Control of teams of unmanned aerial/ground vehicles

ATG applied research overview

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Overview

The domain of intelligence gathering (IRS) missions offers a range of interesting challenges for multi-agent systems research.

1. AgentFly
2. Tactical AgentFly
3. Tactical AgentScout
4. On-going and future work
5. Conclusion
AgentFly

A set of aircrafts in a joint airspace.

control
- path planning
- no-flight zones
- simple missions
- time

conflict avoidance $\rightsquigarrow$ crashes

current solutions
- $\rightsquigarrow$ dispatchers + teleoperation
- $\rightsquigarrow$ fixed rules
UAV control

A*-based manoeuvre planner
UAV control (cont.)

conflict avoidance/deconfliction

- iterated negotiation:
  1. broadcasting plans/plan fragments
  2. identification of conflicts
  3. utility-based plan adaptation

extensions

- mountaneous terrain
- time constraints
- cooperative vs. non-cooperative deconfliction
- weather
Simulation framework

- A-Globe MAS platform
  - asynchronous distributed message passing
  - agent containers

- simulator
  - environment
  - embodiment of agents
  - models of physical dynamics of entities

- visualization
  - 3D, textures, etc.
Demo
Next-gen air traffic control

Airspace becomes too congested $\leadsto$ free-flight concept
- massive distributed simulations $\leadsto$ US/Europe airspace
- US FAA funded efforts
Tactical AgentFly

ISTAR missions in urban environment

= semi/fully-autonomous control of a team of UAVs

current:
- single UAV $\rightsquigarrow$ operator (teleoperation)

near future:
- team of UAVs $\rightsquigarrow$ single operator (team tasking)

far future:
- team of UAVs $\rightsquigarrow$ autonomous control (overwatch)
Subproblems (semi-automatic)

- algorithms for
  - terrain exploration (reconnaissance)
  - surveillance
  - target tracking

- sensors: gimballed/fixed camera, etc.
- occlusions in urban terrain
Subproblems (autonomous)

- dynamic reconfiguration/re-allocation of tasks
- MxN tracking - multiple targets vs. limited resources
- ground mission support

Heterogeneous teams:
- fixed-wing aircrafts (CTOL)
- helicopters (VTOL)
- planning $\leadsto$ 4D planner
  - time
  - physical dynamics model
Surveillance

- surveillance (measure = information-age)
  - spiral
  - zig-zag
  - greedy
  - dynamic reconfiguration: DVRP-based task allocation with various heuristics
tracking (measure = target in view time)

- target dynamics vs. aircraft dynamics
- planning/deconfliction speed vs. aircraft speed
Exploration

- exploration
  - naive vs. DVRP based task allocation
Mission execution

- specification of missions and rules of engagement
- agent-oriented programming (Jazzyk/BSM)
- BDI agents

![Diagram showing simulation environment, agent program, belief base, and goals.]

- Belief base
  - Java
  - Prolog
- Goals
  - Prolog
Integrated demos
Coordination of teams of heterogeneous agents in urban military missions

- unmanned aerial vehicles (fixed wing aircrafts, helicopters)
- unmanned ground vehicles (cars, robots)
- unattended ground sensors
- teleoperated devices (satellites, planes, vehicles)
- humans
Subproblems

Technological objectives

- physical modelling of UGVs
- integration of UAVs, UGVs, VTOLs, etc. into a single (distributed) simulator

Research objectives

1. planning/replanning/plan-repair
   - levels of granularity
   - flexible horizon

2. continuous distributed planning
   - individual vs. collective vs. reactive planning

3. adversarial reasoning
   - patrolling of mobile targets
   - smart targets modelling
Mixed simulations

Transfer the developed algorithms to mixed simulation.

- algorithms $\mapsto$ real robots
- mixed-simulation = reality + simulation

Benefits:
- cost
- rich testbed
- preservation of requirements: deployment vs. simulation

Towards multi-robotics and explicit/implicit MAS coordination.
Demo

On-going and future work
Conclusion

- simulations and prototype-oriented work
- high-fidelity + mixed simulations:
  - path planning vs. vehicle dynamics
  - technology transfer methodology
- military settings:
  - scripting + planning
  - human-robot interaction
  - planning on strategic vs. tactical levels → integration
Thank you for your attention.