Surveillance Video Processing using Compressive Sensing

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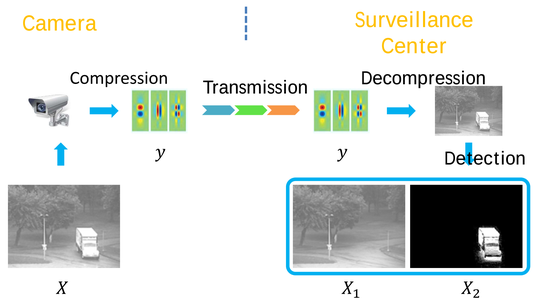
Video Surveillance

- Large number of cameras
- Continuous operation time
- Massive amount of data
  - High bandwidth
  - Human monitoring

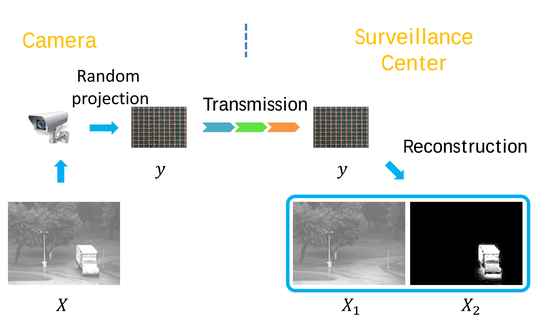
Objectives

- Reduce data rate
- Reduce power consumption
- Automatic foreground detection

Conventional Camera



Our Approach

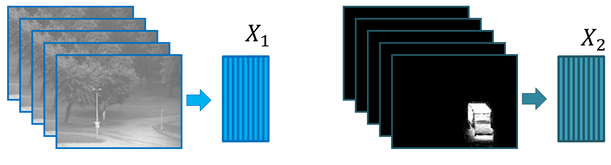


Mathematical Modeling

- Image decomposition
  - Background X_1
  - Foreground X_2
  - Find X_1, X_2, s.t.

$$y = \Psi(X_1 + X_2)$$

- Ill-posed problem



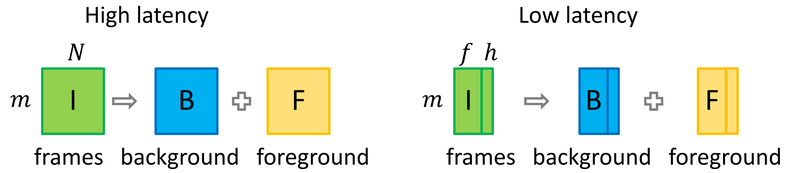
Prior Knowledge

- Background
  - Stationary or changing slowly
    - Low rank: $||X_1||_* = \sum |\sigma_i|$ be small
  - Sparse in spectral domain
    - W_1X_1 be sparse (W_1: wavelet)
- Foreground (moving objects)
  - Small portion of the whole image
    - X_2 be sparse
  - Sparse in temporal-spatial domain
    - W_2X_2 be sparse (W_2: wavelet)

Frame Decomposition

Minimize

$$E = \mu_1||X_1||_* + \mu_2||W_1X_1||_1 + \mu_3||W_2X_2||_1 + \mu_4||X_2||_1$$



High Latency Approach

Augmented Lagrangian Alternating Direction

Variable substitution

$$X_1 \to Z_1,\ W_1X_1 \to Z_2,\ W_2X_2 \to Z_3$$

Each variable can be optimized individually in a simple form

Low Latency Approach

1. Learning background model
2. Updating background model
3. Setting weights

Examples