WASP Overview and Public Safety Research Arenas

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Public Safety and Security

• The area of Public Safety and Security is growing both in Sweden and Europe

• Often extreme situations that require new (technical) solutions

• Dull, Dirty and Dangerous
WARA-PS: Search & Rescue

Scenario:
- Coastal Security Center receives alarms of people in the water
- Locate area for accident
- Navigate resources to the area and plan search patterns
- Deploy all resources and delegate tasks
- Search sea and land for distressed
- Identify, position and track all distressed
- Positions of survivors sent to sea rescue organizations
- Land UAVs and return to base
Scenario for basic system – Add WASP research components
Basic system – Add WASP research components
Autonomous Search and Rescue
Phase 1: Locating the relevant search area

Using the command and control system the operator instructs a high-altitude UAV (Yamaha R-Max) with IR and video sensors to fly to the area and initiate a search pattern to try to detect wreckage and people in the water. Interesting objects are highlighted to the operator for further analysis.
Phase 2: Deploying the resources to the search area

Once the operator and the system has identified a possible crash site, he/she deploys multiple autonomous boats (Piraya and RHIB) to the area and initiates search patterns to locate people in the water. Optimal search patterns are decided based on correlation of reports with meteorological conditions, wind, current, temperature. The high-altitude UAV sends continuous updates on positions of interesting objects that the USVs need to examine in more detail.
Phase 3: Locate and track the survivors

The survivors of the accidents are spread out over a fairly large area with shallow water, lots of small islands and underwater reefs. The USVs (Piraya) and RHIB start conducting a more detailed search pattern. Four smaller UAVs (DJI) are released from the RHIB and initiate a collective search pattern of sea and land using camera and IR-sensors. Data from all sensors are correlated and presented to the operator. Life wests and rubber rafts are dispersed from UAVs and USVs.
Phase 4: Return to base
Helicopters and coast guard arrives and starts to lift people out of the water and rafts. UAVs and USVs continue a search pattern for people in the water and on land. Oil spill from the sunken boat is identified and clean-up crew is directed to the site. Batteries on the DJIs are running low. They need to land on the RHIB or nearby islands.
View from the Surface and the Air
Research Challenges

• Situation Awareness
  • Mission planning
  • Intelligence / Analytics / Deep Learning / Data Fusion
  • Stream Reasoning / Subscriptions on streaming data
  • Visualization
  • Error detection and analysis
  • Information criticality
  • Human Computer Interaction
  • Digital Cognitive Companion
  • Augmented reality
  • New display and interaction systems

• Situation Readiness
  • Plan, prioritize with limited resources
  • Resilience, Graceful degradation

• Intelligent collaborative autonomous systems
  • Planning / Configuration
  • Positioning / Navigation / Collision avoidance
  • Control / Decision Making
  • Task allocation among cooperative platforms in a team, SWARM
  • Coordination and control of multiple platforms
  • Coordination / Many-to-many operations
  • Adjustable autonomy / Mixed Initiative / Interaction
  • Hierarchical / Centralized / Decentralized
  • Many abstraction levels for tasks, information, coordination, decisions
  • Incomplete Information
  • Inspection, Monitoring, Diagnosis, Recovery
Research Challenges

• Perception and Learning
  • Computer Vision, identification, tracking, and localization of objects in complex scenarios
  • Prediction of behaviour of individual objects as well as complex systems and scenarios
  • Machine learning, Deep Neural Networks and reinforcement learning
  • Learning for visual navigation of UAVs

• Mission-critical Cloud / Autonomous Cloud
  • Managing very high load (complex scenario) in a time-critical Cloud system
  • Managing and predicting variability in load
  • Adapting service level to complexity and urgency (graceful degradation, preserving safety also in very demanding situations)
  • On-line distributed analytics for a global knowledge base meeting requirements on response time and resource utilization

• Communication
  • Demands on latency, availability (quality-of-service), and bandwidth
  • Demands total load
  • Deployment and architecture aspects
  • Machine to Machine Communications, Networked Control Systems
  • Communication (C2 vs Data)/Ground vs intra-swarm, Robustness
Research Challenges

• Sensor and Communication networks
  • Resource management over large networks
  • Self-awareness and distributed data sharing
  • Robust sensors for harsh environments
  • Management of sensors and sensor data
  • Multi-sensor fusion
  • Middleware for service-based distributed systems

• Localization
  • Object localization using multiple technologies
  • Sensor fusion and learning
  • Motion planning and decision making
  • Localization in sparse sensor environments

• Software and Scalability
  • Methodology and tools to design and verify large-scale distributed systems
  • System Integration
  • Systems of systems
  • Life Cycle Management
  • MBSE (Model Based Systems Engineering)
Research topics of PhDs

- Command and control of UAV/USV, Martin Pallin
- Coordinated motion planning, Sense & avoid, Kristoffer Bergman
- Augmented reality to improve operator situation Awareness, Mårten Lager
- Positioning without GPS, Bertil Grelsson
- Semantic Image Segmentation, Emil Brissman
- Control of UAVs using sensor/planning information, Per Boström
- Identify objects in video stream, Gustav Häger
- Search using saliency map, Olov Andersson
- Sematic structure from motion, David Gillsjö
- Resource management over large networks, Alexandre Martins
- Unsupervised learning of spatio-temporal models, Mattias Tiger
- Motion Planning, Oskar Ljungqvist
- Optimal Rendezvous Control for UAV, Linnea Persson
- Cloud based sensor fusion with high demand in latency and availability, Per Skarin,
High level time plan

Scenario Definition
System Definition
PhD research matching
Project course
Demonstrator development
Research Integration
Research Integration
Demo
Demo

2017 2018 2019
Task Delegation and Planning Framework

Mission User Interface
- Goal request TST
- Collaborative plan TST

Platform-specific functionalities
- Functionality Requests

Distributed Delegation Process
- Delegation Module
- Platform-specific functionalities

Platform 1: RMAX

Task Representation: Task Specification Trees (TSTs)
WARA Core System

- Yamaha R-MAX Autonomous Helicopter
  - IR and HD Cameras
  - Intel NUC
- UMS Skeldar Large UAV
  - IR and HD Cameras
  - Intel NUC
- 4 DJI Matrice 100 UAVs
  - IR, HD, Laser range finder
  - Intel NUC
- 2 Kockums Piraya USV
  - Axis PTZ Cameras
  - Intel NUC
- Autonomous RHIB
  - Axis PTZ Cameras
- Coast Guard Chase Boat
- UAV Ground stations
- LTE/WIFI communication
- LiU Delegation Framework
- C2 Operator Stations
- Saab SAFE C2 System
- Saab Naval SE C2 System
- WISE System integration SW
- Ericsson (Edge) Cloud Service
WARA PS Core Team

- Martin Rantzer, Saab Aeronautics
- Lars Rundqvist, Saab Aeronautics
- Mikael Lindberg, Axis
- Jens-Olof Lind, Saab Kockums
- Jonas Rosqvist, Saab Kockums
- Johan Eker, Ericsson
- Björn Löfdahl, Ericsson
- Ingemar Johansson, Combitech
- Jesper Tordenlid, Combitech
- Tomas Dahqvist, Saab Surveillance
- Anders Persson, UMS Skeldar
- Patrick Doherty, LiU
- Jonas Kvarnström, LiU
- Mariusz Wzorek, LiU
- Piotr Rudol, LiU
- Tommy Persson, LiU
UAV Testbed - Västervik

• No military or civil flight restrictions applicable for the test range
• Test range of 40 x 60 km and up to 2500 meters
• Situated at the municipal airfield in Västervik
• Test area encompass all terrain types, except mountains
• Application for restricted airspace (R-area) to Transportstyrelsen
UAV Testbed - Västervik

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Område A, B, C, D

GND - 7000 ft MSL