LOCATION PROBLEM: RESEARCH PAPERS

NJRB2 | MVS9 | FA296

This document concludes all research papers read to assist in coming up with solutions for the location problem.

# Shepherding Behaviours

This paper talks about ways a shepherd can herd a flock, and which method is the fastest. Pre-conditions include having more than 10 objects to be considered as the flock, and only one shepherd. They also state that there are four different types of shepherding: herding, covering, patrolling, and collecting.

Herding is when the shepherd steers a flock from start region to goal, covering is when a shepherd guides a flock to visit all positions, patrolling is protecting an area from the flock, and collecting is gathering scattered flock into a designated region.

There are two subproblems they try to solve. One is the Approaching and the Steering.

In the Approaching problem, they state three different methods:

1. Straight line - this is when it approaches the flock in a straight line
2. Safe zone - this is when the shepherd approaches the flock from a safe zone (as not to disrupt the flock)
3. Dynamic - using the environment to approach the flock

In the steering problem, there are two methods:

1. Forward steering - when the shepherd needs to push the flock forward, and there are two ways.
   1. Straight behind the flock - assuming the flock is facing the goal area, the shepherd needs to be in a position to nudge them forward
   2. Side-to-side behind - this is when the shepherd moves repeatedly from one side of the flock to other whilst moving forward
2. Turn steering - this is when the shepherd needs to turn the flock a certain way towards the goal area. There are two types:
   1. Stop-turn steering - the shepherd stops the flock by placing itself in front of the flock to stop it, then steers it in direction
   2. Pre-turn steering - shepherd initiates the process before the turn by placing itself in the direction near the flock boundary (so the shepherd prevents the flock from heading towards the wrong direction)

# Autonomously Herding Ground Robots in a GPS-Denied Environment

This research involves a Roomba and an aerial vehicle with a GoPro attached to it. Their aim was to create a global model. They had four obstacles on the field. The drone uses vision processing to model the environment. It does saw by using the camera input and outputting a list of gridlines (using OpenCV). The Roombas are identified as pixels.

Throughout the project, they also added a deep RL agent (a reinforcement learning machine) that learns where the Roombas are, where to go, and where not to go. Then they let humans have a go, and a number of strategies were developed which were:

1. Follow strategy - it babysits the very topmost Roomba, and taps it when it goes over the boundary
2. Circle strategy - loops around the arena to get a sense of where they are
3. Defensive strategy - travels along the edges, and taps Roombas that might leave

# Robo-Shepherd: Learning Complex Robotic Behaviours

Within the project, they learnt complex behaviours including multiple robots. This research involves one robot guiding another robot to a specific area using genetic algorithms. One robot is the shepherd, and another is the sheep. Their aim is to guide the sheep into the area within a limited amount of time. Much like a Roomba, the sheep reacts to nearby objects by moving away from them.

There are five abstract sensors, the range and bearing of the shepherd from the sheep, the sheep’s direction in respect to the bearing, and the range and bearing to the specific area. The bearings are calculated using sonars.

# Autonomous Quadcopter for Multiple Robot Tracking and Interaction in GPS-Denied Envrionment

This research’s aim is to develop a fully autonomous UAV to track randomly moving objects and interact with them physically, in order to guide them to a specific location. The zone is 20mx20m, and also involves grid lines per metre. (Grids are drawn using white lines, edge detectors are used to identify the edges of lines). The zone will also be populated by Roombas. Some roombas have paddles on top of it to allow interaction with the UAV.

Their challengers were:

1. Localising the aircraft (making sure it stays in one place)
2. Detection/tracking of the objects within the zone
3. Planning and controlling said objects to get to the specific goal

Due to the nature of the challenges, they have also decided to split their solutions in three:

1. Self-estimation - localises the aircraft in a position where it is relative to the grid
2. Perception - the identification and tracking of the objects
3. Planning - generates high-level path commands to optimise the herding

In terms of software, they used ROS and MAVROS to enable remote communication. They also used Raspberry Pi 3. Together, they used it to determine flight path and control of the vehicle.

The UAV has a downward facing camera with a large field view. It processes one frame at a time from the camera feed. They also use *Pixhawk* which enables them to get a more precise estimate of where it is. This information is sent to their path-planning. The Roombas are detected through colour (although they have mentioned that light reflecting it can cause problems), and Gaussian Blur is applied to remove disturbance.

They use Pose Estimation (determines where an object is in relation to a coordinate system) and Linear Projection Estimation (explores characteristics of motion such as velocity and acceleration). They also use Kalman Filter to combine these, enable a predictive and stable estimate to help with decision making.

In the project, the UAV can follow the Roomba, to predict where it’s going, and then slowly descend onto the Roomba.

UAV’s raw data and velocity is transmitted using the gyroscope and accelerometer. They map the current coordinates by calculating its position relative to starting position.

# Autonomous Navigation for BigDog

BigDog is a four-legged robot, equipped with laser scanner, stereo vision system, perception and navigation algorithms. Using the sensors, it can autonomously navigate to goal positions. The process consists of raw scans and camera images processed to produce lists of points that looks like obstacles. These points are tracked over time, and objects are joined to construct the map.

It uses a LIDAR sensor to provide a new scan every 13ms.

# Genetic Algorithms for Autonomours Robot Navigation

Within the project, they learnt complex behaviours including multiple robots. This research involves one robot guiding another robot to a specific area using genetic algorithms. One robot is the shepherd, and another is the sheep. Their aim is to guide the sheep into the area within a limited amount of time. Much like a Roomba, the sheep reacts to nearby objects by moving away from them.

There are five abstract sensors, the range and bearing of the shepherd from the sheep, the sheep’s direction in respect to the bearing, and the range and bearing to the specific area. The bearings are calculated using sonars.

# Resources

[Shepherding Behaviours](https://ieeexplore-ieee-org.chain.kent.ac.uk/document/1308924) <https://ieeexplore-ieee-org.chain.kent.ac.uk/document/1308924>

[Autonomously Herding Ground Robots in a GPS-Denied Environment](http://www.aerialroboticscompetition.org/assets/downloads/2016SymposiumPapers/MassachusettsInstituteofTechnology.pdf) <http://www.aerialroboticscompetition.org/assets/downloads/2016SymposiumPapers/MassachusettsInstituteofTechnology.pdf>

[Robo-shepherd: Learning Complex Robotic Behaviours](https://www.researchgate.net/profile/Alan_Schultz2/publication/2782918_Robo-Shepherd_Learning_Complex_Robotic_Behaviors/links/0046353417dd828b5f000000.pdf) <https://www.researchgate.net/profile/Alan_Schultz2/publication/2782918_Robo-Shepherd_Learning_Complex_Robotic_Behaviors/links/0046353417dd828b5f000000.pdf>

[Autonomous Quadcopter for Multiple Robot Tracking and Interaction in GPS-Denied Environments](http://www.aerialroboticscompetition.org/assets/downloads/2017SymposiumPapers/UniversityofCaliforniaSanDiego.pdf) <http://www.aerialroboticscompetition.org/assets/downloads/2017SymposiumPapers/UniversityofCaliforniaSanDiego.pdf>

[Autonomous Navigation for BigDog](https://ieeexplore-ieee-org.chain.kent.ac.uk/document/5509226) <https://ieeexplore-ieee-org.chain.kent.ac.uk/document/5509226>

[Genetic Algorithms for Autonomous Robot Navigation](https://ieeexplore-ieee-org.chain.kent.ac.uk/document/4428579) <https://ieeexplore-ieee-org.chain.kent.ac.uk/document/4428579>