Spatially-Decentralised Coordination for Agricultural Fleets

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Introduction

As a result of more research into agricultural robotics, many tasks in agriculture are beginning to show the potential of full autonomy, such as with weeding, sowing, monitoring, husbandry, harvesting, allowing farmers to focus their time, effort and resources elsewhere. With more potential of agricultural robotics, comes more robots working simultaneously across the farm and a greater necessity for reliable coordination to avoid issues in cross-farm routing of heterogenous fleets [1].

Summary

This project aims to tackle challenges in inter-field coordination of heterogenous fleets of agricultural and utility robots for use in unstructured agricultural environments. This will utilise and develop the concepts of spatially-decentralised coordination infrastructure and associated technologies such as route planning and task assignment to enable this autonomy of fields.

Arrangement of Agricultural Environments

In many UK agricultural environments, there can be a large variety in potential traversal routes robots could utilise to get to their task location. Riseholme Park Farm, our 230ha research site, has a large variation in such regions, from horticultural and pastural fields, to both public/private roads and footpaths. Along with parkland, woodland, buildings, animal housing, and small growing plots. Many farms across the UK support similar levels of diversity [2], and set to increase under carbon offsetting targets [3], where an additional 30,000ha are set to be converted into woodland annually from 2024.

References

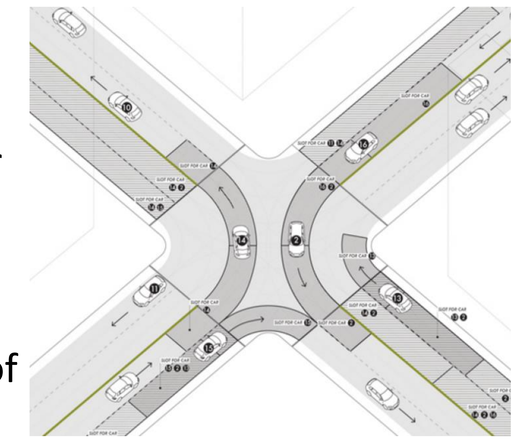
[1] Mao et al, *Research progress on synergistic technologies of agricultural multi-robots*, App. Sci. **11** (2021).
[2] Hill, F*., Medieval Lincoln* (1948).
[3] ONS, *Carbon dioxide emissions and woodland coverage where you live*, (2021).
[4] Aakash, S. and Huosheng, H., *Formation control for a fleet of autonomous ground vehicles: A survey*, Rob. **7**, (2018).

Types of Coordination Infrastructure

	Infrastructure	Description
Centralised	**All agents are under control of a single processing unit.**	
	Simple Centralised	Agents are coordinated by a central system with full control.
Decentralised	**Agents are coordinated in groups.**	
	Collectively Decentralised	Agents are coordinated as groups then groups coordinated.
	Spatially Decentralised	Regions are coordinated for agents to enter and leave.
Distributed	**Agents are treated as independent decision-making entities and can join flocks when desired [4].**	
	Leader-Follower	A single agent acts as a temporary controller for the control of a micro-fleet.
	Virtual - Structure	Agents work to maintain a geometric structure of distance between each other.
	Behaviour-Based	Agents remain autonomous to the group, utilising methods such as potential-fields to coordinate.
Swarm	**Agents are given instructions on how to move and act when around other agents, which results in a natural emergence of coordinated behaviour.**	

Spatially Decentralised Coordination

Spatially decentralised coordination is a coordination infrastructure in which pre-defined **regions are given the ability to coordinate** agents moving within their space. In autonomous car coordination, the region surrounding a traffic light may be considered a region well-suited for structured coordination in this manner. Robots enter the region, identify and connect to the coordinator, are coordinated as part of the collective, then go on their way.



Experimentation

This work aims to develop an approach to coordination which improves field compartmentalisation, modularity, and setup time, while decreasing infrastructure reliance, and resources requirements. To facilitate this, novel **inter-field route planning** approaches will be designed to consider a variety of environmental and traversal restrictions. The development will be assessed in both **Discrete-Event Simulation** to evaluate scalability and routing efficiency, and in a **Physical Deployment** to evaluate reliability.

Collaborators

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