A Forest of Sensors:
Using adaptive tracking to classify and monitor activities

MIT AI Lab

Eric Grimson, Paul Viola,

Chris Stauffer, Raquel Romano,
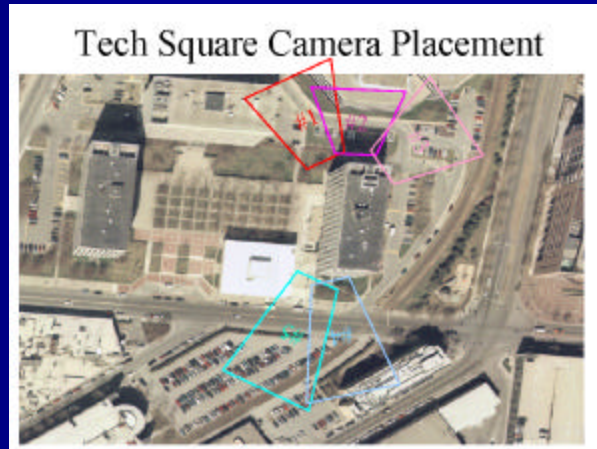
Lily Lee, Gideon Stein

A Forest of Sensors

- Given autonomous vision modules (AVMs): low power, low cost, can compute wide range of visual routines
- Create a forest of disposable AVMs:
  - attached to trees, buildings, vehicles
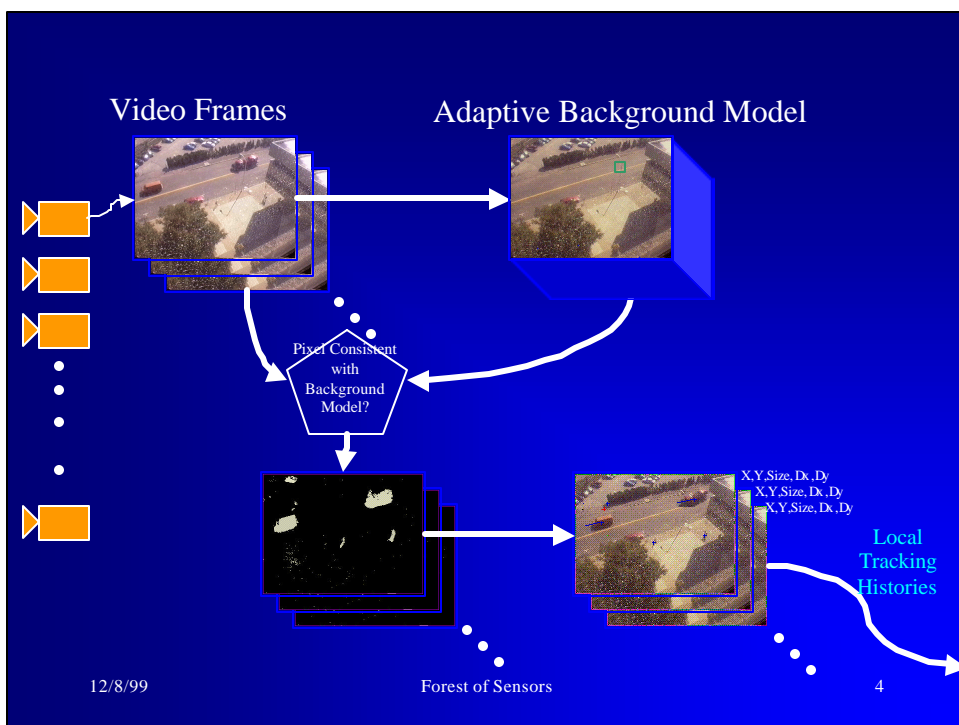- Question: Can the forest bootstrap itself to monitor sites for activities?

Multi-camera version

Tech Square Camera Placement

Video Frames   Adaptive Background Model

Pixel Consistent
with
Background
Model?

X,Y,Size,Dx,Dy
X,Y,Size,Dx,Dy
X,Y,Size,Dx,Dy

Local
Tracking
Histories

Capabilities and components

- Self calibration
- building rough site models
- detecting visibility
- primitive detection
- moving object modeling
- activity detection
- activity calibration

Working hypothesis

- Can achieve all of these capabilities simply by accurately tracking moving objects in the scene.

A robust, real-time tracker

- Model each pixel as an independent process
- Model previous n samples with weighted mixture of Gaussians, using exponentially decaying time window
- Background defined as set of dominant models that account for T percent of data
- Update weights and parameters
- Pixel > 2 sigma from background is moving
- Select significant blobs as objects

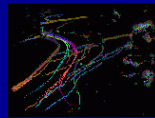# Adaptive tracking

Dynamic calibration

- Track objects in multiple cameras
- use correspondences to find a homography, assuming planar motion
- modify homography by fitting image features
- use non-planar features to solve for epipolar geometry, and refine
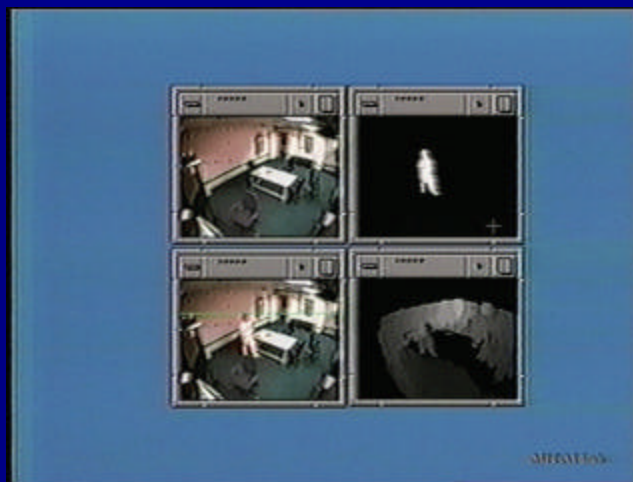
Dynamic calibration

5
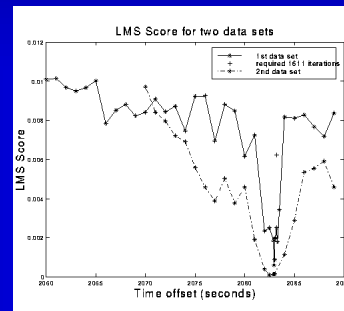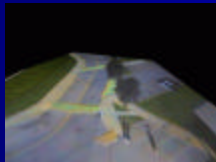
Site modeling

- N camera stereo from calibration
- dynamic tracking updates
- visibility detection and placement update
- reconstruction from multiple moving views

Site models by tracking

Site models by tracking

12/8/99   Forest of Sensors   13

Site modeling from stereo

- Multi-camera stereo reconstruction

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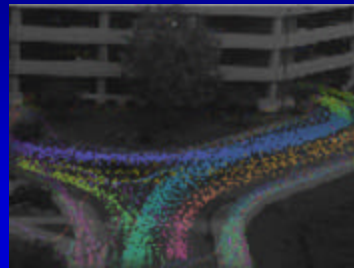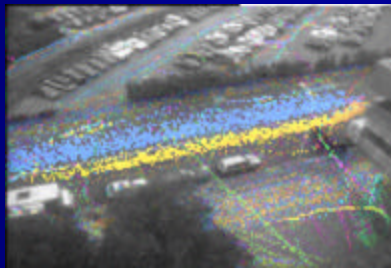# Stereo reconstruction

Activity detection & calibration

- Need to find common patterns in track data

Pattern tracks

Detect Regularities & Anomalies?
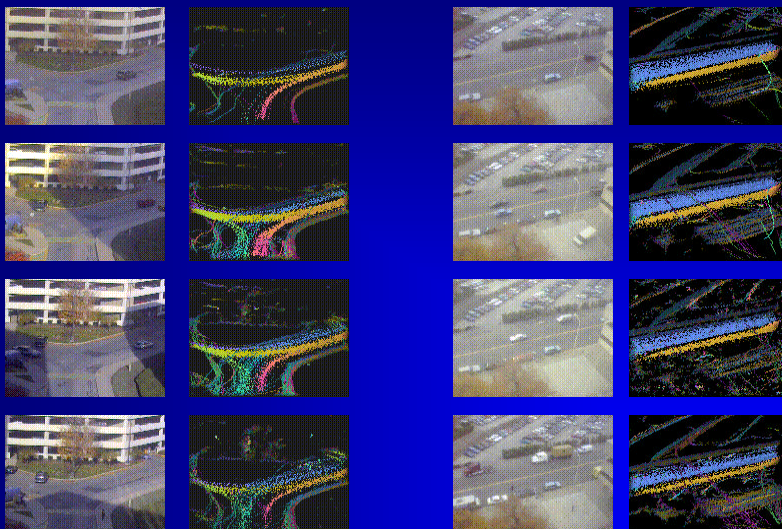
Example track patterns

- Running continuously for almost 1 year
  - during snow, wind, rain, ...
- one can observe patterns over space and over time
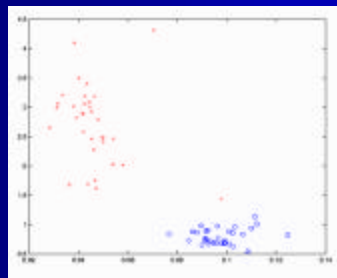- need a system to detect automatically

Classifying objects
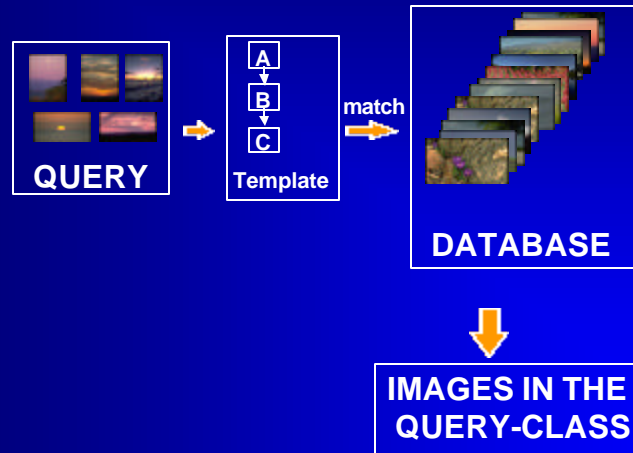
- Simple classifiers based on feature selection

Example -- people vs. cars using aspect ratio and size

Flexible template querying

QUERY → Template (A → B → C) → match → DATABASE

IMAGES IN THE QUERY-CLASS

Example

- Detection

Classifying objects

- Using flexible templates to detect vehicles
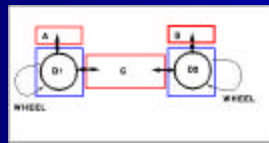
Classifying activities

- Quantize state space of continuous observations by fitting Gaussians
- map sequence of observables to sequence of labels
- compute co-occurrence of labels over sequences -- defines joint probability
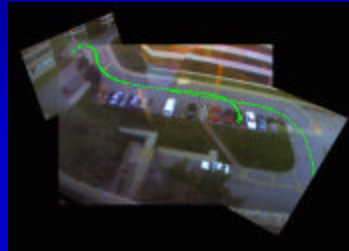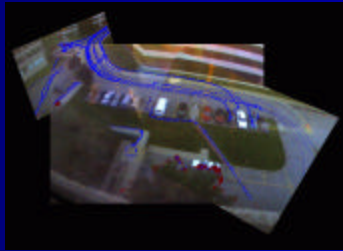- cluster by E/M methods to find underlying probability distributions

Automatic activity classification

Mapping patterns to maps

Multi-camera coordination
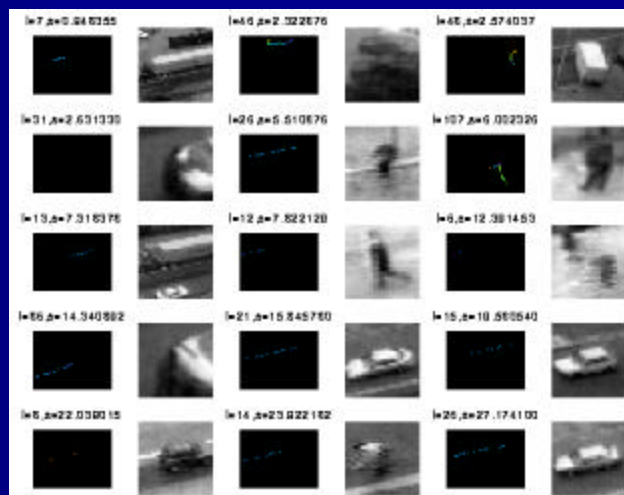
Finding unusual events

Finding similar events
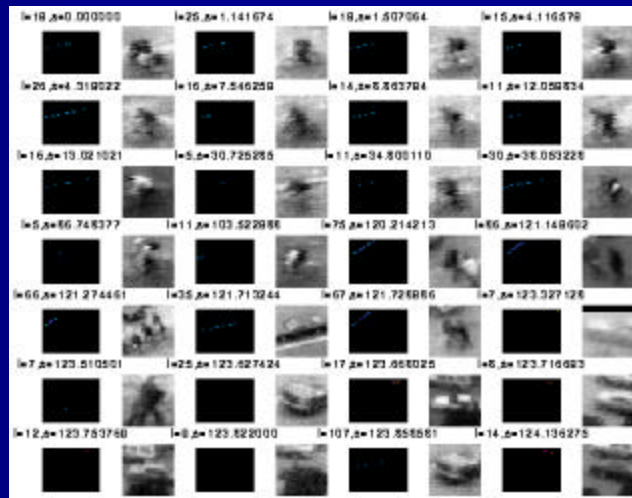
Future plans

- integration of pieces
- site models from dynamic tracking
- activity classification from multiple views
- variations on classification methods
- vocabulary of activities and interactions
- interactions of activity tracks
- fine scale actions