Awareness and Localization of Explosives-Related Threats (ALERT)
A Department of Homeland Security Center of Excellence

Video Tracking of Passengers and Divested Objects at a Checkpoint

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So What? Who Cares?

- **Space**: Monitoring passengers and their divested items in airport security checkpoints
- **Problem**: Automatically detect events of interest at checkpoint (left-behind, theft, …), facilitate risk-based screening
- **Solution**: Computer vision tracking algorithms plus event detection
- **Results** (Passengers/Divested Items/Transfers): \( P_D = 100/90/93, P_{FA} = 8/8/0 \)
- **TRL**: 4 at end of Phase I
  - Working to increase TRL level, address harder scenarios, corner cases
  - Can deploy with limited functionality, evolve to meet additional requirements

→ Support APEX Screening at Speed
Correlating Luggage and Specific Passengers (CLASP)

Objective: Develop automated tracking algorithm (ATA) to track passengers and divested objects at a checkpoint and detect exceptions such as theft and left-behind items.

Benefits to TSA
- **Improved detection performance**
  - Support risk-based screening
  - Potential to integrate information from multiple sources
  - Mix trusted and regular travelers
  - Enhanced situational awareness at checkpoint
  - Reduce cognitive load on TSOs
- **Better passenger experience**
  - Identify bottlenecks and automatically redirect flow/change operation
  - Rapid identification/resolution of events: left-behind items, thefts, ...
Performers

- **Phase 1: Ended June 2018**
  - Rich Radke
  - Octavia Camps
  - Avi Kak
  - Henry Medeiros
  - Stan Sclaroff
  - Venkatesh Saligraman

- **Phase 2: Sept. 2018 – now**
  - Consolidated team
  - Distributed tasks

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Data Collection Facility

- Simulated checkpoint at Kostas Research Institute at NEU
  - Real transportation security equipment and mock equipment
  - X-rays, AIT, Trace, etc. (disabled)
  - Rapiscan, Smiths: Thank you for equipment

- 19 video cameras

- Data collection
  - Actors followed scripts to create events
    - (e.g., theft, left-behind, passenger transfers, etc.)
  - Ground truth generated
  - Automated scoring tools & metrics created
  - Data, metadata and tools in public domain
PAX & Baggage Detection

- PAX & baggage
  - SSD detection
  - Candidate edges
  - Predicted search regions

- Bin contents
  - Estimated bin contour
  - Candidate scene features
  - Predicted search regions
  - Candidate edges
  - SSD detection
ATA PAX or DVI output is correct if IoU (intersection over union) > threshold
  - Default IoU threshold = 0.3 for PAX, 0.5 for DVI

PD = # ATA hits / # GT objects

PFA = # ATA false alarms / # GT objects

ATA transfer (XFR) event is correct if it occurs within ± 30 frames of GT XFR

Switch registered if ATA label changes

Mismatch registered if ATA PAX-DVI association disagrees with GT on divestment
Phase I Results

- Metrics require annotated videos
  - Labor intensive – tracking multiple PAX, TSO, DVI, cameras
  - Many situations to consider (e.g., occlusion)
- Investigating other annotation methods
- Large data required for machine learning algorithms

<table>
<thead>
<tr>
<th>Tracking Metric (%)</th>
<th>Camera 9</th>
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<tbody>
<tr>
<td></td>
<td>RPI/NEU</td>
</tr>
<tr>
<td>$P_D$ (PAX)</td>
<td>95.0</td>
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<tr>
<td>$P_D$ (DVI)</td>
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<td>$P_D$ (XFR)</td>
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<td>$P_{FA}$ (PAX)</td>
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<tr>
<td>$P$ (PAX switch)</td>
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<tr>
<td>$P$ (DVI switch)</td>
<td>0.0</td>
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</tbody>
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Spiral Development

- **CLASP1**
  - Simplified scenarios (e.g., 1 item/bin)
  - Allowed development of mock checkpoint, scoring tools, annotations, TRL~3 tracking algorithms

- **CLASP2**
  - More realistic scenarios; TRL~5 algorithms, improved metrics
  - Interaction with airports
  - Workstation requirements and (optional testing)
  - Real time implementation of algorithms
  - Initial engagement with industrial partners
Objectives of Phase II

- Improving $P_D/P_{FA}$
  - Fine-tuning for PAX/DVI
  - Improving/leveraging camera geometry
  - Multi-camera integration

- Events
  - Person to person transfer
  - Secondary inspection

- Track additional corner cases
  - PAX in wheelchairs, children on strollers; family units

- CLASP 2 – received funding to continue developing the algorithms and to explore transition to the field
Potential Concept of Operations

Near Term
- Single separate CLASP workstation monitoring multiple screening lanes, from entry of checkpoint to exit
- Alert on possible transfer of ownership of items to operator, who can direct remediation actions
- Alert on left-behind items in real time, identifying ownership

Longer Term?
- Integration of CLASP information into appropriate monitoring systems
- Risk-based screening exploiting CLASP output to perform appropriate screening on PAX and their divested items
- ...

Need more interactions with stakeholders to define needed functionality and desired performance requirements.