Semantic Technology for Intelligence, Defense, and Security 2010:
Collected Imagery Ontology
Semantics for Airborne Video

Engineered for life
Overview of the Ontology Study & Model

- Vast amounts of collection information from persistent surveillance system will be stored in relational databases, including imagery, support and format metadata, process data, performance or quality information and exploited products.

- Ontologies can be used to better communicate the meaning and context of this data in a consistent manner. Initially, ontology terms are only used to represent a limited number of fields in a database. An ontology, in this context, essentially functions as a controlled vocabulary and few formal relations are used between database fields. A full representation of PS collection content, using a principled approach to ontology, encoded using a formal language such as OWL provides significant additional benefits.

- Benefits include data consistency checks, the ability to formulate highly expressive queries, and the potential for seamless interoperability with other data resources (e.g. SIGINT databases). The efforts of this program study are to make such a representation available for the IMINT and VideoIMINT Database for Persistent Surveillance collections.
Ontology Study Deliverables

1. IMINT Ontology (videoIMINT considerations) in OWL
2. Infrastructure for Motion Imagery feature extraction
3. Motion Imagery support metadata extraction demo
4. Integrated 1, 2, 3 demonstration
5. Sensor/UAV tasking approach (using Ontology)
6. Final Report
Preliminary IMINT Ontology Class Structures

• Platform Sensor and Sensor Operation
  – Platforms
  – Sensors
  – Operational Parameters
  – Calibration and Quality Metrics

• Collection and Collection Performance
  – Collection Variables
  – Collection Operational Parameters
  – Sensor Performance Metrics

• Mission and Targets
  – Mission Description
  – Detection and Characterization Requirements

• Imagery and Exploitation Products
  – IMINT Data Hierarchy
  – Product Descriptions
  – Product Utility
  – Data Assurance Metrics

• Integrated Ontology
  – Relationship and Rule Algorithms

\[ Task = \text{Upper Domains} \]

\[ Task = \text{Define Properties} \]
Platform Sensor Ops Ontology

Assets …
- Aircraft
  - Type
  - Tail No.
  - With a sensor s2
  - Has parameters
    - Array density
    - Optical FL
  - Has calibration history
    - Accuracy, Precision
    - Detection response
- @ time = tn … With sensor sn

Ops Domains
- Platforms
- Sensors
- Operational Parameters
- Calibration and Quality Metrics
Ontology should provide a means to…

- Utilize information from sensor metadata
- Visualize sensor coverage in Google Earth
- Provide metrics for Mission Assurance
Dynamic Collection Ontology

Collection Domains
- Collection Variables
- Collection Operational Parameters
- Sensor Performance Metrics

Collection Variables
- Dynamic Oblique Footprints:
  - Red \( s_1 \)
  - Green \( s_2 \)
  - Orange \( s_3 \)
  - Brown \( s_4 \)
  - Yellow \( s_5 \)
  - Magenta \( s_6 \)

Sensor Performance
- Type:
  - \( s_2 \) has view
    - GSD
    - IFOV
    - LOS
    - With sensor \( s_n \)

Collection Operational Parameters

Sensor Performance Metrics

Single Platform, 6-Pack of Cameras
Multiple Platforms, Single cameras

@ time = \( t_0 \)...

Circle of Persistence

\( \text{time} = t_0 \)...

\( \text{time} = t_1 \)...

\( \text{time} = t_2 \)...

\( \text{time} = t_n \)...

... Calculate

GSD

IFOV

Asymmetric Considerations

Altitude

Scanning

Line of Sight

Radius of Earth

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Mission & Target Ontology

Mission Domains

- Mission Description
- Detection and Characterization

Integrated Air Defense System

Mission / Target
is_a Type
- Convoy support
- Track
  - Vehicle
    - Person
  - Ship
  - Aircraft
  - Aid Defense Suppression
    - Manpad
    - IADS
  - Sensor Rqmts (optimize)
  - ROI (extent)
  - Materiel
  - Context
Ontology should provide a means to…
• Visualize sensor collection
• Utilizing imagery data and sensor metadata for registration

Point to image for metadata, icon tagging…
Product and Exploitation Ontology

Product Domains

- IMINT Data Hierarchy
- Product Descriptions
- Product Utility
- Data Assurance Metrics
- Feature Extraction
Classification & Semantic Search
The Principal Subtypes of Entities

The **dependent** side of the divide defines information objects such as the output of imagery capture and the variable characteristics of objects such as altitude, speed, and direction.

The **independent** side of the divide defines objects of the domain, their parts and the composites they sometimes form.
Objects –
The Kinds of Individuals of the Domain

Subtypes of Facility include:
- Airport
- Control Tower
- Hangar
- Runway
Metadata Scalar Measurements

- The Subtypes of Scalar Measurement Include:
  - Corner Latitude Point 1
  - Corner Latitude Point 2
  - Corner Latitude Point 3
  - Corner Latitude Point 4
  - Corner Longitude Point 1
  - Corner Longitude Point 2
  - Corner Longitude Point 3
  - Corner Longitude Point 4
  - Density Altitude
  - Frame Center Elevation
  - Frame Center Latitude
  - Frame Center Longitude
  - Ground Sample Distance
  - Image Bearer Height
  - Image Bearer Horizontal Coordinate
  - Image Bearer Vertical Coordinate
  - Image Bearer Width
  - Modulation Transfer Modulation Measure
  - Outside Air Temperature
  - Pixel Depth Value
  - Platform Heading Angle
  - Platform Indicated Airspeed
  - Platform Pitch Angle
  - Platform Roll Angle
  - Platform True Airspeed
  - Sensor Horizontal Field of View
  - Sensor Latitude
  - Sensor Longitude
  - Sensor Relative Azimuth Angle
  - Sensor Relative Depression Angle
  - Sensor Relative Roll Angle
  - Sensor True Altitude
  - Sensor Vertical Field of View
  - Slant Range
  - Static Pressure
  - Target Width
  - Unix Timestamp
  - Wind Direction
  - Wind Speed
Characterizing the State of Real-World Objects by Relating their Properties to Data

- a Sensor is part of a UAV
- Platform Tail Number identifies Platform True Airspeed
- Platform Airspeed has value of 90 MPH
- Platform Pitch Angle has value of -3 degrees
- Platform Location identifies a Roll
- a Speed is measure of a Pitch
- a Roll identifies a Location

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Sample Screenshot for Proof-of-Concept Demo

All data is stored and displayed based on the ontology

GV3.0 Viewer Interface

Tracked Objects in Video. Also indicates location within video

Known objects in video or mission

Create a new object in the video

Video information

Sensor measurements of selected object

Sample Screenshot for Proof-of-Concept Demo
General Architecture of Utilizing Ontology

- Video Feed (MPEG)
- Sensor Data Input Processor
- Image Processing Algorithms
- Ontology
- GV 3.0 Viewer
  - GV 3.0 Core
  - Ontology Plugin
    - Jena Ontology API

Visualization Panes
- Known Artifacts
- Tracked Artifacts
- Measurement / Pedigree View
- Video Information View
Level 1 Interface Mock Up
Summary

- The volumes and temporal nature of persistent surveillance collection information include imagery, support and format metadata, process data, performance or quality information, and exploited products.
- Ontologies can be used to better communicate the meaning and context of this data in a consistent manner.
- A full representation of PS collection content, using a principled approach to ontology domains and properties, encoded using a formal language such as OWL provides significant benefits.
- Benefits include the ability to formulate highly expressive queries, data consistency checks, and the potential for seamless interoperability with other data resources.
- The long term efforts of this program will make such a representation available for the IMINT and VideoIMINT Database for Persistent Surveillance collections.