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# AN EFFECTIVE RULE-BASED SHEPHERDING ALGORITHM BY USING REACTIVE FORCES BETWEEN INDIVIDUALS

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Abstract. *In this paper, we present an effective shepherding algorithm suitable for practical applications, which are based on a simple reaction mechanism between individuals. The shepherding is to guide or control flock behavior by one or more external individuals (called shepherd). In general, most of all shepherding methods usually use a complex mechanism and demand absolute positions of all individuals. These are costly and unsuitable to real-world applications. Our method is based on a simple scheme (like Boid proposed by C. Raynolds) by employing reactive force between individuals and required no absolute positions of all individuals. Behavior of the shepherd is determined by simple arithmetic operations using limited local information obtained through sensors. The validity of the proposed method is confirmed by demonstrations on a flock making and guiding. The simulation results show that with the proposed method it is possible to guide a flock of 25 members by a single shepherd and that of 30 members by two shepherds. Furthermore, we also show that autonomous cooperative action of two shepherds can be generated by the proposed mechanism. The proposed method is an inexpensive approach and suitable for implementation to actual mobile robots working under practical conditions.*

**Keywords:** Flock control, Shepherding, Swarm intelligence, Rule-based system, Multi-agent, Mobile robot

1. **Introduction.** A lot of research applying mechanism of animal's behavior to mechanical control such as autonomous robot control has been reported [5-8,14,17]. They are interesting trials which are making use of superior ability of creatures in engineering. In general, a complex mechanism is necessary to generate complex behavior. Therefore many researchers had thought that animal's complex behavior was hard to model well. Raynolds [1] had succeeded in describing such complex animal's behavior by simple mechanism using reaction between individuals. After that, many studies concerning animal's modeling and flock behavior have been reported and Reynolds' rules are also applied to a lot of research in real platform.

This research is divided into two categories; one is to control living things (such as ducks, cows and human beings and so on) by artificial mechanisms like mobile robots, and the other is to control artificial things by artificial mechanisms. As researches in the first categories, interesting trials have been reported. Vaughan demonstrated herding a flock of ducks by a mobile robot in the sheepdog project [6,7]. Butler et al. introduced