Chapter 1

Design Documentation

1.1 Summary of Proposal

"A robotic swarm is composed of a large number of simple physical robots. From the local interactions between the robots and the interactions of the robots with the environment, an efficient global intelligence emerges. Multi-robot coverage is the problem in which a swarm of robots needs to coordinate decentralised in order to effectively and efficiently cover an unknown environment. Examples include various monitoring, rescuing, and patrolling scenarios. The purpose of this project is to set up an experimental demonstrator, i.e. 'a dark room', in which multi-robot coverage experiments can be conducted using e-puck robots, implementing the stigmergy principle as observed in ant colonies. Ants use chemicals, called pheromones, to communicate with each other via the environment. However, despite of a few reports of using chemicals in robotic experiments, this is not a straightforward approach due to difficulties in implementation and limited extendability. Therefore, we take advantage of a glow-in- the-dark foil (i.e. a foil covered by phosphorescent material which absorbs UV light and re-emits the absorbed light at a lower intensity for up to several minutes after the original excitation). As robots need to emit light to the glow-in-the-dark foil, each e-puck robot is equipped with a UV-LED pointing toward the floor. The glowing trails will take up the role of natural pheromones."

The Aims of the Project are to construct a testing arena for the e-Puck robotic platform, notably a "dark room," which will allow the usage of the robot's lights to leave localised messages on flooring which can store and emit light. Sucessfully fulfilling the aim will mean that other users of the e-Puck system have a basis to create their own dark room. This may improve research in swarm robotics or, if used for demonstration purposes, can bolster interest in applicable fields.

The primary Objective of the project are to build said arena with dimensions small enough to fit on a circular table approximately 60 centimetres in radius. As a secondary Objective, completion of the project will produce a program for the e-Puck robotic system to demonstrate the effectiveness of the environment the robot will be placed in. The program will initially be an implementation of StiCo[6], but may have modifications dependant on time constraints.

The original requirements document stated that the program will be similar to

StiCo and HybaCo[4]. The language used suggests that the final program will be a variant of the two algorithms. This is no longer the case – the program will be an implementation of the StiCo algorithm and a separate, modified program will only be available should there be enough time to change the original implementation. This is to allow the time to properly implement the StiCo algorithm as the compiled code is used as a proof of concept that the constructed dark room is a viable environment for the testing of light based communication using the e-Puck system.

1.1.1 Relevant Research and Analysis

There has been some research on Stigmergic algorithms. The main algorithm used within this project will be StiCo[5, 6, 7]. When implemented, the algorithm can help to reduce the total area of terrain covered by multiple robots which would improve efficiency and total area being patrolled upon. This algorithm will be used to show that the dark room that will be built is functional.

BeePCo is another, different algorithmic solution in stigmergic robotics. Whilst it is not applicable for the project due to it's reliance on direct communication between agents and would be a very different implementation compared to StiCo, it can be useful with fewer robots to help monitor all of the area by maintaining distance through network connections.

HybaCo is a combination of both StiCo and BeePCo – initially running the latter algorithm whilst a direct connection is available and then switching to StiCo when connecting to other robots is no longer possible, perhaps due to range limitations[1]. If time permits, I will modify the code to implement the BeePCo algorithm, and mold the final result into a HybaCo implementation.

1.2 System Design

Anticipated components for the project include documentation for each stage of development, source code and it's compiled version of the StiCo algorithm for the e-Puck robotic platform. The final component will be a constructed arena for testing the source code with the e-Puck system, along with blueprints that are provided in the Design phase of the project. These together will complete the aim of providing a dark room for researching and testing of algorithms for the e-Puck system, along with a demonstration program to show whether the constructed arena is successful.

Currently, it is believed that the project will not contain data structures such as Sets, Queues, Arrays or Stacks. The program will have basic datatype variables to store the radius of the circular path the robot will take, a variable to check whether the robot has scanned a light path successfully and, time permitting, an integer variable to be used as a state machine - running StiCo initially then BeePCo/HybaCo should the user wish the state to change. The changing of state could be called by pressing a button on the robot before it starts it's run, for example.

With the StiCo algorithm, no user input would be required to manipulate the data structures in place. When a light trail is detected, the motor strength to each wheel will be swapped to allow the robot to turn in the other direction. If the HybaCo algorithm is implemented, buttons on the e-Puck system could be used to differentiate between running the initial StiCo implementation and the potential implementation of the HybaCo algorithm in a similar manner to a state machine e.g. 2 button presses could indicate running the HybaCo algorithm whereas 1 button push will run the StiCo algorithm only.

Apart from a connection to a computer to pass compiled files over to the e-Puck system, there are no initial plans for an interface for the project. An interface will only be considered as required, such as to implement a state machine to the robots so the user may pick and choose which algorithm each robot runs. Should this be the case, the buttons available on the robot will be the user interface, where the user pushes a single button to denote which algorithm should be run. If a second button is available on the robot, this will be used to execute the currently selected algorithm. Lights on the robot can be used to indicate which state is currently running.

Evaluating the Project will fall into two categories: the constructed dark room and the implementation of the algorithms, StiCo and potentially HybaCo too.

The dark room will be evaluated based on how little light gets through the covering and how the edges can keep the robots from leaving the sectioned area. Testing for the light levels can be done by looking at the constructed arena to see how strongly the flooring glows after normalising it's charge. A torch can then be shone into the arena to see whether the floor can successfully hold the light for an amount of time.

For evaluating the program, the robots need to interact with the light trails they leave behind in some form to help evaluate the effectiveness of the dark room. This is achieved by implementing the StiCo algorithm, where the robots will change direction when they come into contact with a light trail.

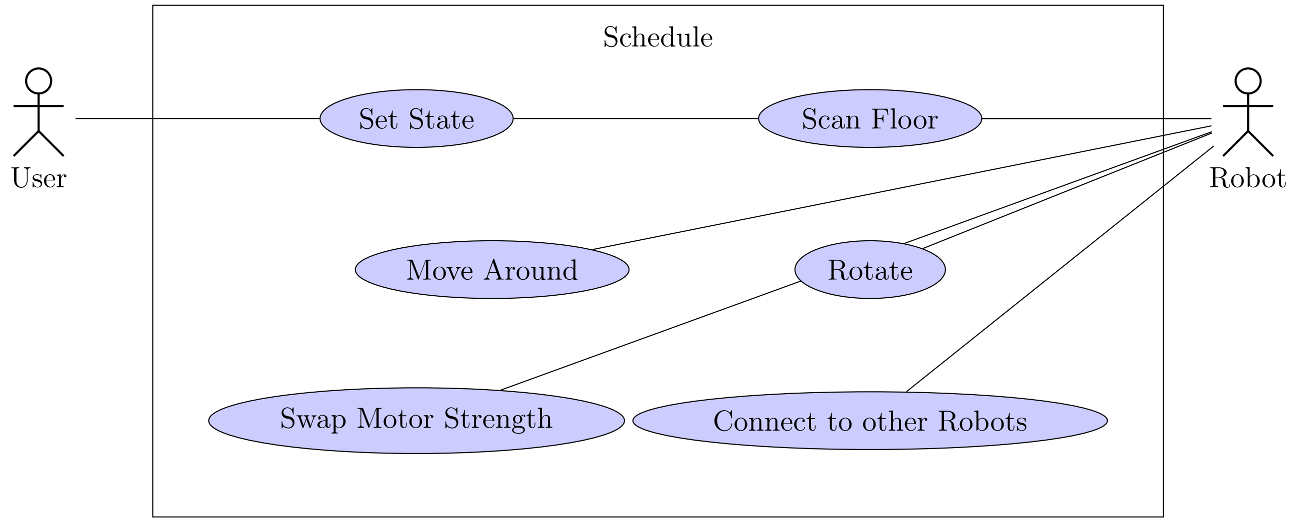

Figure 1.1: Use Case Diagram for proposed software solution

This is the StiCo Pseudocode algorithm[6].

This is the BeePCo Pseudocode algorithms[3].

This is the HybaCo Pseudocode algorithm[2].

1.3 Evaluation Design

As mentioned earlier in the document1.2, the elements that fall under evaluation are the dark room to be constructed and the compiled program that will be placed on the e-Puck robotic system to demonstrate the effectiveness of the construct as a dark room.

The Dark Room

- The room can contain multiple robots
- Light level is low enough to not affect the glow in the dark flooring
- Being able to view the robots without leaking light into the arena
- Portable and flexible; easy to set up

The Compiled Program

- Helps to evaluate the dark room
- Interacts with the light messages left on the flooring
- Implements the StiCo algorithm

It is difficult to evaluate how user friendly the final products will be. This is because the user will have minimal interaction with the robots. The robots will flash to indicate a change in the algorithm that will be executed. To construct the dark room, the user will require basic knowledge of creating knots. There are no users to acquire feedback from.

The criteria will be mainly assessed when the dark room is completed. Robots can be placed within the arena to assess the correct size. A handheld torch will be used to test whether the flooring can hold a charge, and to see the difference between ambient charge and directly exciting the flooring. Evaluating the robot's capabilities can be done using only one agent, by using a torch to simulate another agent's light trail and seeing a change in agent's behaviour.

Evaluation will be primarily completed by one person, as there are only one person required to set up the robots and their states.

There is no use of Human Data or Human Participants within this project – all parts of the project are covered by one person and therefore does not require ethical limitations to be placed upon the project.

The conclusion of the project is expected to be a small arena to be used to simulate darkness or night time situations. The robot will be expected to interact with light trails on the flooring in the manner that StiCo defines.

1.4 Project Review: Design Stage

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