Universitatea Politehnica București

Facultatea de Automatică și Calculatoare

Catedra de Calculatoare

Formation Flight for Unmanned Aerial Vehicles

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Presentation Layout

- Domain
- Autonomous UAV
- Hirrus
- Platform Objectives
- Platform Simulation Architecture
- Autopilot Architecture
- Thesis Objectives
- Formation Flight
- Types of Formation
- Tested Formations
- Evaluation and Results
- Conclusions and Future Work

UAV (*Unmanned Aerial Vehicle*)

- no pilot **on board**
- remote controlled or
- completely autonomous
- envisioned by N. Tesla in 1915
- used in military and civil missions
- rotor based or fixed-winged

Figure 1: Fixed-wing UAV with surmountable camera [1]

About:

- in collaboration with *Teamnet International S.A.*
- aims to build a management platform for a fleet of UAVs

Objectives:

- development of an autonomous flight software agent embedded on Raspberry PI for Hirrus
- development of a software platform for programming, monitoring and autonomous mission deployment for UAVs

Platform Objectives

- Ground Control System (based on QGroundControl)
- Mission Monitoring System
- Adding *collision avoidance* and *formation flight* capabilities to the Hirrus Autopilot
- Designing and implementing an embedded AI software agent responsible for mission management (re)planning and execution

Figure 2: Hirrus UAV [2]

Destination	law enforcement, reconnaissance, search and rescue, cartography
Dimensions	Wingspan 2.35 m / Length 1.1 m / Weight 7 kg
Speed	Max 130 km/h, Cruise 90 km/h
Payload	0.7 kg
Propulsion	Electric
Endurance	180 min
Range	15 km

- simulated using Rascall Drone

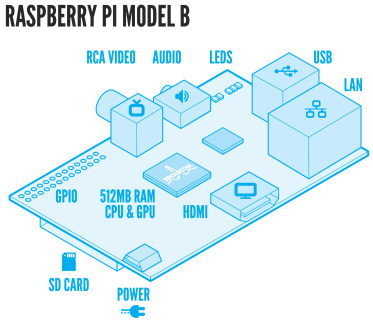

Figure 3: Raspberry PI

Figure 4: Flight Gear Flight Simulator

Figure 5: QGroundControl

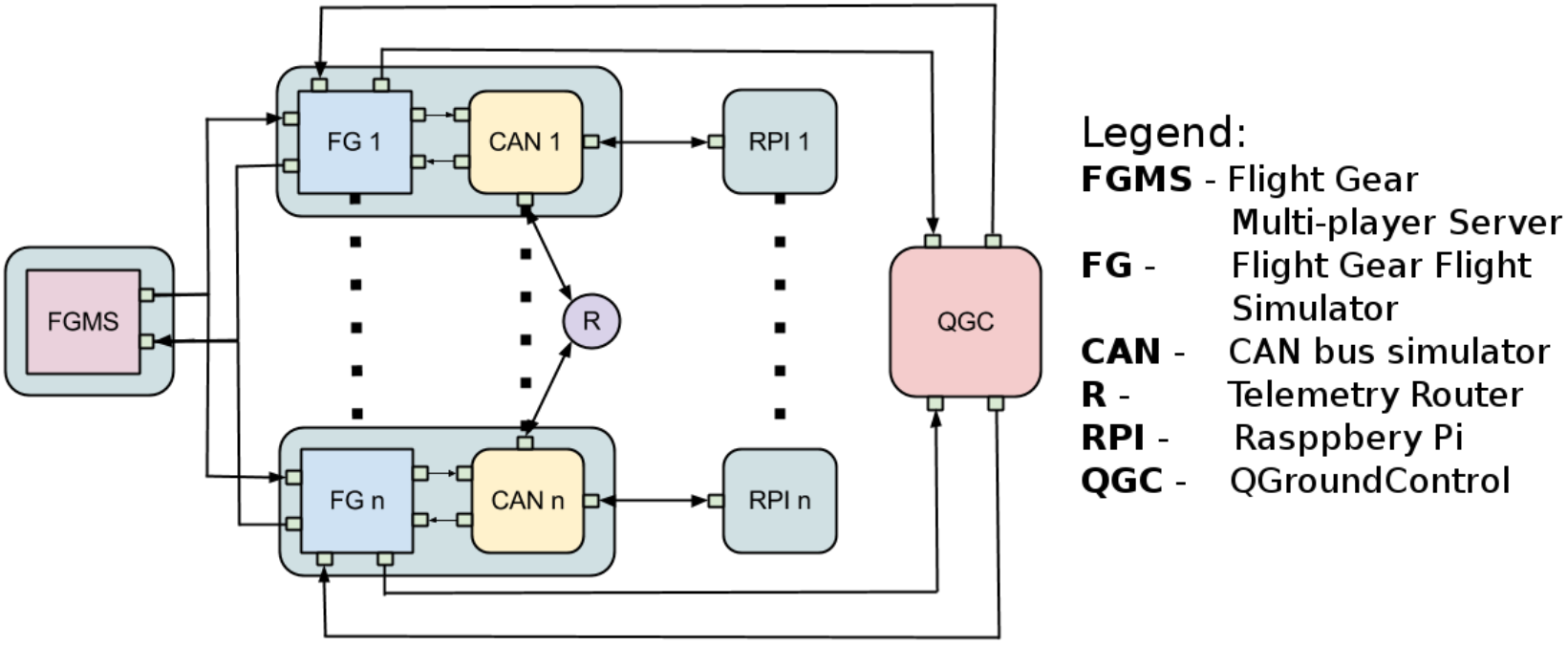

Figure 6: Platform Architecture

Embedded Software Agent Architecture

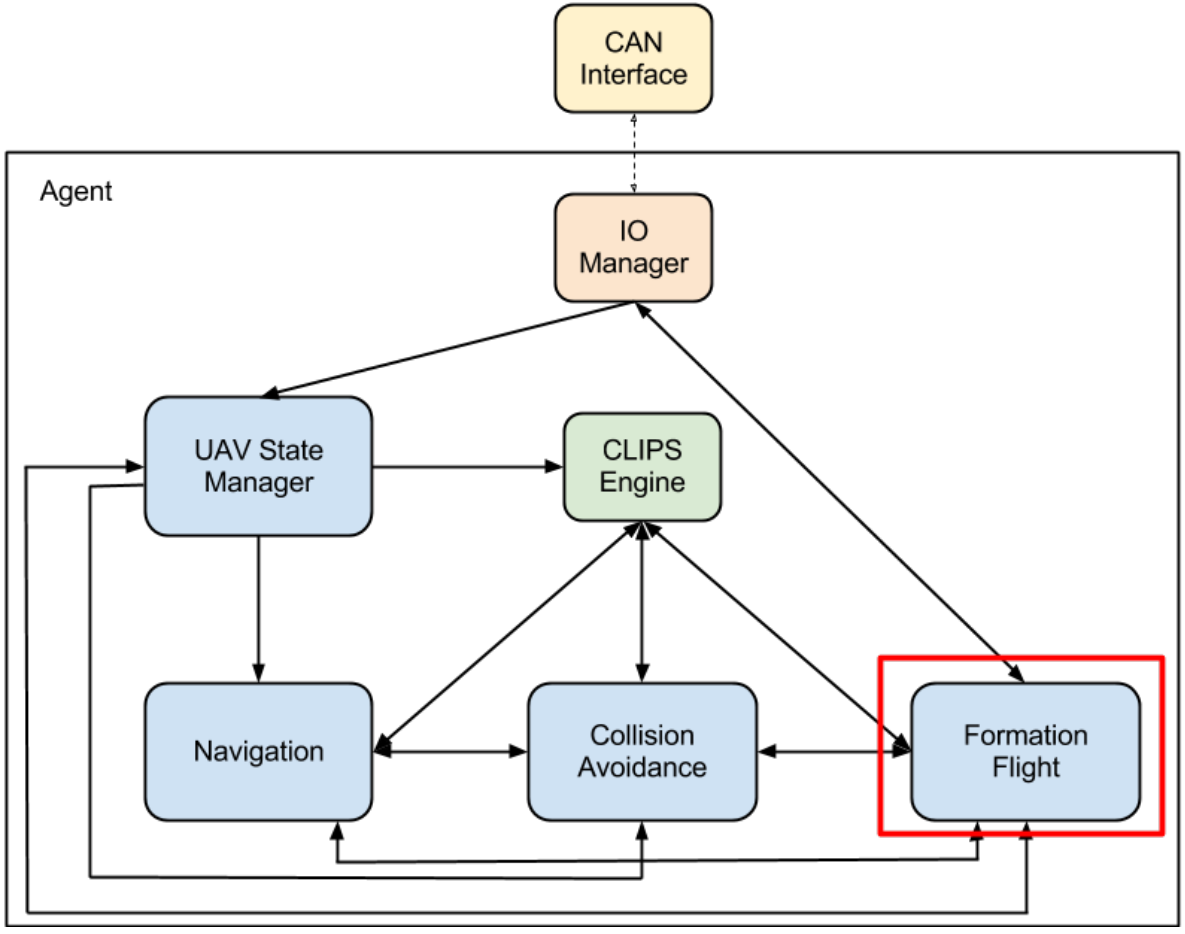

Figure 7: Embedded Software Agent Architecture

Thesis Objectives

- close range formation flight module
- using decentralized communication
- multi agent system with reactive agents inspired by swarm structures and behavior models
- 3 or more UAVs flying in formation
- drones flying at close range

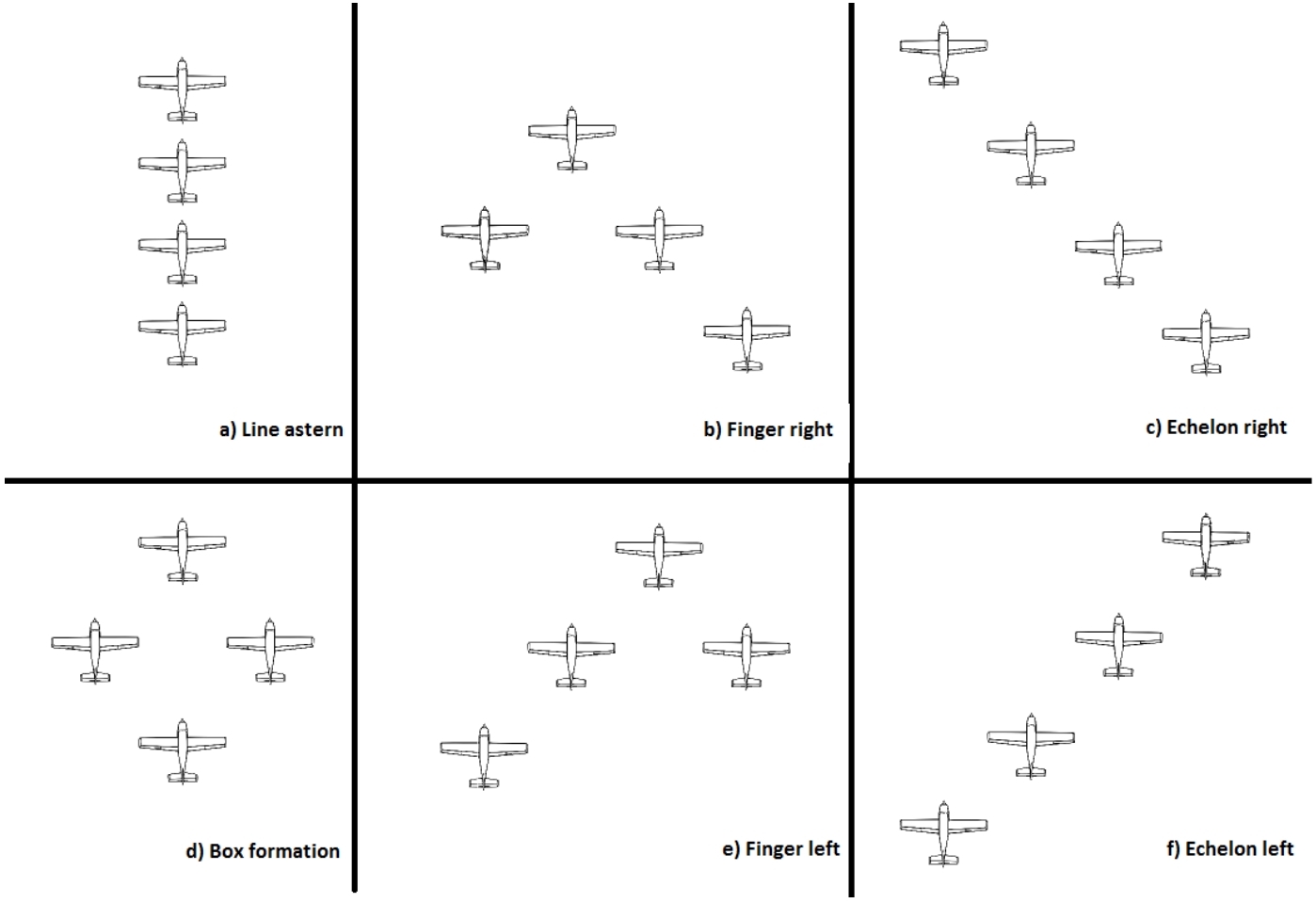

Figure 8: Formation Types

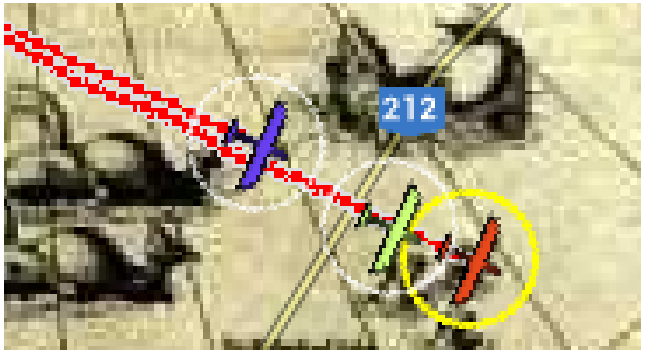

Figure 9: Top view of Line Astern

Figure 10: Top view of V Formation

Implementation details

- follow the leader behavior
- GPS and ECEF coordinates based on WSG84 ellipsoid
- *variable matching behavior* for formation maintaining
- *follow behavior* for entering formation
- C++ with Boost library code base

Evaluation and Results

- tested with dedicated leader
- leader with predefine mission
- other UAVs have a *follow the leader* behavior
- communication delay increases probability of breaking formation and increases efforts for formation maintaining
- 300 feet ($<$ 100 m) distance between UAVs
- for closer formations a more robust coordinate system is needed
- computational errors are induced by the ellipsoid model while converting coordinates

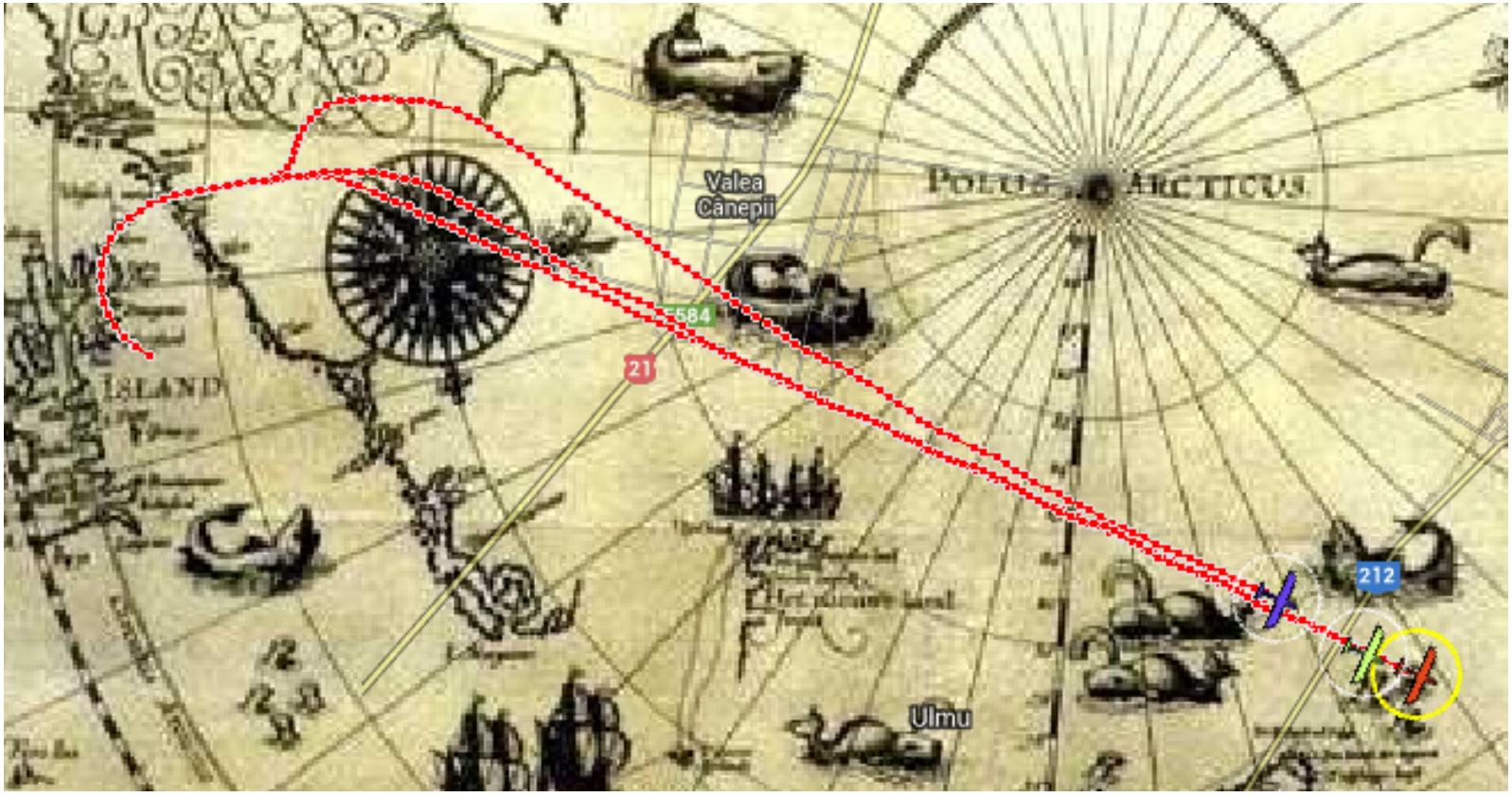

Figure 11: QGroundControl flight path for Line Astern simulation

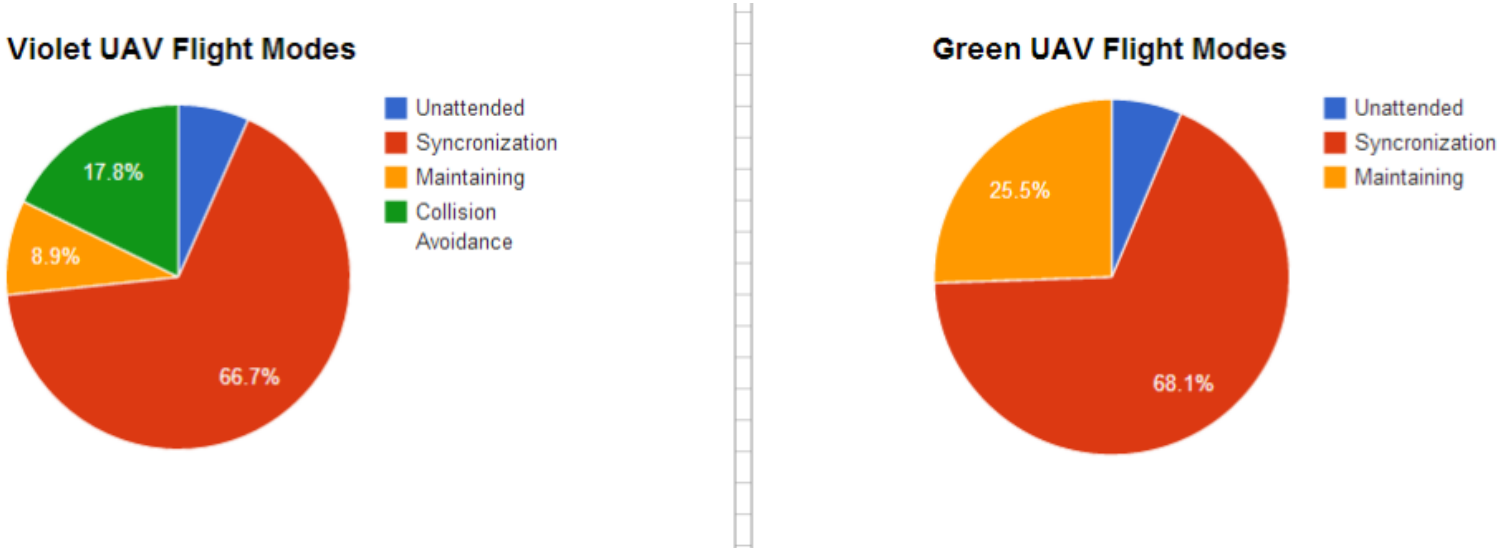

Figure 12: Time percentage of flight modes usages

Conclusions and Future Work

Conclusions:

- *Line Astern* and *V Formation*
- reactive software agent for formation flight
- decentralized communication

Future Work:

- formations based on a virtual leader (geometrical center of formation)
- simulating with Flight Gear instances running on dedicated machines
- communication between Raspberry PI (holding AI software agents) and Hirrus via CAN bus
- PID controllers for speed and steering

References

- *[1] http://http://aerosdb.com/uav-drone/*
- *[2] http://aft.ro/bro.pdf*

Q&A