Surveillance in an Urban environment using Mobile sensors

The EDA SUM Project

2012, September 13th - FMV SENSORS SYMPOSIUM 2012
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SUM PROJECT DESCRIPTION
INTRODUCTION


- 3rd Call “Data Analysis, including Data Fusion from various Sources” in May 2008.


- Consortium led by GMV (Spain) including:
  - RMA Royal Military Academy (Belgium).
  - TUM Technische Universität München (Germany).
  - DLR Deutsches Zentrum für Luft und Raumfahrt (Germany).

- Project Kick-Off Meeting in July 2009.

- Project duration: 36 months. PM06 held on July 2012.
PROJECT OBJECTIVES

- Obtain a real time reliable estimation of localization and classification of different type of threats.

- Disseminate this information in a proper manner optimizing the resources for neutralization.

- Design and development of:
  - Low cost demonstrator.
  - Multi-sensor vehicle protection system.
  - Enhancing situational awareness.
  - Providing C4ISR capabilities.
  - Urban environment.
TECHNOLOGICAL CHALLENGES

- Sensors & data acquisition:
  - Very different states of maturity (off-the-shelf, from scratch)
  - Fusion of very different types of data.
  - Different acquisition parameters (FoV, refreshing time, resolution).

- Processing & Fusion:
  - Classification of threats.
  - Temporal and spatial alignment of sensors and data fusion engine.
  - Combination of field sensory and additional auxiliary data.

- Man-machine interface:
  - Creating intuitive interface & Reducing cognitive load.
  - Integration into a C4ISR system.
  - Exploitation of the information provided by other systems on the battlefield.
PROJECT SCOPE

- Propose and develop several innovative concepts and approaches for a multi-sensor vehicle protection system.

- Implement a demonstrator including several of these concepts.

- Test these concepts and get some assessment about their utility.

- Describe the findings, establish some recommendations and produce a roadmap to achieve the goal.
PROJECT GUIDELINES

- Multi-sensor system:
  - Millimetre-wave Radar.
  - Millimetre-wave Radiometer.
  - Infrared imaging system.
  - Optical imaging system.

- Supported in addition by auxiliary data sources (e.g. images from UAVs and satellites).

- Incorporation of context and collateral intelligence information including the domain knowledge.

- Comprehensive data fusion mechanisms to exploit the synergies among the different sensors.

- The real time threat information is presented adequately through a specifically designed HMI.
PROPOSED SOLUTION

auxiliary data
maps, city models
GPS position/orientation

data processing & fusion
candidate threats
final fusion
threat map

UAV / satellite sensors
fusion
a priori
risk map

low update rate
high update rate

ground sensors

The EDA SUM Project
PROJECT OVERVIEW

The EDA SUM Project
SUBSYSTEMS DESCRIPTION
MMW RADAR (I)

- E-Band: 72...79 GHz.
- Array of 4 transmitters, 4 receivers (horn antennas).
- Stand-alone system with own processing unit.
- Delivery of radar pictures in 3 different operational modes.
- Short reconstruction time for imaging.
- Feature extraction and list of targets by Constant False Alarm Rate post-processing.

<table>
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<th>Surveillance Mode</th>
<th>High Resolution Mode</th>
<th>Imaging Mode</th>
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MMW RADAR (II)
RADIOMETER

Technical main characteristics

- Spatial resolution: 0.75°
- Image size elev. x azim.: 30° x 80°
- Frame rate: 1 s
- Sensitivity in the image: < 2 K
- Data rate: < 500 kB/s
- Estimated size: 1.4 x 0.7 x 0.7 m³
- Estimated weight: < 65 kg
- Detection range: up to 100 m

Solved challenges

- Low-cost system (only two receivers).
- Wide field of view at high frame rate.
- High-speed rotation of deflection plate (air resistance).
- Proper drive rules for seesaw motion.
- Low total receiver noise (attenuation of optical signal path) and high sensitivity.
- Compact design even for demonstrator.
VISUAL & IR CAMERAS

- Isolines projected on the frames to give a framework for localization of the threats.

- Fit is rather sensitive to the vehicle position (pitch), accurate ground grid is essential.
DATA FUSION

Sensor weighted voting $= f(\text{auxiliary data})$

The sensors "vote" for each candidate.
MAN MACHINE INTERFACE (I)

- Provides effective mechanisms to convey the threats detected to the operator:
  - GIS.
  - Displaying the threats over the acquired images.
  - Threat info viewer.
  - Warnings: pop-up, voice warning.
  - Reporting is configurable beforehand and on the field.

- Embedded into a vehicle-based C4ISR system:
  - Sharing capabilities and equipment.
  - Avoiding redundancies.
  - Incorporation of C4ISR data: navigation, tactical information.
  - Mission planning, monitoring and control and post-analysis.
  - Access to external C4ISR systems (including info from UAVs and satellites).
MAN MACHINE INTERFACE (II)

- Sensor viewer:
  - Displays the image acquired by the sensor.
  - Allows switching between the visible camera, the infrared camera, the radiometer and the radar.
  - Threats’ locations on the image.

- Threat info viewer:
  - Detailed info about the current threats.
  - Relative position: range, azimuth and elevation.

- GIS:
  - Map of the area.
  - Own position.
  - Absolute positions of the threats.

- Sensor Viewer History (Image List).
- Threat Info History (Threat List).
MAN MACHINE INTERFACE (III)
MAN MACHINE INTERFACE (IV)
SUM DEMONSTRATOR DESCRIPTION
DEMONSTRATOR ARCHITECTURE

VISUAL CAMERA

VIDEO + DATA FUSION SERVER

IR CAMERA

RADIOMETER

RADIOMETER SERVER

RADAR

RADAR SERVER

SWITCH

TABLET: MMI
DEMONSTRATOR VEHICLE (I)

Vehicle (Unimog) with all ground sensors will perform the demonstration trials:

- Ground sensors were mounted on the rooftop of the vehicle and will observe the area ahead.
- Sensor subsystems were connected to data fusion engine and MMI.
- Sensor operators supervised the subsystems from inside the vehicle.
- Vehicle operator supervised the data fusion results on the MMI.
DEMONSTRATOR VEHICLE (II)

- Radiometer
- Cameras
- Radar

- Radar supply
- Radiometer rack
- Data fusion Engine rack
A Geographical Information System will be integrated in the MMI showing:

- Geo-referenced map (or even pictures).
- A Digital Terrain Model (DTM).
- Common Relevant Operational Picture, including:
  - patrol position.
  - pre-loaded intelligence data.
  - detected threats.
  - sensors vision area.
  - routes if they are defined.
  - others.

- Different layers and filters to show information.
DEMOnSTRATION SITE (II)
Heverlee military area coordinates: 50°51′12.74″ N; 4°42′36.48″ E
DEMONSTRATION SCENARIOS

- Scenario 1: Two garbage bags at roadside.
- Scenario 2: Two cardboard boxes at roadside.
- Scenario 3: Two barrels at roadside, one standing, one laying.
- Scenario 4: Two barrels covered / camouflaged.
- Scenario 5: Two metallic trigger plates, one at roadside, one in the middle.
- Scenario 6: Two metallic trigger plates covered / camouflaged.
- Scenario 7: Two person at roadside, one with backpack.
- Scenario 8: Two person at roadside, one with RPG.
SCENARIO TRACK

Stretch of road ca. 100 m long:
SAMPLE SCENARIO 1

Scenario with garbage bags (one explosive IED simulant):
SAMPLE SCENARIO 4

Scenario with covered / camouflaged metallic barrels (one explosive IED simulant):
SAMPLE SCENARIO 7

Scenario with two persons (One person with explosive backpack simulant):
CONCLUSIONS & ROADMAP
CONCLUSIONS (I)

- Multi-sensor approach has been validated:
  - Increase in potential sensory sources of threat detection.
  - Radiometer, radar and image technologies have shown their feasibility for threat detection.
  - Taking advantage of the synergies between them.
  - Data Fusion is able to provide a better result than each one of the sensory technologies by itself.
  - Improving the sensors technology directly leads to an enhancement in SUM performance.
CONCLUSIONS (II)

The detection and localization of the threats should be focused on a multi-sensor approach to consolidate the advantages achieved by exploiting multiple signatures of a threat:

- Implementation of image processing algorithms detecting anomalous objects which represent suitable feature detectors of a potential threat.

- Advanced development of the radiometer and radar sensors for military platforms, getting adapted to severe constraints in weight, size, ergonomics and power autonomy for vehicle deployment.

- Incorporation of collateral information and domain knowledge.

- Implementation of enhanced fusion algorithms in order to search for threat patterns in the sensory data.

- Exploitation of the operative capabilities of the vehicle based system such as navigation, Geographical Information System and data from other C4I systems.
ROADMAP (I)

- SUM project has obtained promising results:
  - Threat detection systems will incorporate several of its concepts.
  - In any case, to properly follow SUM approach still some technological development is needed.

- Adaptation to Human Factors:
  - Reduction of weight and size.
  - Ergonomics.
  - HMI to reduce the cognitive load.

- Specification of the system:
  - It is fundamental to bring into the loop the players altogether.
  - Coordination of actors involved: Ministries of Defence, military experts and industry.

- Technologies used in SUM: Room for the enhancement of the performance by improving sensors and algorithms.
ROADMAP (II)

- SUM system could take advantage of the incorporation of other sensory technologies.

- Power autonomy, power management methods, new materials and techniques for power supply.

- 3D Positioning and Navigation especially in Urban Environments.

- Incorporation and exploitation of the information provided by other systems on the battlefield.

- Improvements in communication capabilities such as Quality of Service and securing the network.