have the ability of sharing and exchanging information to accomplish a common goal. An agent is a computing element that could be a software code residing on a computer, a processor, a node in a network, or a robot such as a drone. A fundamental problem in MASs is the cooperative control of the agents under the influence of localized information exchange, i.e., each agent interacts with its neighbors only. The distributed control will allow for higher performance and fault tolerance. This is in contrast to the centralized control, where the agents are controlled by a central entity. An example of the centralized control is the formation of thousands of drones during the Winter Olympics in PyeongChang of South Korea, 2018. Some examples of the localized cooperative control include flocking of birds, the rendezvous problem, spacecraft attitude alignment, and formation control. Formation control is in reference to maintaining a pattern among the agents on a spatial scale. This study is focused on the circle formation among agents, which is the basis for transforming the formation into other symmetrical patterns.

A major shortcoming of a number of studies on circle formation is the fact that the approaches are ad hoc. Furthermore, many research efforts assume each agent has the global view of the field or the ability of communicating with all agents directly, and assume agents are transparent to avoid dealing with the collision problem. Finally, hardly any study has focused on an approach that distributes the agents elegantly and evenly using localized communication. This study instead presents a formal approach to the circle formation of a large number of agents. The agents will cooperatively adjust their positions to evenly distribute themselves on the circle. The proposed approach will also depend on the realistic assumptions that the observation and communication are limited to the neighbors, and the agents are mass agents. To accomplish the task, each agent independently experiences three phases: 1) decide on the center and size of the circle, 2) travel toward the circle in a short path possible while avoiding collisions with the neighbors, 3) cooperatively travel on the circle while avoiding collisions with the neighbors in order to form an evenly distributed circle. This in progress research will present the formal approach followed by some simulation.