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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This material is based upon work supported by the U.S. Department of Homeland Security under Award 2013-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied of the U.S. Department of Homeland Security.

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

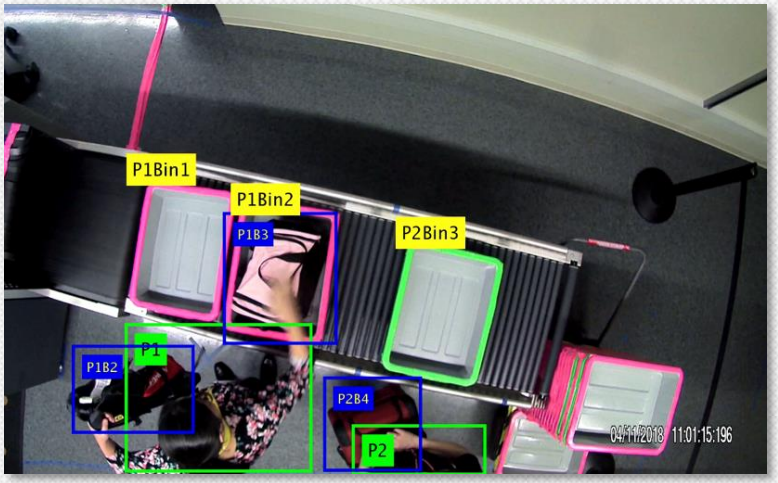
➔ Support APEX Screening at Speed

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**

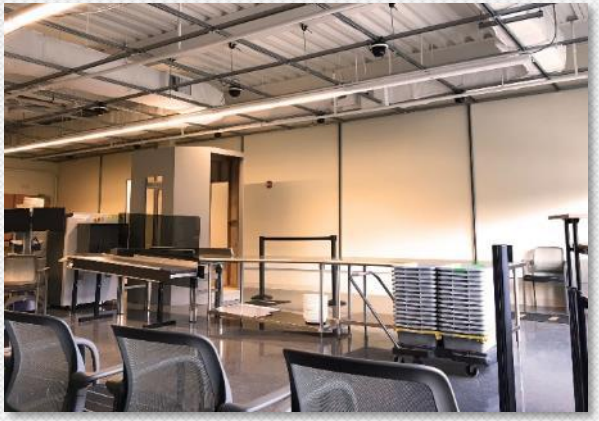
Rich Radke	Octavia Camps	Avi Kak	Henry Medeiros	Stan Sclaroff	Venkatesh Saligrama
Rensselaer	Northeastern University	PURDUE UNIVERSITY	MARQUETTE UNIVERSITY	BOSTON UNIVERSITY	BOSTON UNIVERSITY

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

Rich Radke	Octavia Camps	Henry Medeiros
Rensselaer	Northeastern University	MARQUETTE UNIVERSITY

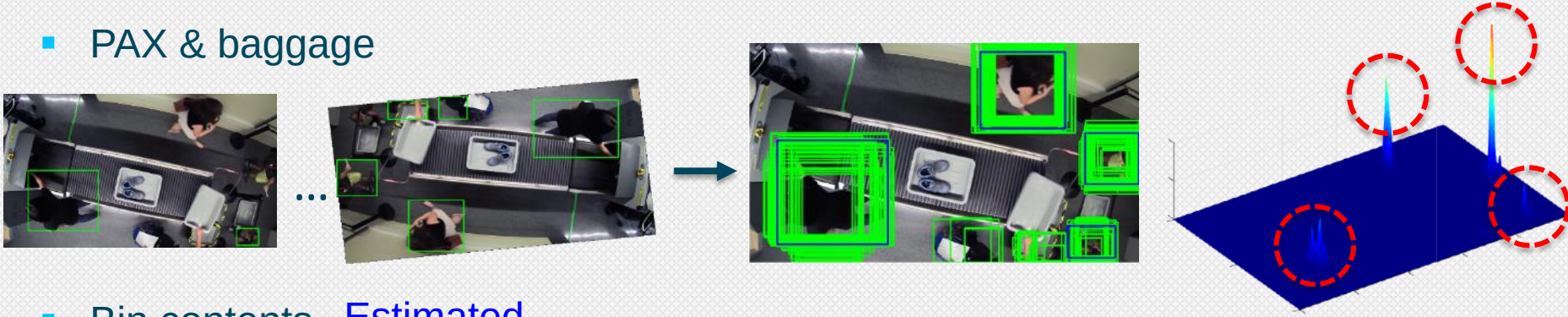
Data Collection Facility

- 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

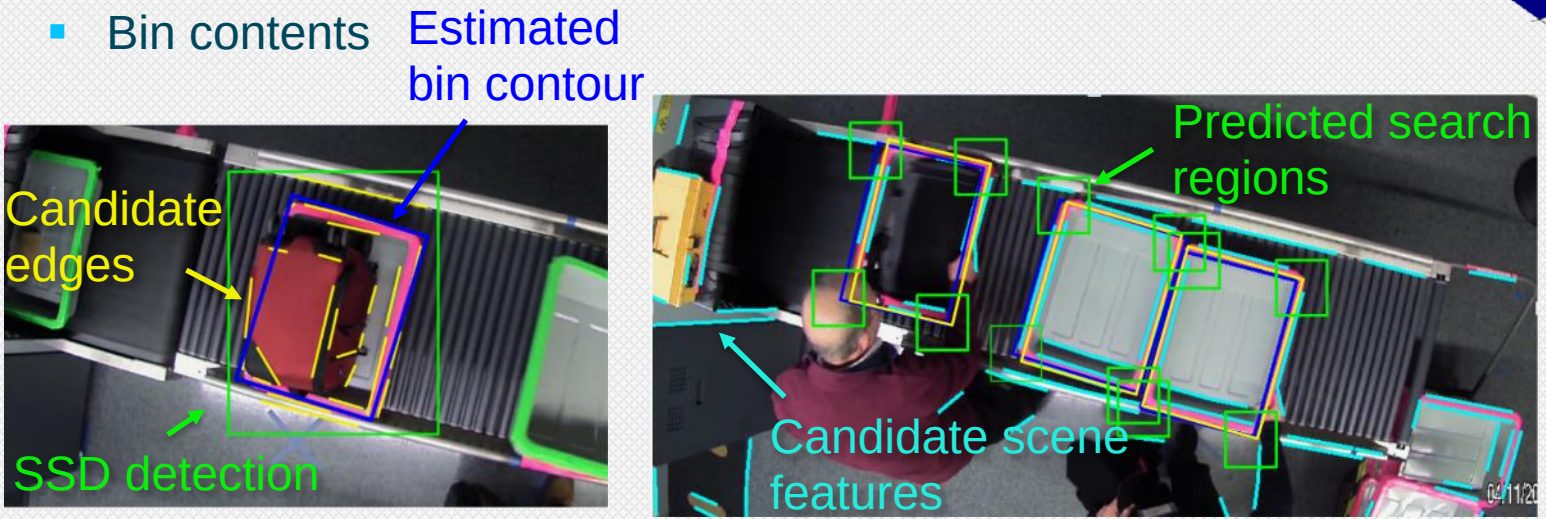


PAX & Baggage Detection

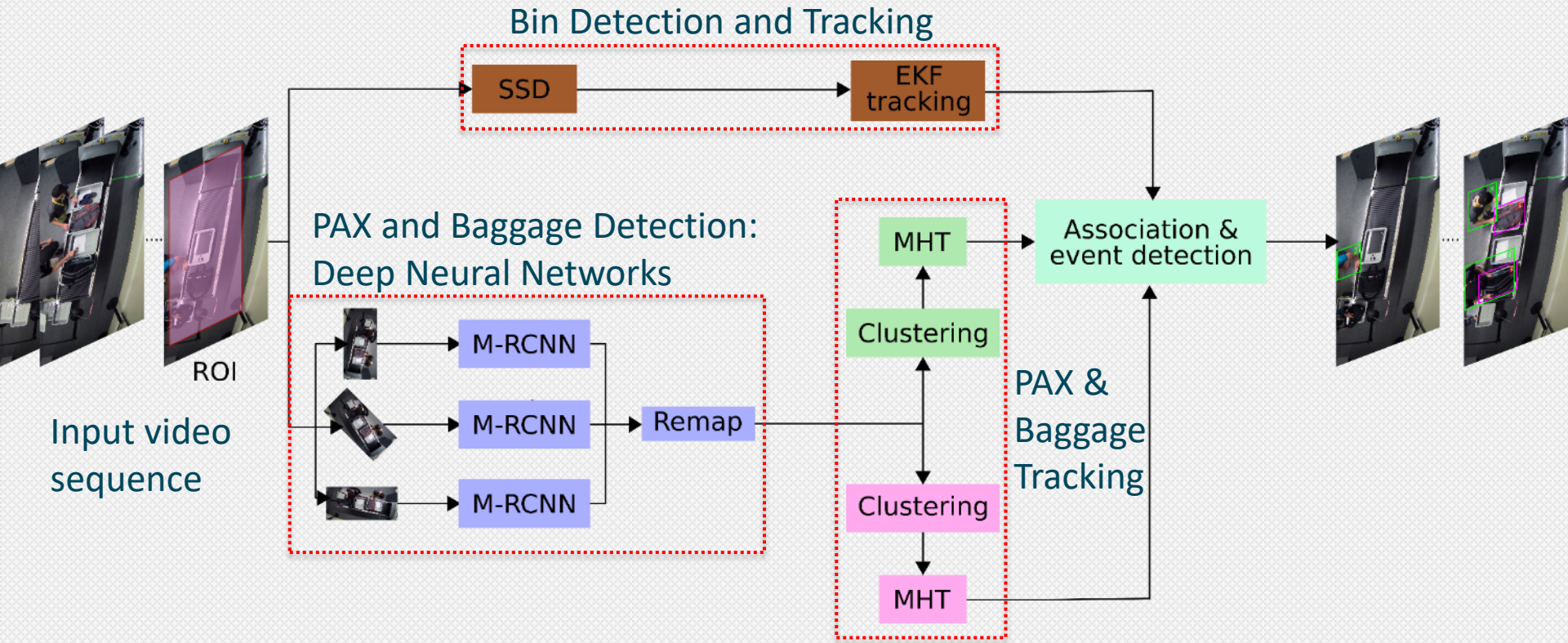
- PAX & baggage



- Bin contents

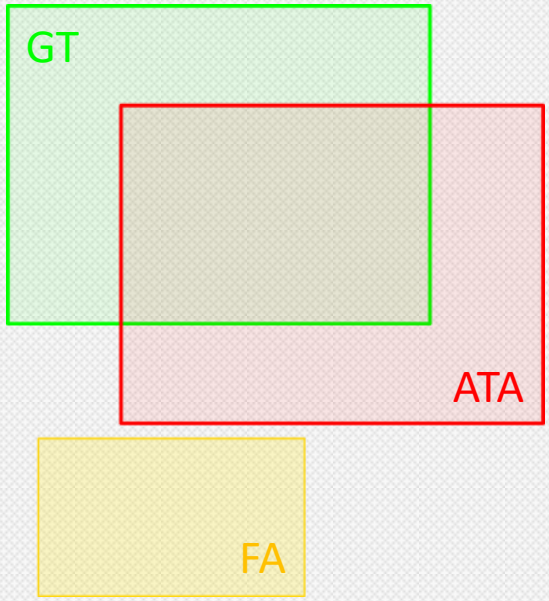


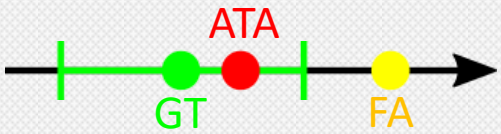
Typical Automatic Tracking Algorithm (ATA) Architecture



Scoring Metrics and Evaluation Tool

- 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

Tracking Metric (%)	Camera 9
	RPI/NEU
P_D (PAX)	95.0
P_D (DVI)	91.4
P_D (XFR)	87.5
P_{FA} (PAX)	27.5
P_{FA} (DVI)	25.0
P_{FA} (XFR)	0.1
P (PAX switch)	0.0
P (DVI switch)	0.0

- 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

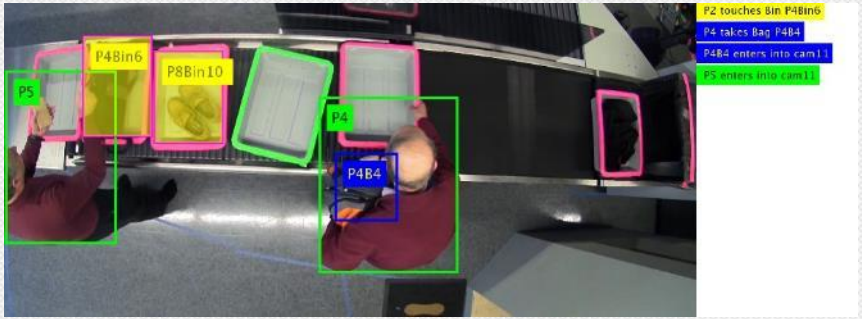
Spiral Development

- 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

False negative



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.