Ongoing Experiments in Autonomous 2D Shape Formation, With A View to Developing Autonomous 3D Formations With Unmanned Dirigibles

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2nd March 2001

Abstract: This paper reports on the preliminary simulation experiments that have been conducted in the search for a control system design that will allow an unknown number of autonomous dirigibles to manoeuvre into a pre defined three-dimensional formation.

1.0 Introduction

In recent years, a large amount of research has been conducted into producing two and three-dimensional flocking. This has been accomplished with wheeled robots by Kelly and Keating [1996] & Gulliford [1998], in simulation by Reynolds [1987], and Graves [1997], and with autonomous dirigibles by Welsby [2000]. Spatial self-organisation and team building has also been studied by Unsal & Bay [1994], and Sharman [1994]. The findings that are reported in this paper are part of an ongoing research project in developing a high level control system, along with the necessary hardware, that will allow an unknown quantity of unmanned dirigibles to produce a three dimensional formation. It is the author's belief that this type of spatial self-organisation has not previously been attempted with dirigibles. In order to achieve this task the current dirigible hardware design includes equipment that allows for, the reception of orders, agent identification, agent alignment, and range finding. By adapting an idea from Arai *et al*. [1999], where a ring of infrared transmitters and receivers are used for obstacle avoidance, one possible method of achieving the above task is currently being developed.

A computer simulation has been used to test how well the current behaviour based control system performs when instructed to produce line, square and cross-shaped formations. The simulated agents each possess eight sensor modules that are arranged around the circumference of the agent's body. Each module contains wide and narrow angle infrared transmitters and receivers for identification and alignment, ultrasonic range-finding equipment for collision avoidance and spacing, and a radio frequency transceiver for receiving orders and passing on information. A behaviour based control system is employed, and was originally implemented with a subsumption like architecture [Brooks 1985]. This has since been changed for the purposes of simulation.

This paper first describes the target platform for the developed control system. This has been decided upon with knowledge gained from previous dirigible research work, payload capacity and available sensor systems. The simulation models this hardware arrangement onto the agents, details of which can be found in section 2. Section 3 details the first experiment, which attempts to arrange the agents into a straight line. Section 4 reports on the results obtained when a square formation was attempted in experiment 2. Details of the final experiment, which attempts to produce a cross shaped formation, can be found in section 5. This paper is then concluded in section 6, along with a discussion of the next steps that are to be taken in this ongoing research project.

1.1 Real World Target for Developed Algorithms

The algorithms developed with the computer simulation are to be applied to real-world unmanned dirigibles. Each robot contains a central control unit, a radio communications system, an array of sensor modules, four vectored fan units, and a set of batteries. These components are mounted into an enclosure and suspended from the underside of a 1.7 metre helium filled balloon. When the balloon is filled with fresh helium at the maximum recommended pressure, a payload capacity of 1.5 kg's can be carried.

The four vectored fan units are attached to the underside of the enclosure (gondola) via two 1-metre carbon fibre rods. Two of the vectored fan units are placed at the outside ends of a single carbon rod that is coupled to the gondola via an actuator. The actuator allows the fan units to be positioned at any angle between horizontal (0 degrees) and vertical (90 degrees). The second pair of vectored fan units are attached directly to the gondola with an identical carbon rod, and is positioned perpendicularly to the first. With this configuration, the dirigible has 6 degrees of freedom (climb,