Tasking problems

Presented by

Dymkou Siarhei

Temasek Laboratories

Control Science Group,

National University of Singapore

Technical Report

— April 2014 —

NUS
National University
of Singapore

Outline

- Summary of the Results
- Problem class description
- Overview of the whole system
- Achievements and Limitations
- Simulations
- Conclusion and Future Work

Summary of D8 Results

Algo	Final Validation Objective	Phase	Means	Results
B-3	Resource Allocation. To show that the optimal assignment and schedule can be found faster than conventional method. Conventional method: The operator manually determines the optimal assignment and schedule.	Final	The simulation results will be provided for scenario where multiple unmanned air vehicles (UAVs) are required to prosecute geographically dispersed target (zones). The UAVs must perform the task on each zone. The optimal performance of these tasks requires cooperation amongst the UAVs such that the critical constraints are satisfied.	Completed We have developed new supporting optimization algorithm (SOA) based on constructive approach for using an Integer Linear Program (ILP) formulation to find the optimal solution to multiple-task assignment problem where the tasks are coupled by timing and task order constraints.
	Distributed Tasking. To show that the feasible assignment can be found faster than conventional method. Conventional method: The operator manually determines the feasible assignment.	Final	The simulation results will be provided for solutions for multi-agent multi-task allocation problem over networks of heterogeneous agents. The current version supports tasks with time windows of validity, heterogeneous agent-task compatibility requirements, and score functions that balance task reward and fuel costs.	Completed We have developed a distributed approach and enhanced the existing ones in order to give a mathematical description of models for task assignment problems of MAS (Multi-Agent Systems) for different possible scenarios, namely we show the functionality of the Control Net Protocol algorithm for the Benchmark Problem 3 (Search and Track) and also have tested the Consensus-Based Bundle algorithm for multi-agent multi-task allocation problem over networks of heterogeneous agents.

NUS National University of Singapore

Problem Class Description

Item	Description
General description	***To assign UAVs to perform as many simultaneous service request as possible***
Starting conditions	**Given:** • The MAS is performing some job • Multiple requests for service with the following information: *Number of UAVs required* *Location where UAVs need to visit* *Earliest time of 1st visit* *Latest time of 1st visit* *Minimum duration per visit* *Maximum interval between visits*
Mission objective	**Find:** • UAVs to be assignet to request and the corresponding path to take to servise request • Variations to request with minimal change if the request cannot be met **That:** • Maximizes the number of service request that can be serviced
Constraints	**Subject to:** • UAVs perfomance and dynamics • Sensor perfomance • Air to Air datalink perfomance

Overview of the Whole System

NUS National University of Singapore

Configuration

- ➢ UAV Airspace;
- ➢ Range for air-to-air communications between the UAVs;
- ➢ Homogenous\Heterogenous Service UAVs;
- ➢ Local information about targets;
- ➢ Static and moving targets.

Requirements

- ✓ Manage UAVs themselves automatically as a team in a hierarchical and / or distributed manner;
- ✓ Provide automatic self-allocation and self-deployment.;
- ✓ Maximize the local reward for each Service-UAVs.

Considerations

- Limited UAV sensing range and communication range;
- Breakdown of UAVs and variations of communication topologies;
- Distributed information fusion between UAVs;
- Distributed motion planning for UAVs.

Solution Description

The distributed tasking protocols with performance guarantees obtained through mathematical analysis and proofs as opposed to only via simulation and empirical tests (which are always limited).

Main issues: Coupling and Communication:

- Agent score functions depend on other agents decisions
- Joint constraints between multiple agents
- Agent optimization is based on local information

Rationale

Algorithms	Rationale
Supporting Optimization Algorithm (SOA) (centralized)	• Applicable to scenario when the GCS (Ground Control Station) is available; • Very fast computation by using the special optimality conditions, which is suitable for the online calculations.
Consensus Based Bundle algorithm (CBBA). (decentralized)	• Applicable to scenario when the GCS is not available; • Very fast computation by using the special structure of the algorithm, which is necessity for the planning over large teams due to the increasing communication and computation overhead required for centralized planning with a large number of agents.
Contract Net Protocol (CNP).	• Applicable for the Collaborative Search & Track scenario. Namely, the algorithm can automatically search the area and automatically task UAVs to track the targets found and automatically adjust the “search plan” when UAVs originally performing search are now doing tracking.

General requirements

NUS National University of Singapore

Assign the tasks between UAVs

Ensuring proper coordination and collaboration between agents in the team is crucial to efficient and successful mission execution

Key question

- to coordinate team behavior to improve mission performance
- to hedge against uncertainty in dynamic environments
- to handle varying communication constraints

NUS National University of Singapore

Achievements and Limitations

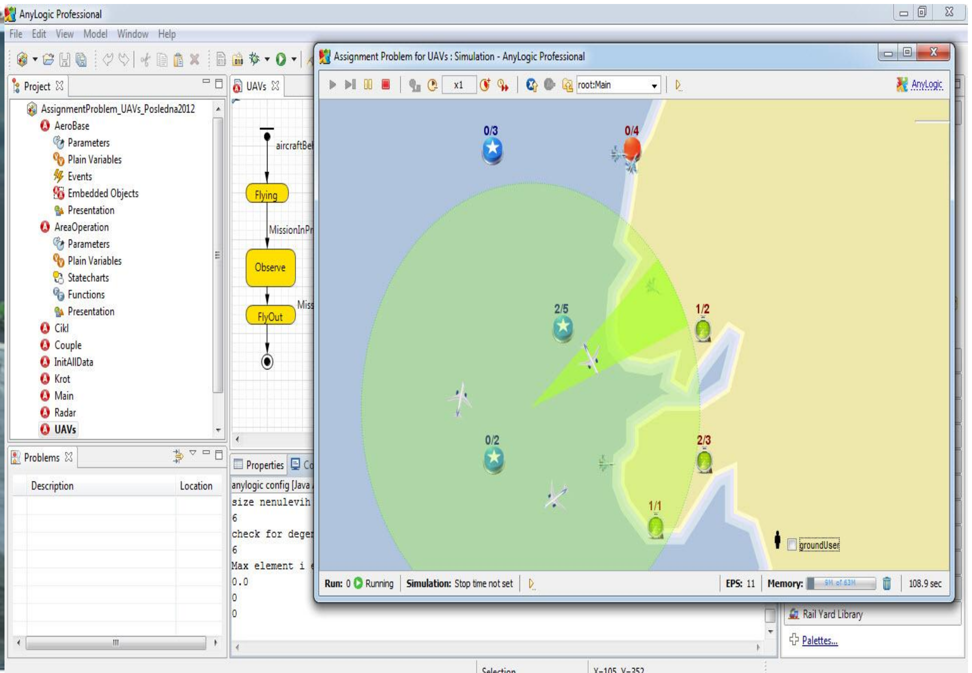
Achievements	Limitations
• Optimal solutions can be found by supporting optimization algorithm (SOA) • Task selection - Polynomial-time, provably good feasible solutions (CBBA,CNP) • Guaranteed real-time convergence even with inconsistent environment knowledge (SOA,CBBA,CNP) • Time-varying score functions (SOA,CBBA,CNP)	➢ SOA not supports heterogeneous agent-task compatibility requirements. ➢ To find optimal assignment is possible only in case when GCS available all the time.

Concluding Remarks

1. SOA has been successfully implemented in AnyLogic environments.
2. CBBA and CNP are successfully tested for asked scenarios.
3. The objective of D8 has been achieved

Deliverables

1. AnyLogic simulator for SOA
2. Integrated simulator for CNP (see Meng Wei slides)
3. Toolbox for CBBA (using Matlab and UDK)



NUS
National University of Singapore

Thank you!