Overview

- Parent Project Objectives
- Relation to Resilient Controls
- Large Scale Anomaly Detection
Hypotheses:
- Cities have a pattern of life that can be studied and modeled
- Anomalous behaviors have transactional signatures
- Behavior models can be used for high fidelity simulations

Objective:
- Develop an automated system with direct and indirect sensing to aid a human in anticipating, discovering and tracking nefarious transactions
Core Team Members

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• Rik Warren, PhD – AFRL / RHXB
• Jeff Graley, M.S. – AFRL / RHXB
• Lt Col Brett Borghetti – AFIT / ENG
• Prof. James W. Davis – Ohio State Univ.
• Prof. Amit Sheth – Wright State Univ.
Layers of Sensors & Data Types

• Video cameras in public places
• Publically available web-based social networking data
Interactive Visualization and Camera Control

Matt Nedrich and Prof. James W. Davis
Ohio State University

- Cameras fused with their environment
- Fully geo-registered framework
  - Live – pano – ortho registration mapping
- Multiple control layers for efficient camera control
- Allows operators to concentrate on environment rather than cameras
- Embedded GIS information (e.g., floor plans, class schedules)
- Upgrade of camera network
Objective: Model the movement patterns of pedestrians and detect anomalies from learned behavioral trends.

Research Tasks:
- Real-time multi-object tracking algorithm
- Accumulate tracks over time (24/7)
- Search for “Patterns of Life” – Multiple Instance Learning
- Investigate influence of contextual factors
  - Day/Night, weather, scene density

Real-time Multi-object Tracking

Accumulated Tracks

Typical scene

Morning (8 am)

Evening (8 pm)
Example Scenarios

**Drop Off**
- Drop off of person A and big bag
- Phone call made to person B
- Loitering of person A

**Bag Exchange**
- Meeting
- Set down both bags
- Check for contents
- Walk off briskly

**Tracking of Bag**
- Camera follows person B
- Person B walks towards bus stop

**Sensor Handoff**
- Use bus system routes and schedule
- Follow bus, check for dismount using bus stop surveillance
Experimentation Plans

- **Variety of alerts**
  - Unusual groupings
  - Exchanges
  - Unusual velocities/loitering
  - Off the path

- **Confuser Events**
  - Buses group for orientation
  - Textbook Hand-off
  - Truck on sidewalk for construction

- **Prioritize and address alerts**

- **Access indirect layers & visualization (schedules, maps, etc)**

- **Ability to view multiple windows & multiple cameras simultaneously**

- **Tracking capabilities**

- **Histograms show patterns**
• Goal: Increase situation awareness and security through video-based surveillance

• Assumption: Ever-increasing video availability, but human resources limited

• Problem: Too much video for unassisted humans to be fully effective in finding indicators & analyzing events

• Solution: Machine-aided anomaly detection and analysis
Large Scale Anomaly Detection

Lt Col Brett Borghetti
Air Force Institute of Technology

New Data

Video / Imagery

Learning System

Classifier

Stored History

Normal

Anomalous

Discover behavior not associated with POL
(Pattern Recognition / Machine Learning)
Building Patterns of Life Info

- Process Video
- Identify entities & tracks
- Aggregate POL from “normal” paths

Patterns of Life

Video

Tracking
Classifiers

**Supervised**
- Video / Imagery
  - Tracking, Labeling
  - Labeled Track-space Data
  - Binary Classifier

**Unsupervised (Clustering)**
- Video / Imagery
  - Tracking
  - Track-space Data
  - Cluster Generator
Validation with Anomalous Tracks

- Simplest method for initial testing of the classifier
- Hard to Visualize / Analyze the results
- Doesn’t evaluate image processing or tracker
Challenges

• Need to validate system behavior
• Difficult / Expensive to coordinate anomalies during live collection
• Can we synthesize anomalous behavior?
  – Alter Image Data
  – Simulate Collection Process
Spiral 2: Image Manipulation

• Alter images prior to tracking (or labeling)
  – Add entities that are behaving anomalously in each image
  – Use MATLAB to automate the process

Original Video / Imagery  
Add Anomalies  
(Labeled) Track-space Data
Spiral 3: Simulating Collection

- Recreate normal and add anomalous behavior within a simulated version of area of interest
- Collect & process video from simulation’s virtual camera to test end-to-end system

Track-space Data From Real World

Standard Behavior

Hand-scripted Anomalies

Virtual Battlespace 2 Simulation

Virtual Camera Video

Virtual video used as source for full system test
Possible Future Work

• Compare performance of classifier with humans

• Model the human security worker’s actions
  – Decision to look for more info in existing data
  – Decision to take control of camera control / collection assets
  – Decision to direct emergency services / forces to anomalies