Stadium Security In a Changing Environment

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Our Project

1. **Experiments to Understand the Performance of Walk Through Metal Detectors (WTMDs)**

2. **Walk-Through Metal Detector Data Collection at a concert venue**

3. **Drone Detection Software Experiments at a stadium**

Problem Statement

1. **Experiments to understand how human gait may impact WTMD detection of metallic objects**

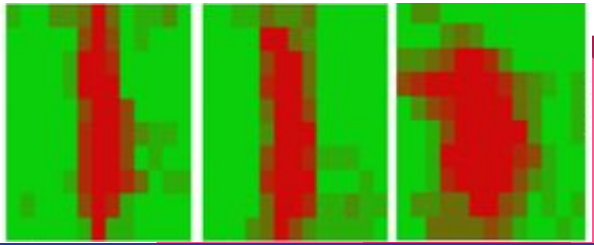
- Building on prior REU Work and Research
  - Walk-Through Metal Detectors for Stadium Security. (Nelson et al, 2016)
    - Experiments to understand performance of field-used WTMDs (object height, orientation, speed passing through the WTMD portal)
  - Performance of Walk-Through Metal Detectors against Curvilinear Motion (Nelson, 2017)
    - Experiments on how different walking pattern affected results of WTMDs
- Our research assesses how different pathway motions affect the detection of metallic objects
- Performed experiments for a single orientation, height, and metallic test object.

Problem Statement Background

1. **Experiments to understand how human gait may impact WTMD detection of metallic objects:**

Overview:

- Create heatmaps of vulnerabilities
- Curvature in motion through WTMD
- Delay in alarm (sometimes found in prior work)
- Importance of field test in original environment
- Exploring other possible impacts
- Test items to be used correspond to NILECJ 0601.00 standards for WTMDs (to meet a certain quality level)



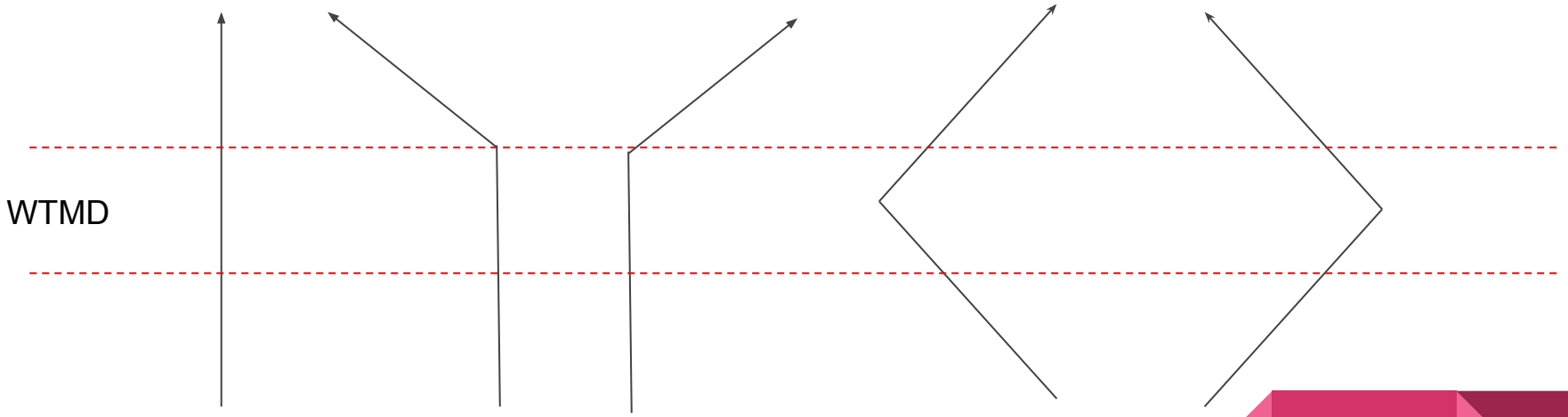
Experiments on WTMDs

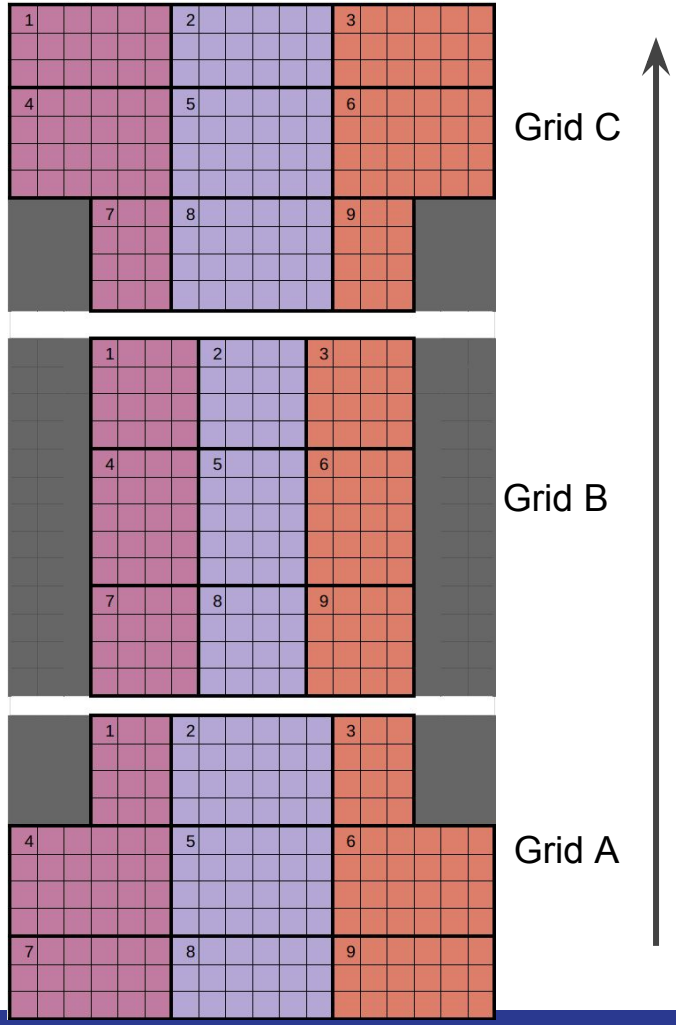
Typical stadium security setup:

1. Bag Check
2. WTMD/Primary Screening
3. Secondary Screening (if WTMD alarms)
4. Ticket Scanners

Experiments on WTMDs

Walking Pathways Considered for the experiments



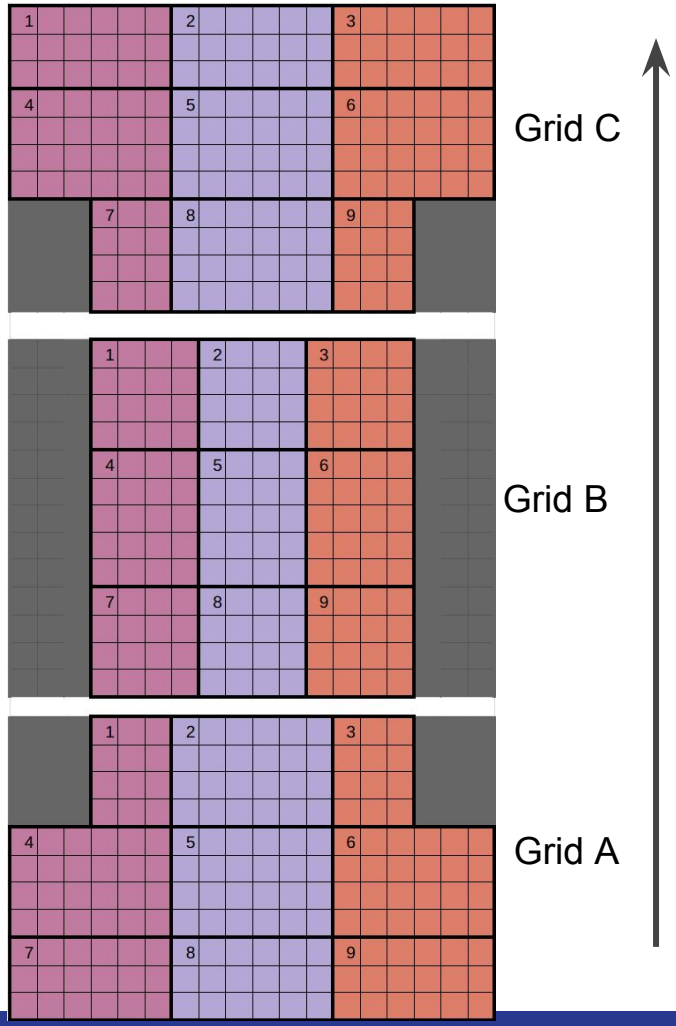


- Three Grid boards:
  - one before the WTMD (Grid A)
  - one on the WTMD (Grid B)
  - one after the WTMD (Grid C)

- Each grid then divided into 9 regions, and 3 grid locations are picked out from each region to list out the possible trials to compute for a particular path.

  Eg: Path 1 can be

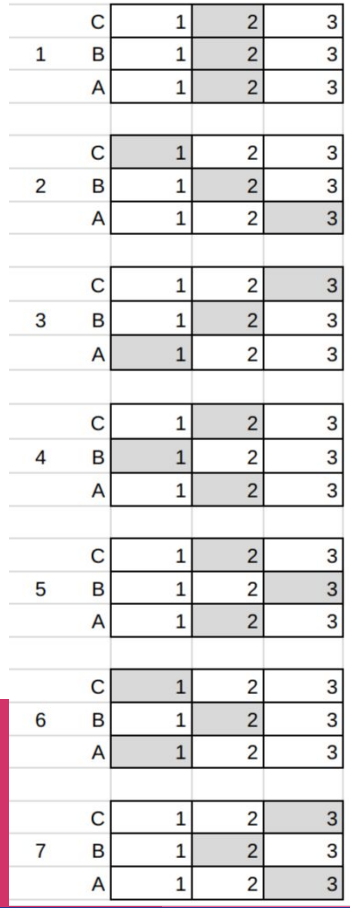
  A5 -> B5 -> C5
  A5 -> B5 -> C8
  A5 -> B5 -> C2
  .
  .



- Actual Number of combinations for a path
  - 3 x 3 x 3 - 6 = **21**
  - 6 combinations were found to be unfeasible for walking normally through the WTMD
- Total ways of passing through the WTMD, considering only 3 grid locations in each zone for a path: 21 * 3 * 3 * 3 = **567**
- 5 paths. So, total number of experiments with one WTMD = 5 * 567 = **2835**
- Each experiment is carried out 3 times to ensure correctness. So, total number of trials = 2835 * 3 = **8505**
- Progress so far: 4 paths complete.
  So, 4 * 567 = **2268** paths
  and 2268 * 3= **6804** trials

Experiments on WTMDs

- How we chose the 5 walking pathways:
  - Based on idea that patrons walk in direction of their personal items placed on side of WTMD, after walking through the metal detector.
  - We experimented with many pathways which covered various regions inside and outside the metal detector.
  - Narrowing down to feasible pathways for experiment took much brainstorming and trial and error



Early iteration of some of the possible pathways

Initial Results

- Experiment results suggested that patron movement in specific pathway motion affects detection accuracy of WTMD.

- Found interesting anomalies with certain pathways causing no detection. Lack of detection delay, WTMD results showed no delay in alarm.

- Unfeasible paths through the WTMD: 272

- Out of (2268 - 272) = 1996 paths,
  - 121 cases (6%) where the metallic object was not detected at all three trials.
  - 283 cases (14%) where the metallic object was not detected at least twice.
  - 485 cases (24%) where the metallic object was not detected at least once.

Initial Results

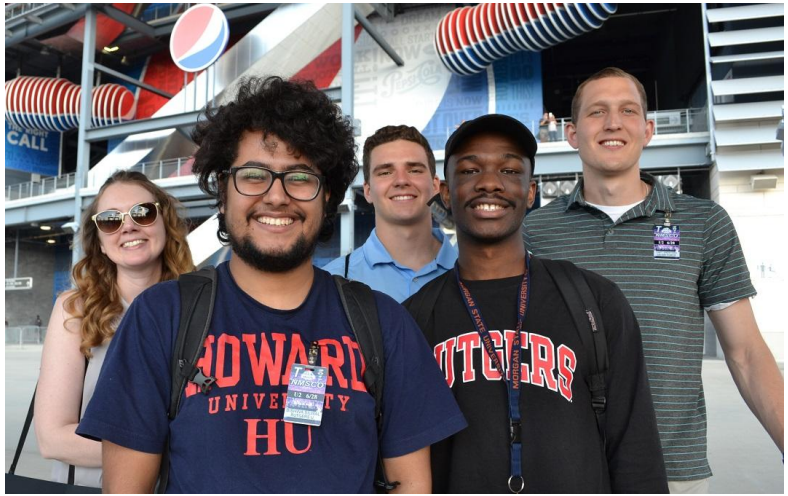
Pathways	Never Detected	At Least Twice Not Detected	At Least Once not detected
1	30 (1.5%)	70 (3.5%)	120 (6%)
2	32 (1.6%)	90 (4.5%)	154 (7.7%)
3	44 (2.2%)	110 (5.5%)	178 (8.9%)
4	4 (0.2%)	13 (0.7%)	33 (1.7%)
Total	121 (6%)	283 (14%)	485 (24%)

Next Steps

- Complete all paths for a single WTMD
- Try similar experiments on another make/model WTMD
- Explore ways to visualize which paths are more difficult to detect
- Analyze full results once complete

2. WTMD Data Collection and Analysis at a Concert

- Worked with CCICADA Stadium Security Project Research Team



- Observed and collected data on WTMDs at a stadium venue

Screening Times and Ticket Scan Data

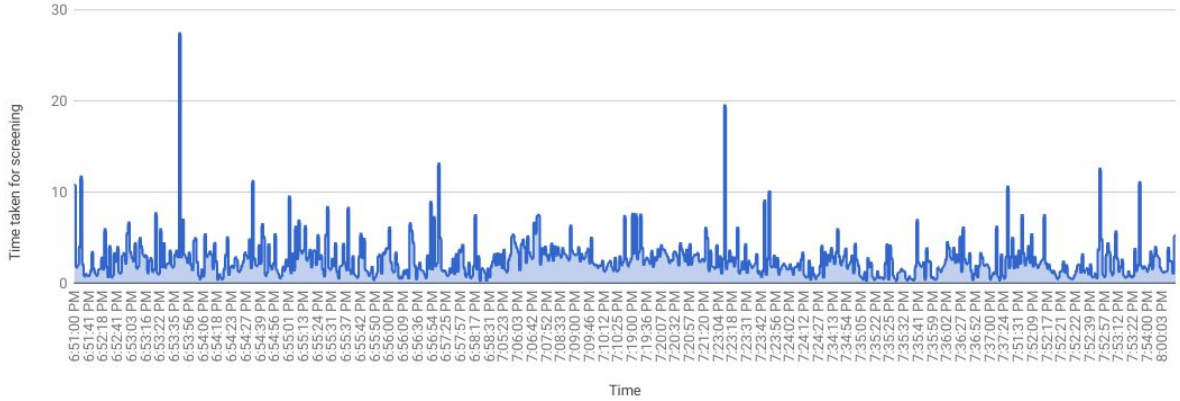
Primary Screening Time: Time taken for a patron to walk through the metal detector

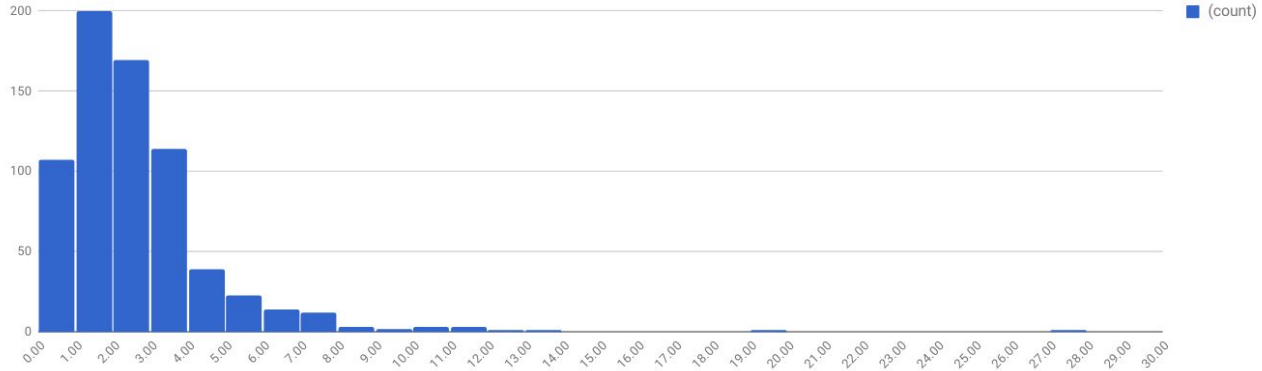
Secondary Screening Time : Time taken for additional screening in case of detection alarm by metal detector

Ticket Scan Time: Time taken to scan and confirm patrons' tickets after screening was complete

693 observations were recorded for screening times and **51** observations were recorded for the ticket scan time.

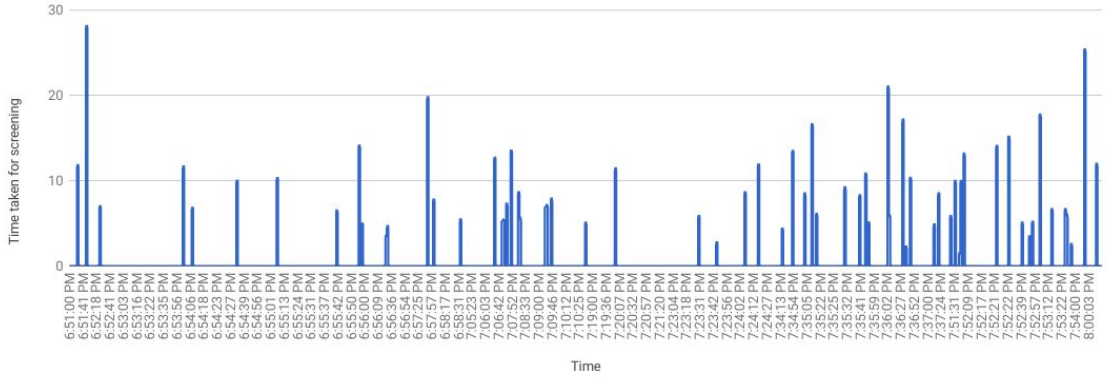
Primary Screening Results

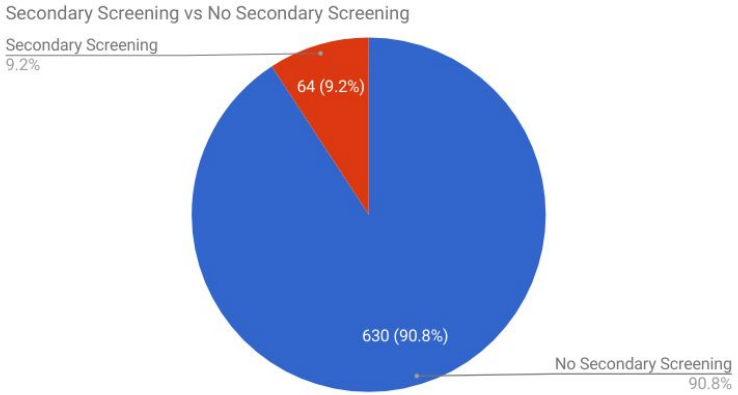




Min:	0.280
1st Quartile:	1.380
Median:	2.160
Mean:	2.645
3rd Quartile:	3.220
Max:	27.420

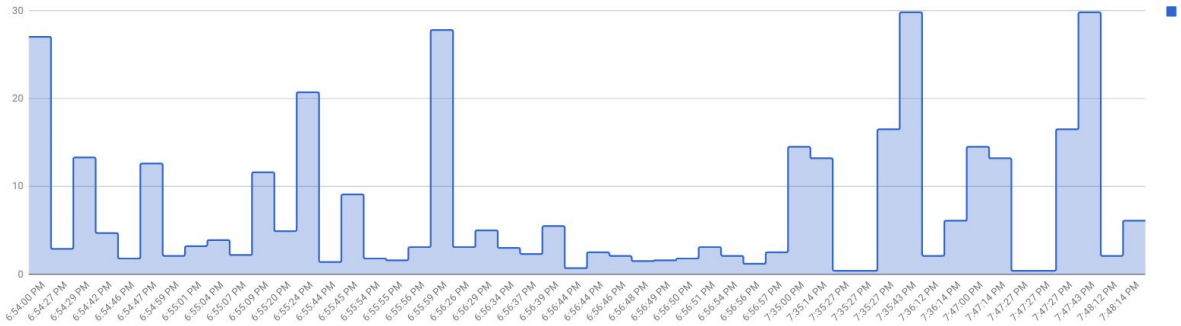
Secondary Screening Results

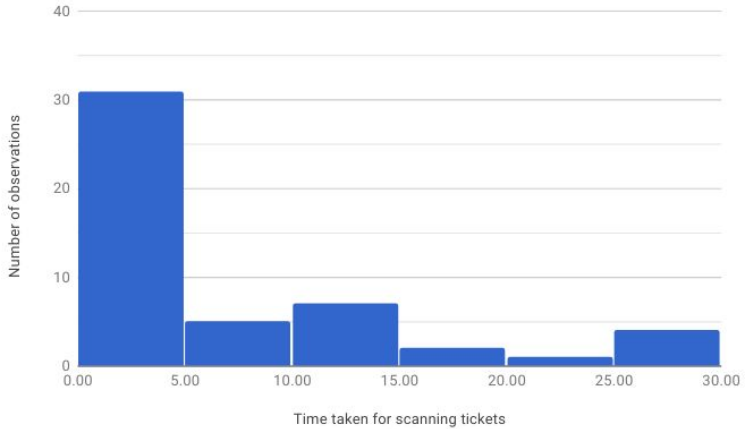




Min:	1.500
1st Quartile:	5.345
Median:	7.005
Mean:	8.605
3rd Quartile:	10.002
Max:	33.700

Ticket Scan Data Results





Min:	0.40
1st Quartile:	1.80
Median:	3.10
Mean:	6.79
3rd Quartile:	11.60
Max:	29.80

Drone Detection Software Testing

- Being that drones are a security threat to large crowd venues, drone detection systems have been tested, analyzing their consistency in detecting drones and their controllers in respects to location precision and time.
- Our team assisted in the experiments of a drone detection system for potential for use at large stadium venues.
- The system used several sensors positioned for identifying drone activity, along with associated software
- Experimentation and testing took place June 29 and July 11.
- Data collection process (for both drone and controller) included testing location detection accuracy, time for detection, and precision of detection
- Total of drone 4 controllers used along with 1 drone, with testers maneuvering through stadium parking lots.

Photo Credit: PCMag Website

Acknowledgements

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Our mentor Dr. Christie Nelson

References

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