OVERWATCH™

TEXTRON Systems

Enhanced Decision Support with Adaptive Data Fusion

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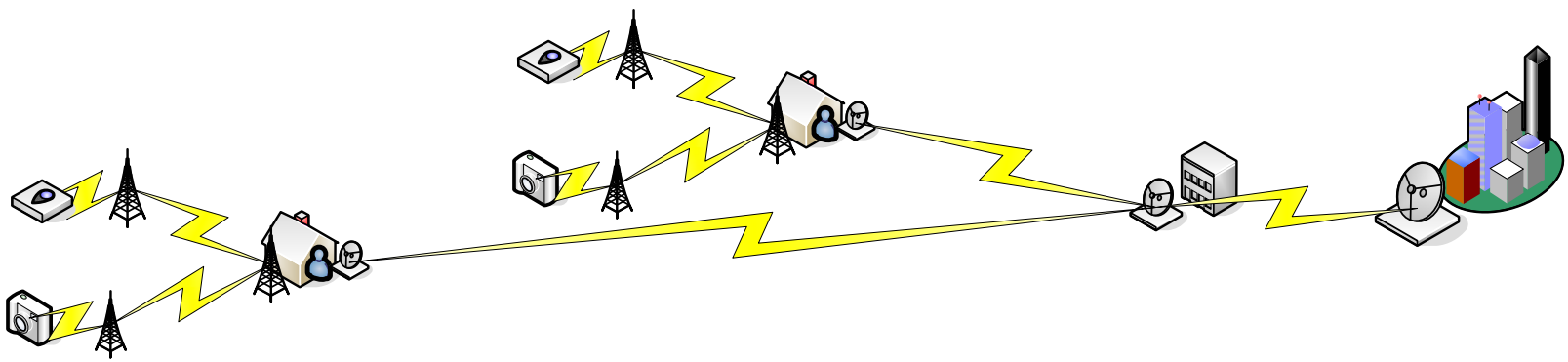
Goal

- Provide semi-automated assistance to decision maker for resource allocation issues
  - What data to send over scarce communications bandwidth
  - Where to focus limited number of analysts
  - Where to focus sensors
  - When to change focus
- Get the right people looking at the right data sooner



Approach

- Use all available (archived) sensor and event reports to train a filter to monitor sensor report stream
  - Results of training allow:
    - Reduce amount of real-time, high priority, data sent from sensor to processing node by selecting most relevant subset of data
- Monitor filter performance to determine when something has changed:
  - Sensor relevance/performance
  - Tactics of sensor targets

Motivation

- Too much raw data to send from collection nodes to processing nodes in real-time over limited bandwidth links
- Too much raw data to process in real-time from collection nodes at processing nodes
- We need to limit what we process and still produce relevant results
- We need to determine when we need to change what we use as input

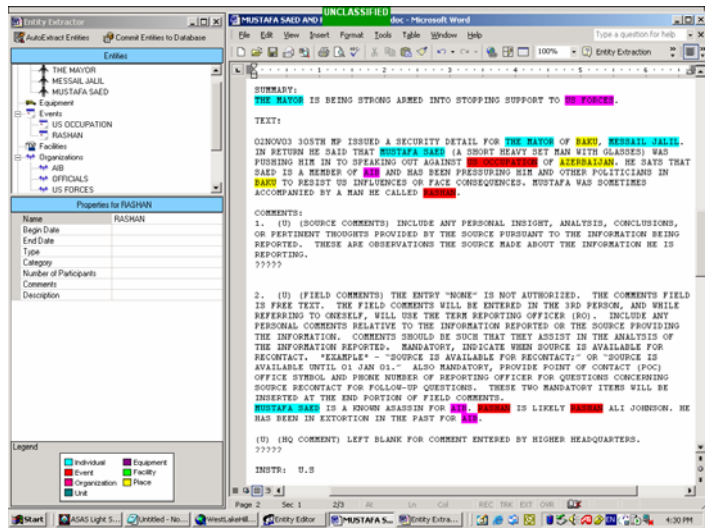
Process

- Observe sensor reports - HUMINT sensors and SIGINT internals
- Use current archive of reports to generate patterns of interest (e.g. correlated with events of interest) by training the system with complete set of archived reports
- Select relevant sensor reports (features) to reduce delay from collection to finished processing - Soft Retasking™
- Train the system using selected sensor reports (features) to identify patterns of interest
- Use trained system to process selected sensor reports
- When system needs to add/learn a new pattern, restart process with training the system with complete set of archived reports

Sensor Reports

- Use attributes from HUMINT and SIGINT internals reports as sensor inputs
- Sources of attributes
  - Individual fields as applicable and available
  - Extracted entities and attributes from reports and transcripts
    - Other projects working on this aspect
- Use generated data for testing:
  - Three Bayesian Belief networks for (Actor, Action, Target) generate data.
  - Based on factors that are plausibly connected to end-state attribute of each.
  - Conditional probability tables that relate these factors to the (Actor, Action, Target) end state selection implicitly represent adversarial tactics and are, in fact unknown.
  - Change in values in tables represents change in tactics.
  - Goal is to recognize change and adjust processing to account for this change.

Raw HUMINT reports



Sample Sensor Reports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-[CASE-1]->~

.e created by PalmerJ at AustinInfo using Netica 1.12
 Jun 28, 2007 at 14:10:36.

 ActorThreat FinTies     Ethnicity   Wkly_Contact_Hostiles   Religious_Focus   Criminal_Focus    Religion    Actor_Ge
 Hostile     Direct      Arab  30.6085     Religious   Some  Shia  Male  Sibling     Normal      46.6888     Yes   Ye
 Neutral     None  Arab  18.57 Religious   None  Sunni Female      None  Zealot      30.0792     Yes   No
 Friendly    None  Kurd  1.48767     Zealot      Some  Shia  Female      None  Normal      62.1113     No    No
 Neutral     None  Arab  11.6549     Religious   None  Sunni Female      None  Zealot      29.0059     Yes   No
 Hostile     None  Arab  33.3205     Zealot      Some  Shia  Male  Uncle Zealot      47.3395     No    No
 Neutral     None  Arab  22.2961     None  None  Sunni Female      Village     Normal      6.65112     No    No
 Hostile     ShareBank   Turkmen     31.712      Zealot      Some  Sunni Male  Tribe Zealot      14.5116     No    No
 Friendly    None  Arab  2.59035     Religious   None  Christian   Male  None  Little      11.0394     No    No
 Hostile     ShareAcc    Arab  20.8006     Zealot      Some  Shia  Female      Sibling     Zealot      26.2274     No
 Hostile     Direct      Arab  21.0734     Zealot      Some  Shia  Male  Sibling     Normal      43.9205     No    Ye
 Hostile     ShareAcc    Arab  30.6085     Zealot      Some  Sunni Male  Tribe Zealot      23.9845     Yes   No
 Hostile     ShareAcc    Arab  34.46 Zealot      Some  Shia  Female      Sibling     Normal      33.4881     No    No
 Friendly    None  Arab  0.00136909  Religious   Habitual    Jewish      Male  None  Little      19.9033     No    No
 Neutral     None  Arab  0.251959    Religious   Habitual    Shia  Male  None  Normal      38.7663     Yes   No
 Neutral     None  Kurd  17.9544     Religious   None  Shia  Female      None  Zealot      42.0997     No    No
 Neutral     None  Kurd  17.2083     None  None  Sunni Female      Village     Normal      8.61916     Yes   No
 Friendly    None  Arab  2.73632     Religious   None  Sunni Male  Village     Normal      14.228      No    No
 Friendly    None  Turkmen     9.01729     Religious   None  Shia  Female      None  Little      14.4174     No    No
 Neutral     None  Kurd  21.5407     Religious   None  Shia  Male  None  Zealot      21.6535     Yes   No
 Hostile     ShareAcc    Arab  25.4288     Religious   Some  Christian   Male  Uncle Zealot      47.3212     Yes   Ye
 Friendly    None  Kurd  7.72351     Religious   None  Sunni Male  Tribe Normal      52.4941     No    No
 Friendly    ShareBank   Arab  6.78893     Religious   None  Shia  Male  Uncle Little      9.90032     No    No
 Hostile     ShareBank   Arab  33.817      Religious   Some  Shia  Male  Uncle Zealot      29.3863     Yes   No
 Friendly    None  Arab  14.5183     Religious   None  Hindu Male  None  Little      12.2821     No    No
```

Pattern Recognition - ARTMAP

- Adaptive Resonance Theory (ART) is a neural network architecture developed by Stephen Grossberg and Gail Carpenter
  - Build output categories to classify inputs
  - Carpenter, G.A. and Grossberg, S., 1987, “A massively parallel architecture for a self-organizing neural pattern recognition machine”, Computer Vision, Graphics, and Image Processing, 37:54-115
- ARTMAP learns to classify arbitrarily many, arbitrarily ordered vectors into recognition categories based on predictive success
  - Two ART networks
    - One for input observations
    - One for event/result observation
    - With network to link results of output and input networks
  - Carpenter, G.A., Grossberg, S., Reynolds, D.B., 1991, “ARTMAP: Supervised real-time learning and classification of nonstationary data by a self-organizing neural network”, Neural Networks, 4:565-588

Find Patterns of Interest

- Use current archive of reports to generate patterns of interest by training ARTMAP with complete set of archived reports
  - Input ART network gets sensor reports as input
    - Example: Financial Ties, Ethnicity, Religion, Gender, etc.
  - Event/Result ART network gets event or result reports as input
    - Example: Actor-Threat

System Training

- ARTMAP supports on-line and off-line learning
  - Off-line takes advantage of statistical nature of selecting different training and validation sets from training data
    - Often trained until correctly classify all training data and weights stabilize
    - Can use “Don’t know” classification as indicator that need to retrain system with potentially new sensor report features
  - On-line allows system to start processing immediately, albeit with a potentially higher error rate
  - Combination possible
    - Start with off-line and update weights as new reports are available
    - Use category creation as indicator of need to retrain

Select Relevant Features

- Soft Retasking™
  - Select relevant sensor reports (features) to reduce delay from collection to finished processing
  - System indicates which features should receive bandwidth and process priority

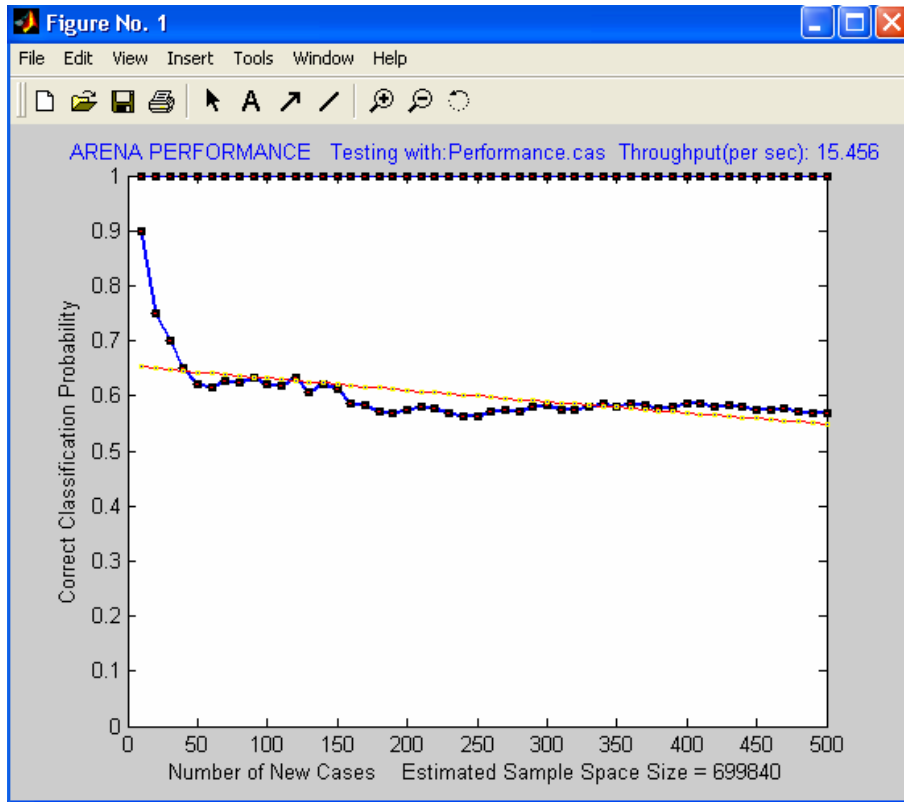
- Selection process based on weights allocated to feature during training
  - Motivating example from Carpenter, Grossberg, Reynolds categorization of mushrooms into poisonous or non-poisonous
    - 22 observable features
    - Categorization system used only 17 of these features

Patterns Specific to Relevant Features

- In experimental test, trained ARTMAP using selected sensor reports (features) to identify patterns of interest
- Original model using 5 features obtained error rate of 2% with 500 training samples
- Computing statistical correlation of category weights with observed threat identified features that could be excluded
- Reduced model using 3 features obtained error rate of 1.2% with 500 training samples

Monitor Sensors and Performance

- Use trained system to process selected sensor reports
  - Potential reduction of communication and processing time to get reduced selection of sensor reports
  - Potential for increased accuracy due to reduction in noise
- Monitor classification error rate and number of input classification categories to determine when to retrain with potential new set of features (sensor reports)



New Patterns as Required

- When system needs to add/learn a new pattern, restart process with training ARTMAP with complete set of archived reports
  - Restart when system needs to add a new classification category
  - Not restart when system only adjusts using current classification categories

- Retraining with complete set of reports allows for identification of need for new features to allow identification of potentially new tactics

Other Applications

- Processing multiple types of SIGINT and event reports
  - Identify patterns in SIGINT data associated with events
    - Identify network activity patterns (social network analysis) associated with events of interest (IED activity)
      - Networks built from SIGINT externals
      - Events culled from HUMINT reports and SIGINT internals
    - Allow watch for new patterns/tactics while monitor current activity

- Multi/Hyper-spectral decoy identification
  - Each layer as sensor report feature
  - Each decoy/threat type as result
  - Allow adapt to and identify new decoy/threat types

Other Applications

- Person identification
  - Usage pattern (e.g. radio, radar) as sensor report
  - Person identification as result
  - Allow adapt to and identify new persons

- Sensor fusion
  - Sensor data and metadata, i.e. data about the sensor, as sensor report
  - Fused picture as result
  - Allow adapt to and identify changes in sensor performance

Summary

- Goal:
  - Get the right people looking at the right data sooner
- Motivation:
  - Too much raw data
  - Select what data is relevant
  - Mechanism to identify when “relevant” changes
- Approach:
  - Use filter to identify reduced feature set of interest
  - User reduced filter to monitor reduced sensor stream
  - Monitor filter performance to determine when to adjust feature set

Contact

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