Video Tracking of Passengers and Divested Objects at a Checkpoint

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So What? Who Cares?

- **Space**: Monitoring passengers and divested items in airport security checkpoints
- **Problem**: Support risk-based screening, e.g., changing ATR per passenger
- **Solution**: Computer vision tracking algorithms
- **Results** (Passengers/Divested Items/ Transfers): PD=100/90/93, PFA=8/8/0
- **TRL**: 4
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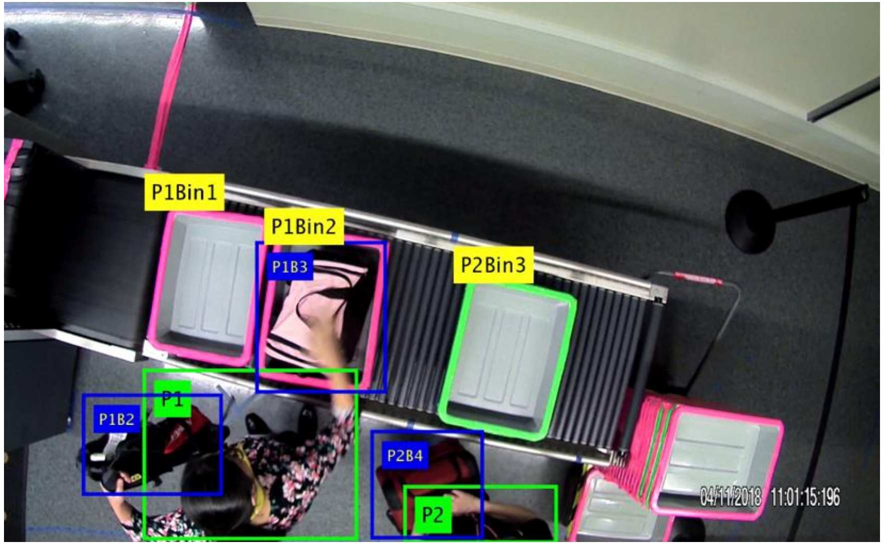
Correlating Luggage and Specific Passengers (CLASP)

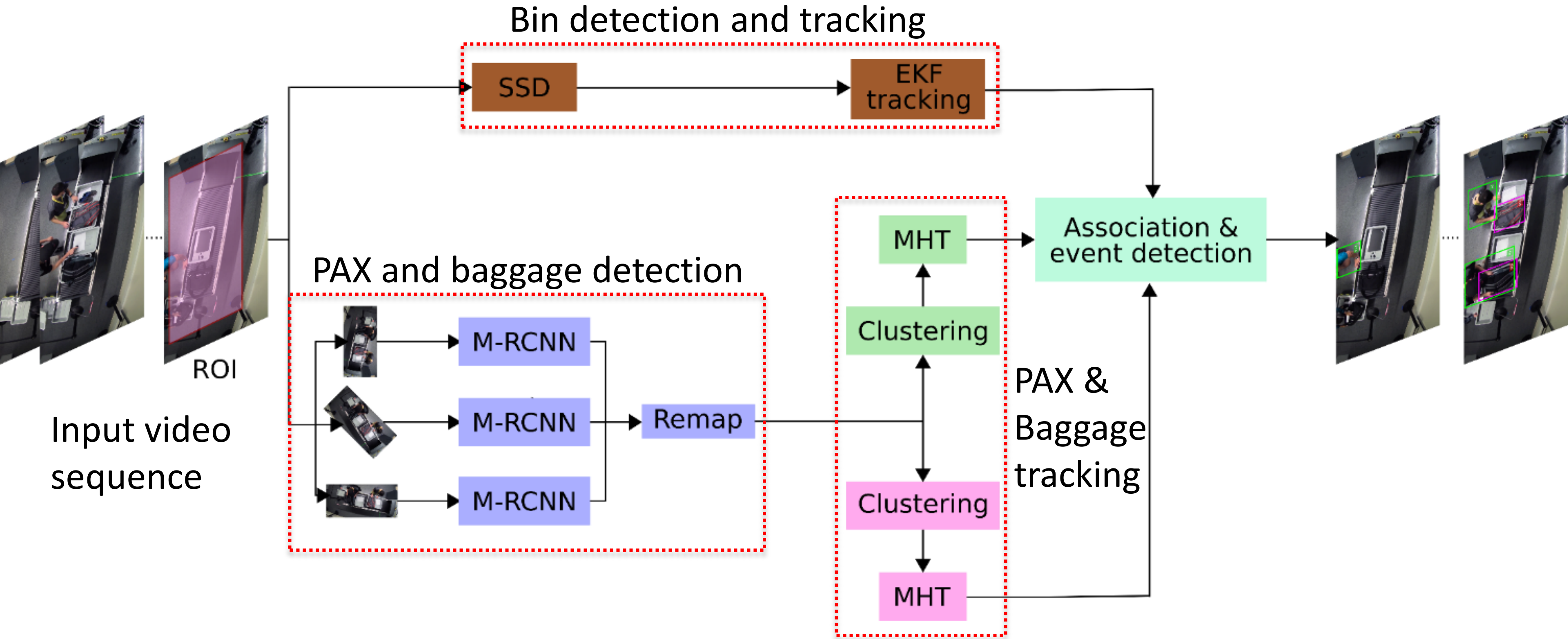
- **Objective:** Develop automated tracking algorithm (ATA) to track passengers and divested objects at a checkpoint and detect exceptions such as theft and left-behind items
- **Benefits to TSA**
  - Improved detection performance
    - Support risk-based screening
    - Potential to integrate information from multiple sources
    - Mix trusted and regular travelers
    - Reduce cognitive load on TSOs
  - Better passenger experience
    - Identify bottlenecks and automatically redirect flow/change operation
    - Reduce concerns about theft



Data Collection

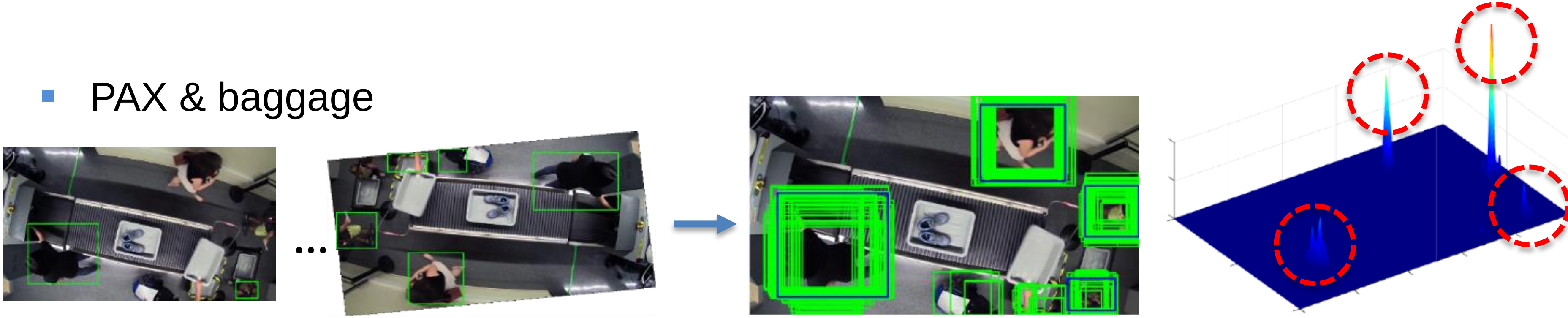
- Simulated checkpoint at Kostas Research Institute at NEU
  - Real transportation security equipment and mock equipment
  - X-rays, MMW, etc. disabled
  - Rapiscan, thank you for AT2
- 19 video cameras
- Data collection
  - Actors followed scripts to create events (e.g., theft)
  - Ground truth generated
  - Automated scoring tools & metrics created

Purdue/Marquette ATA Architecture

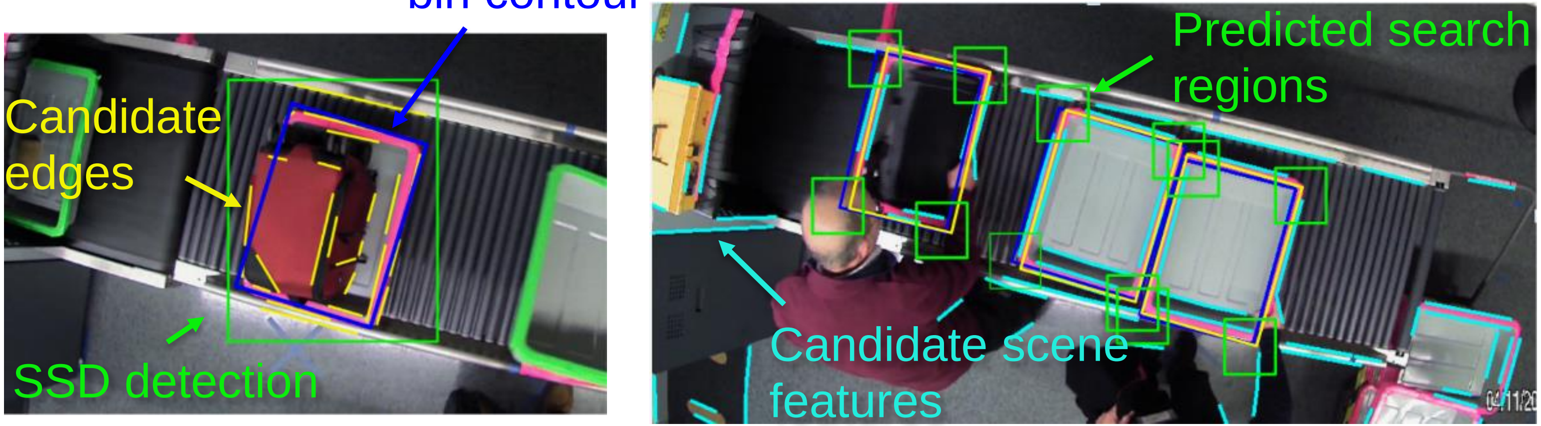


PAX & Baggage Detection

- PAX & baggage

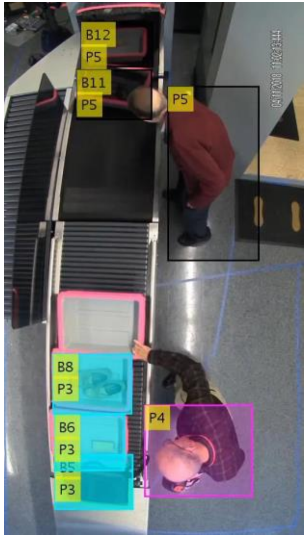


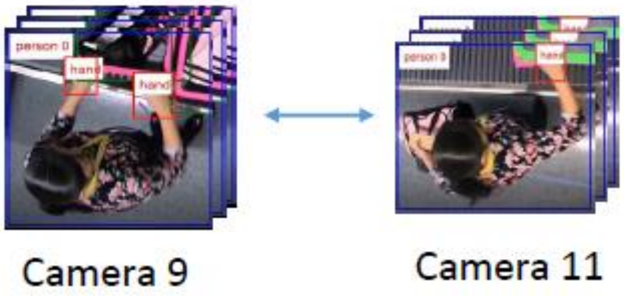
- Bin contents

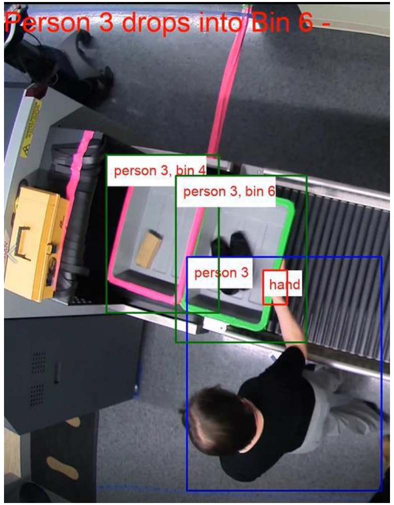


Other Performers' ATA Architectures

- RPI/NEU
  - Optical flow + deep learning for passenger and bin tracking
  - Upper body joint detection + spatial heuristics for event detection
- BU
  - Deep learning + Kalman filter for passenger and bin tracking
  - Appearance-only inter-camera tracking
  - Distance-based event detection

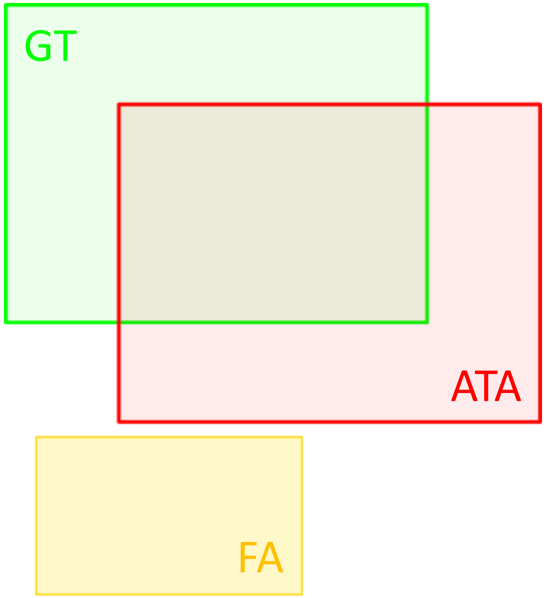


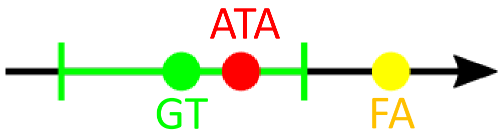




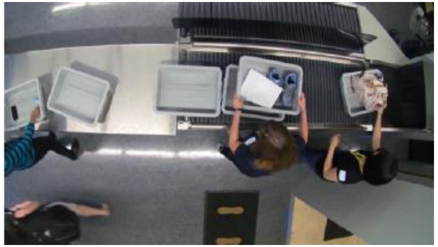
Scoring Metrics and Evaluation Tool

- 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





Results



Camera 11

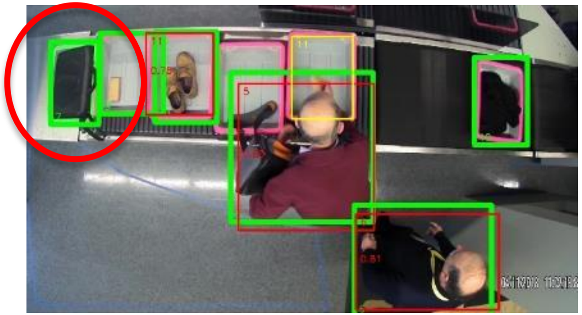
Camera 9

Tracking Metric (%)	Camera 9			Camera 11		
	PU/ MU	RPI/ NEU	BU	PU/ MU*	RPI/ NEU	BU
PD (PAX)	100.0	95.0	100.0	100.0	100.0	100.0
PD (DVI)	90.0	91.4	77.1	76.9	92.0	71.1
PD (XFR)	93.8	87.5	62.5	75.0	62.5	62.2
PFA (PAX)	35.0	27.5	25.0	7.5	7.5	16.3
PFA (DVI)	7.5	25.0	20.0	17.5	25.0	12.8
PFA (XFR)	0.0	0.1	0.1	0.0	0.1	0.1
P (PAX switch)	5.0	0.0	5.0	6.7	0.0	27.6
P (DVI switch)	0.0	0.0	0.0	1.9	0.0	14.6

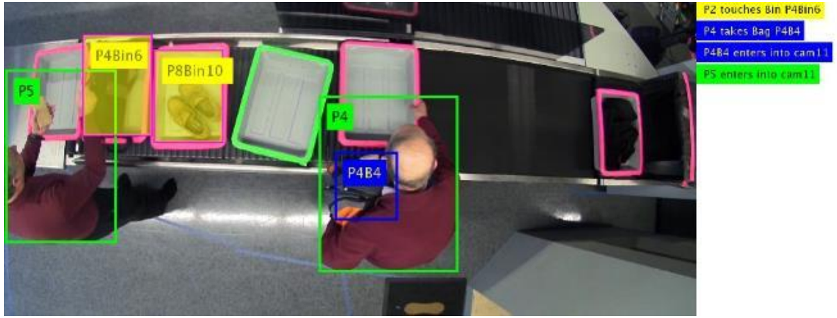
*Preliminary results obtained using a simplified method

Future Work

False negative



- Improving PD/PFA
  - Fine-tuning for PAX/DVI
  - Improving/leveraging camera geometry
- Events
  - Still learning how to represent them
  - Characterizing every case may be unfeasible – Machine learning solution?
- Track additional corner cases
  - E.g., person on a wheelchair, children on strollers



- **CLASP 2** – received funding to continue developing the algorithms and to explore transition to the field

THANK YOU

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