Methods and System Design of the FOI Information Fusion Demonstrator – IFD03

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Outline

- Introduction
- Information Fusion Methods
  - Force Aggregation
  - Tracking
  - Sensor Resource Management
- System Description
- Conclusion
Introduction

- What is the IFD03?
  - A *concept* demonstrator for information fusion methodology in a future Network Based Defence C4ISR system
  - Focus on analysing intelligence reports at the division level in a ground warfare scenario

- Reasons for building the IFD03
  - Explore how fusion methods can be combined in a single system
  - Show information fusion in a concrete fashion to our customers
Scenario → Fusion Node

Log

Visualizer
Information Fusion Methods

- Force Aggregation
  - Clustering
  - Classification

- Ground Vehicle Tracking
  - PHD Particle Filter

- Sensor Resource Management
  - Random Set Simulations
Force Aggregation

- **PROBLEM:** Determine positions and organizational structures of enemy units
- **SOLUTION:** Dempster-Shafer Clustering and Classification
Aggregation = Clustering + Classification

- Clustering of intelligence reports
- Clustering of vehicles
- Clustering of platoons
- Clustering of companies
- Classification of vehicles
- Classification of platoons
- Classification of companies
- Classification of battalions
Clustering

- Evaluate all pairs of intelligence reports
- Find whatever is against that two reports are referring to the same object
  - Wrong type of vehicle? (Dempster-Shafer conflict)
  - Is distance too long?
  - Wrong direction?
- This yields a potential conflict between each pair of intelligence reports
Cluster example:
31 intelligence reports are clustered into 5 clusters
Classification

40% "3 T-80"
20% "2 T-80 + 2 RPG-16"
10% "4 T-80"
20% "2 MBD-1 + 1 T-80"
10%...
Ground Vehicle Tracking

- **PROBLEM:** Tracking of a large number of vehicles in terrain from incomplete observations.

- **SOLUTION:** PHD Particle Filtering
  (PHD = Probability Hypothesis Density)
PHD Particle Filtering – Approach

- We track the first moment of joint distribution, i.e., PHD
  - Integral of PHD over an area is expected # targets – compare with PDF with integral 1
  - Avoids combinatorial explosion – good for large number of vehicles

- Here – particle filter implementation
  - No need for analytical motion and observation models
  - Suitable for non-linear problems
PHD Particle Filtering – Illustration

- A PHD is represented by $N \times 500$ particles
- $N$ is expected number of targets

- Posterior at $t-1$
- Propagate
- Prior at $t$
- Multiply with SUM of likelihoods
- Resample
- Posterior at $t$
Sensor Resource Management

- **PROBLEM:** Given positions and possible strategies for the enemy, find an optimal sensor control policy
- **SOLUTION:** Evaluate sensor allocations by simulating different futures
Enemy positions now
One possible future path

Sensor doesn’t hear tanks!

P = 0.4
Another possible future path

P = 0.6

Tanks are observed!
Sensor Resource Management

- Compare pre-determined sensor allocations
- Best sensor allocation is determined by averaging over many possible future paths
System Description

- Simulation Framework (Flames)
- Terrain model generator (Terra Vista)
- Analysis methods implemented in Matlab
ICCRTS-04 Christian Mårtenson

MatlabFlames (C)

Visualizer

Terrain model

Scenario

Fusion Node

Aggregation

Track

Sensor Resource Management

Log

Actors

Platforms

Sensors

Communication

Cognition

Visualizer

Scenario

Flames (C)

Matlab
Visualizer

Intelligence/ Ground truth

Aggregation/ Track

Parameters/ Sensor Management
Conclusion

- We have developed a concept demonstrator for information fusion methodology
- Focus on intelligence processing at the division level
- A demonstration of IFD03 in December 2003 for the Swedish Armed Forces was a great success
Questions?

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