Computational Imaging for Persistent Pervasive Surveillance

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MSR

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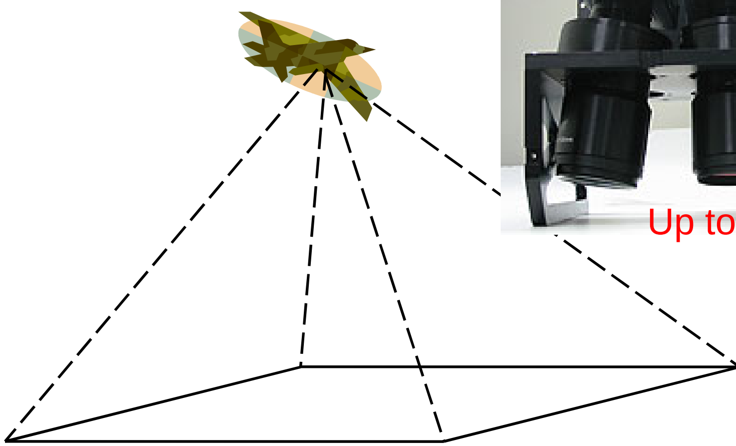
Problem

Reduce data volume for Persistent Pervasive Surveillance tasks by jointly designing novel optics and post-processing

- Current airborne surveillance systems create vast amounts of image data, far too much to download in real time.
- Most of this data is of little interest (unchanging buildings, etc.) but computationally extracting desired information on the platform is impractical.
- Using Computational Imaging techniques, one can design imaging hardware that optically selects information of interest.

Background



Current Persistent Pervasive Surveillance (PPS) systems can generate GigaBytes of image data each second, far too much to download in real time.

In most cases, full video is not required, but real-time wide-area tracking (e.g.) would be extremely valuable.

Objective

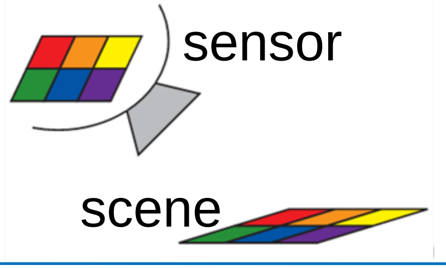
- **Three-year objective: develop imaging technology capable of directly sensing relevant data (tracking, changes, etc.) with reduced data volume**
  - Perform system design including SWAP analysis
  - Build and evaluate demonstration system.
- **First-year (FY09) objective: evaluate candidate technologies and develop sample design demonstrating tangible benefit**
  - Engage with academic research community and extend the community's understanding of candidate technologies
  - Develop fundamental limits on these technologies as well as practical constraints.

Activities

- **Differential Combinatorial Group Testing (dCGT) – architecture for compressive motion tracking**
  - **Derive theoretical bounds**
  - **Develop design strategies**
  - **Design and simulate.**
- **Coded Exposure Photography – fluttered exposure for low-light imaging and motion inference**
  - **Develop motion inference**
  - **Reconstruct (de-blur) objects of interest.**

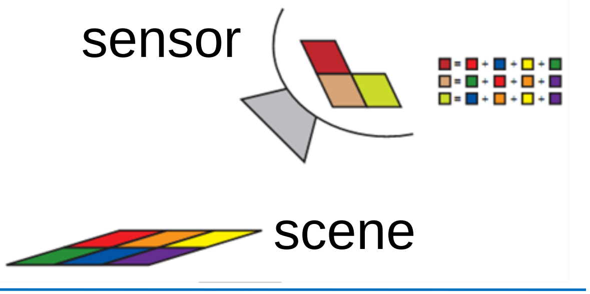
Technique 1: dCGT

dCGT – Differential Combinatorial Group Testing

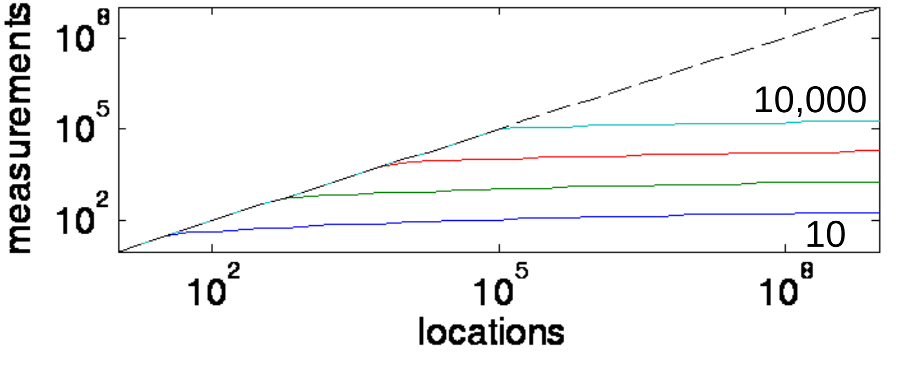


traditional imagers measure every location independently:
measurements = # locations

dCGT sensor efficiently measures groups of locations and changes can be separated later – optical compression!



dCGT requires far fewer measurements, depending on number of locations L and targets T

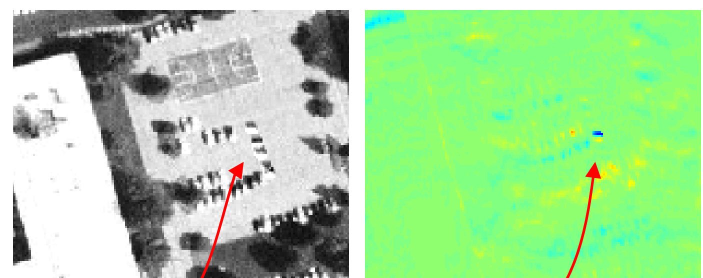


Technique 1: Coded Exposure

Coded Exposure Imaging

long coded exposures allow clear low-light images by inverting the blur function…

… and motion inference by finding the code within a single image.



a moving object appears as a dashed blur in the raw image; this pattern can be easily found algorithmically.

Impacts

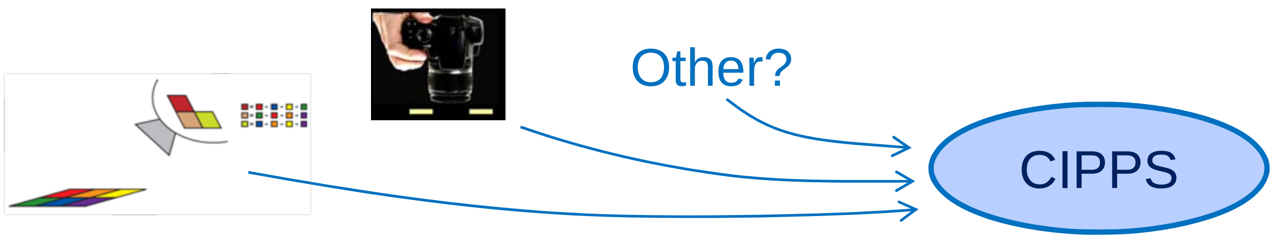
- Customer mission (PPS)
  - Reduce data volume, allowing real-time access to most-valuable data (i.e., tracking)
  - Improve hardware tracking capabilities.
- Collaboration with academic community
  - Subcontract with University of Arizona (Prof. Gehm)
  - Contributing to areas of active academic research.
- Developing work programs
  - Close integration with ongoing DARPA projects.

Future Plans

- **Finalize technology choice – choose technologies best-suited for PPS problem.**

Other?

- **Integrate complimentary technologies.**



- **System design for PPS application – adapt the CIPPS design for practical mission-oriented constraints.**