Example-Based Object Detection in Images by Components

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Summary

- Goal: Detect objects in static images
- How: Exampled-based person detection framework by components
  - Heads, legs, left arms and right arms detectors
  - Components are present in the proper geometric configuration
  - Person detector combines the results of the component detectors for person detection
  - Adaptive combination of classifiers (ACC)
  - Harr wavelet transform + support vector machines (SVM)
- Significantly better than a similar full-body person detector

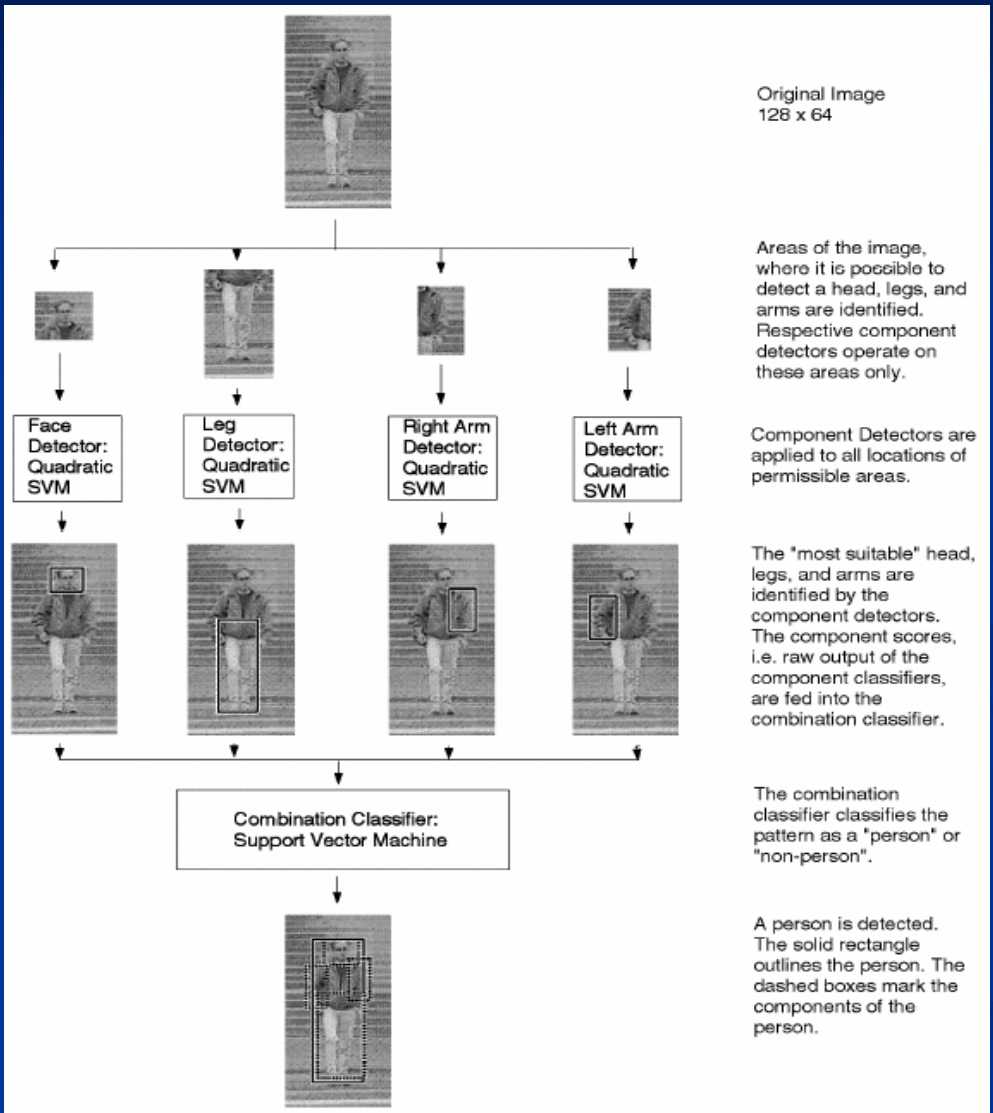
Previous Work

- Object detection
  - Model-based
  - Image invariance
  - Example-based
- Classifier combination algorithms
  - Bagging, Boosting, Voting and so on

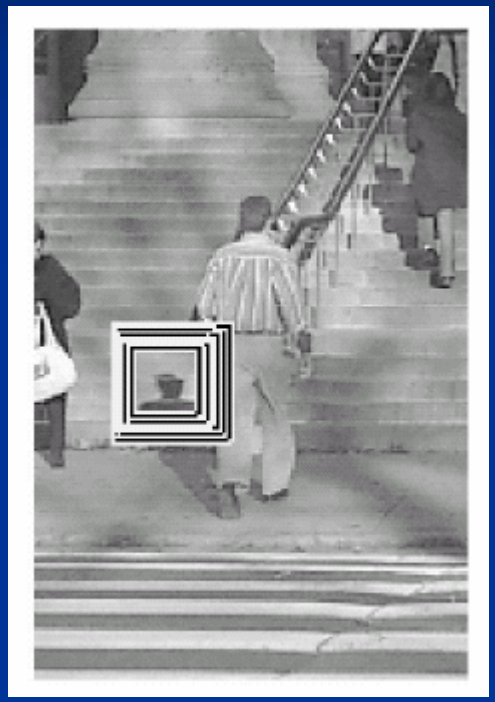
Challenges in Person Detection

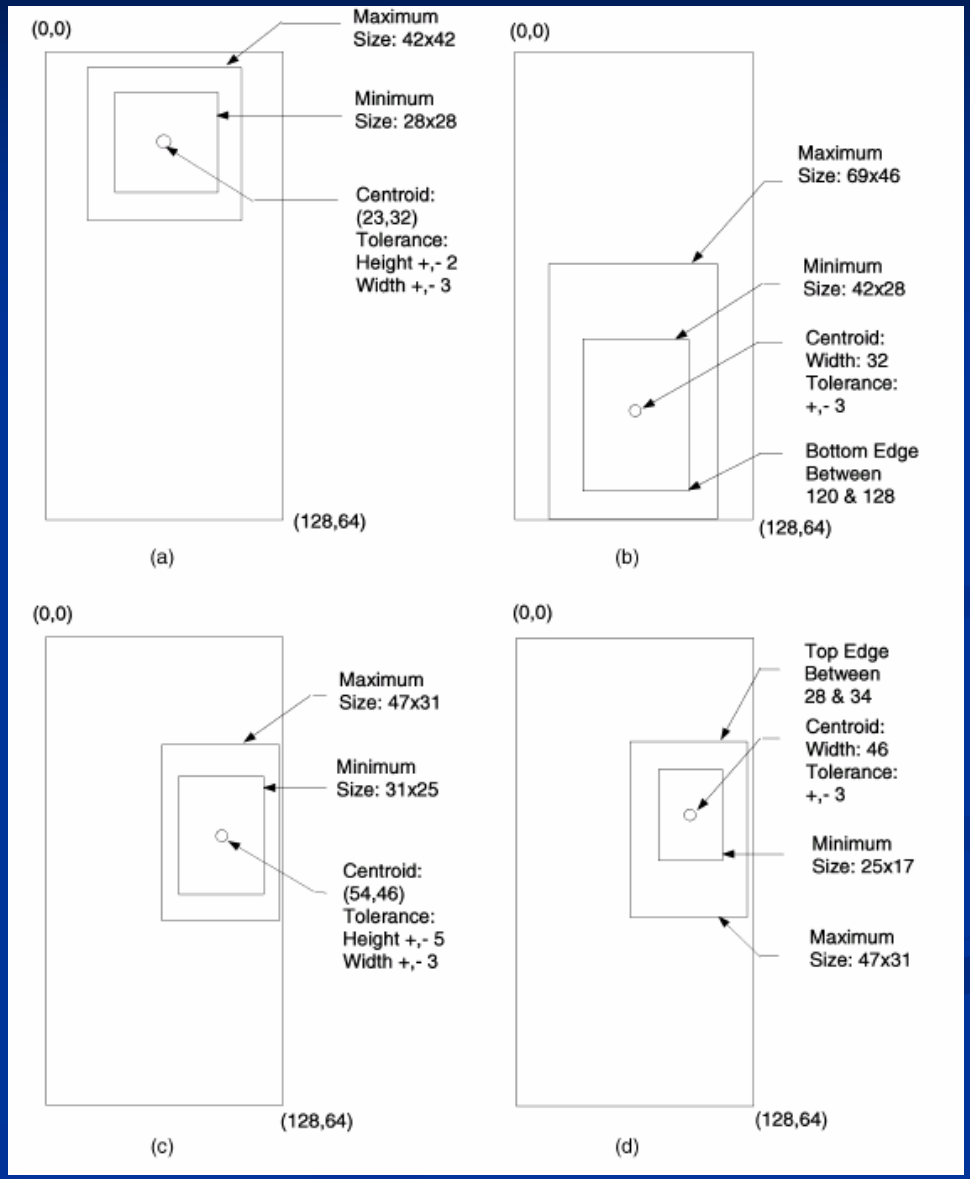
- Nonrigid objects, colors, garment types
- Rotated in depth, partially occluded or in motion

System Diagram

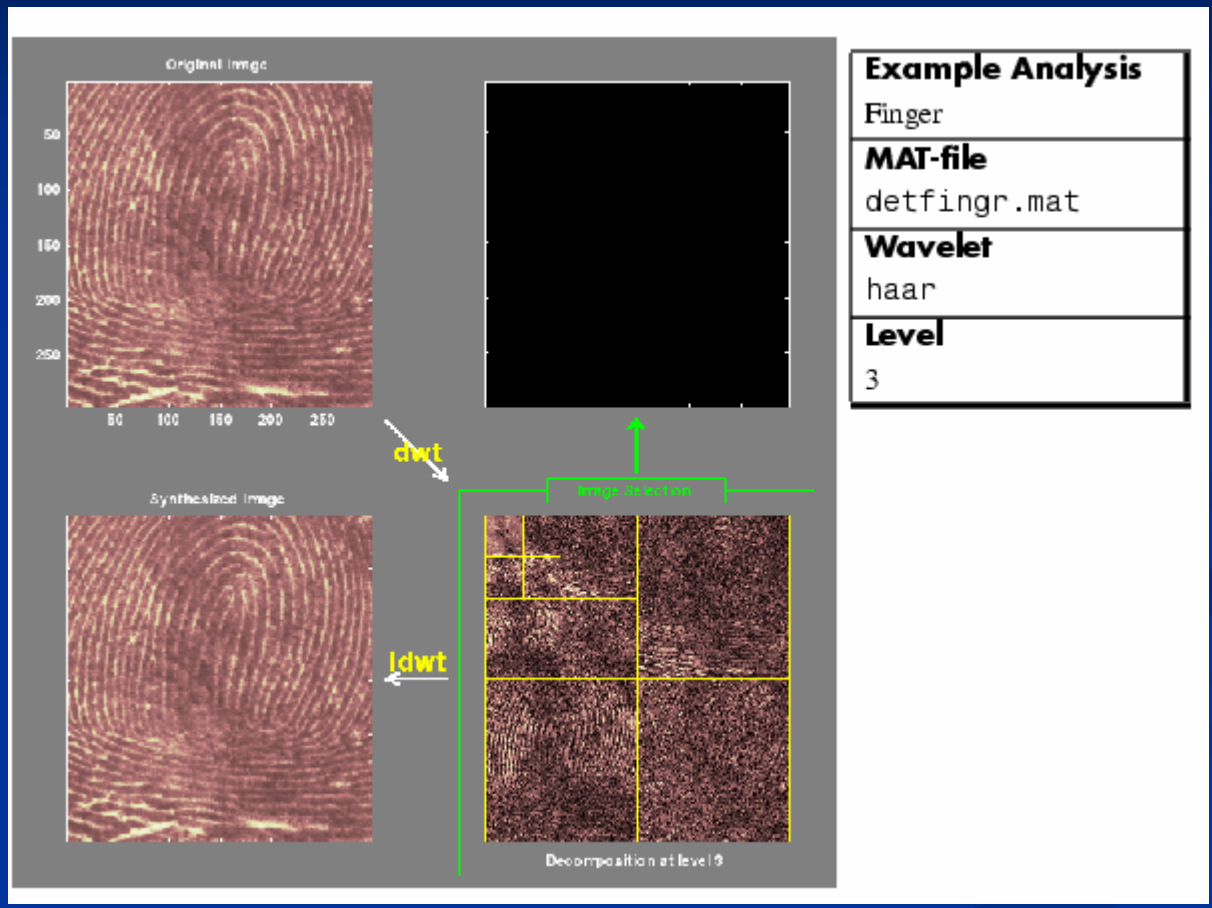


Geometric Constraints





Harr Wavelet Transform



Example Analysis
Finger
MAT-file
detfingr.mat
Wavelet
haar
Level
3

From www.matlab.com

Support Vector Machines (SVM)

- First, project input data nonlinearly and implicitly by kernel functions to a feature space
  - Mercer's kernels (Polynomial kernels and Gaussian radial basis function kernels)
- Second, find optimal decision hyperplane in the feature space by maximizing soft margins and an upper bound of training errors
- The raw output of an SVM classifier is the distance of a data point from the decision hyperplane

$$f(\mathbf{x}) = sgn(g(\mathbf{x}))$$

$$g(\mathbf{x}) = \left(\sum_{i=1}^{l^*} y_i \alpha_i K(\mathbf{x}, \mathbf{x}_\mathbf{i}^*) + b \right)$$

$$K(\mathbf{x}, \mathbf{x}_\mathbf{i}^*) = (\mathbf{x} \cdot \mathbf{x}_\mathbf{i}^* + 1)^2$$

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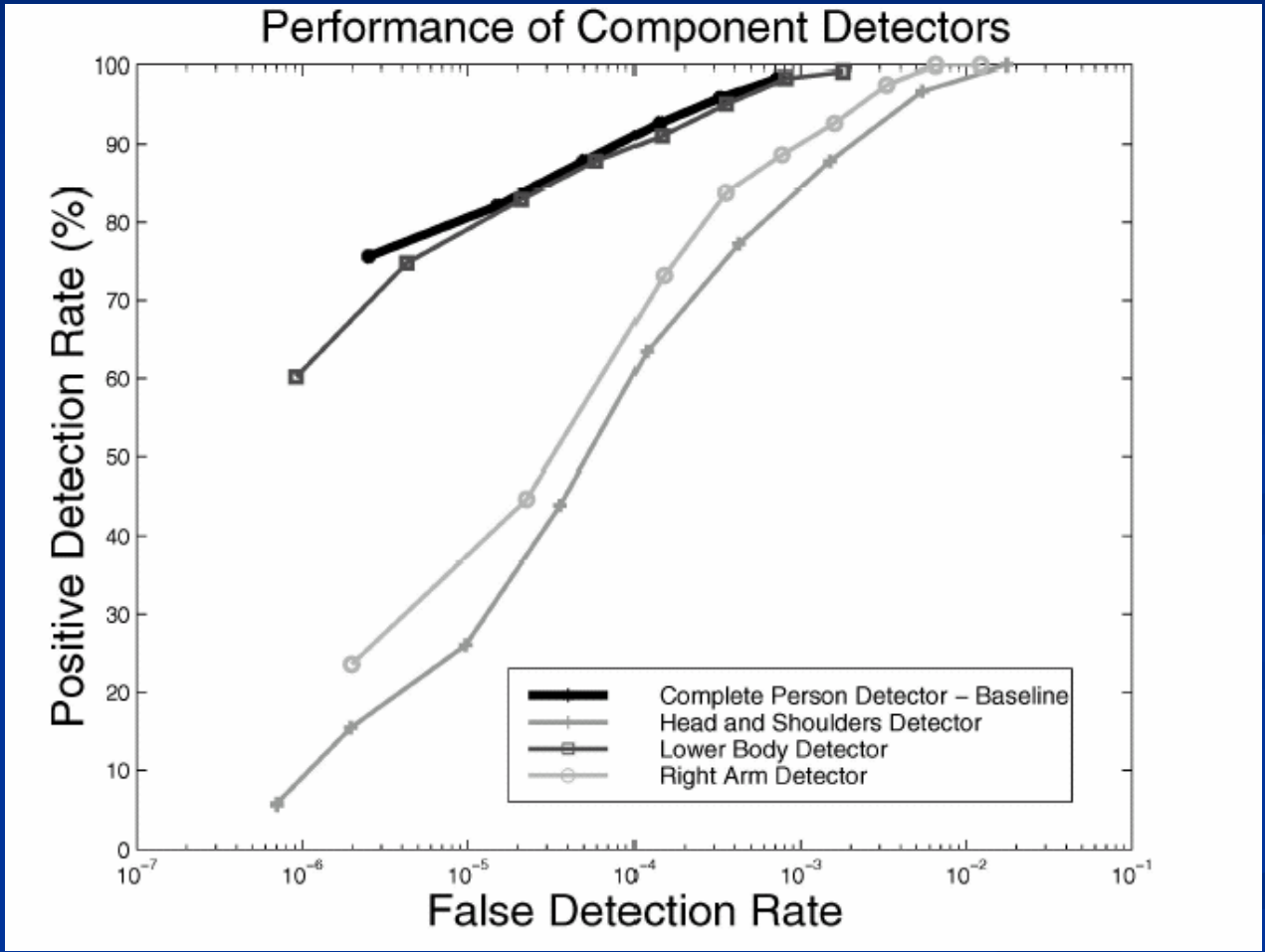
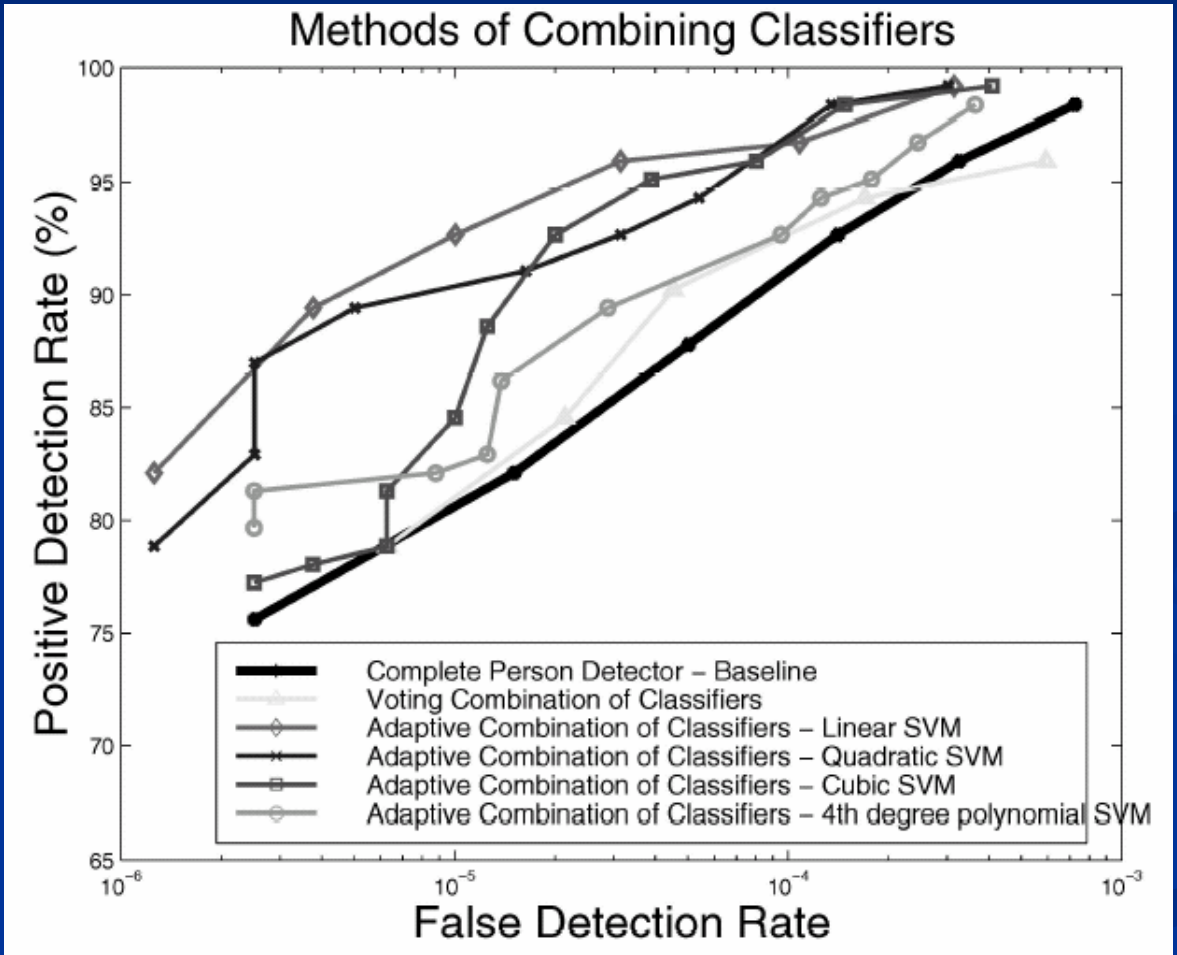
Training Examples

Experimental Results



Experimental Results (Cont.)



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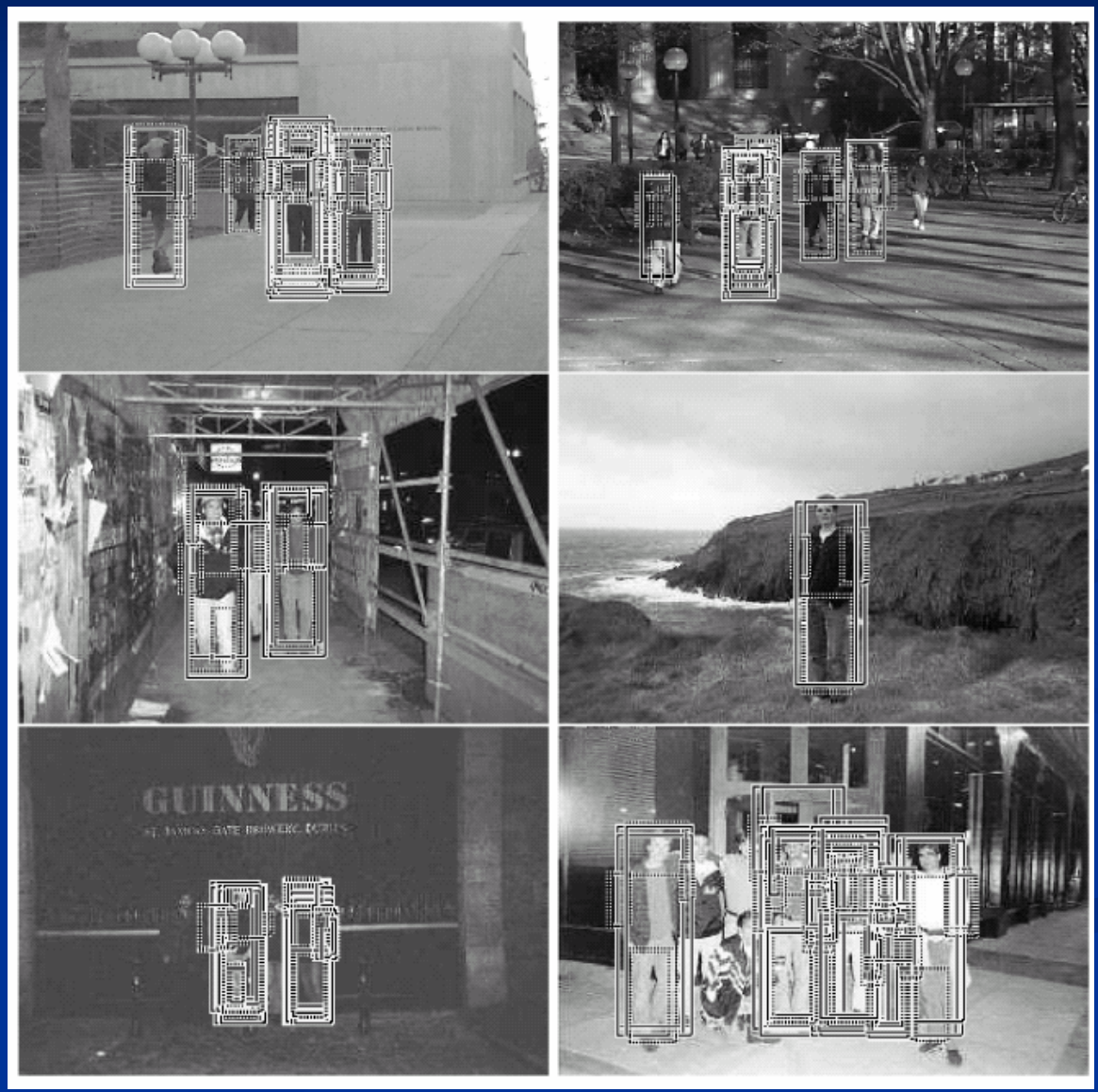
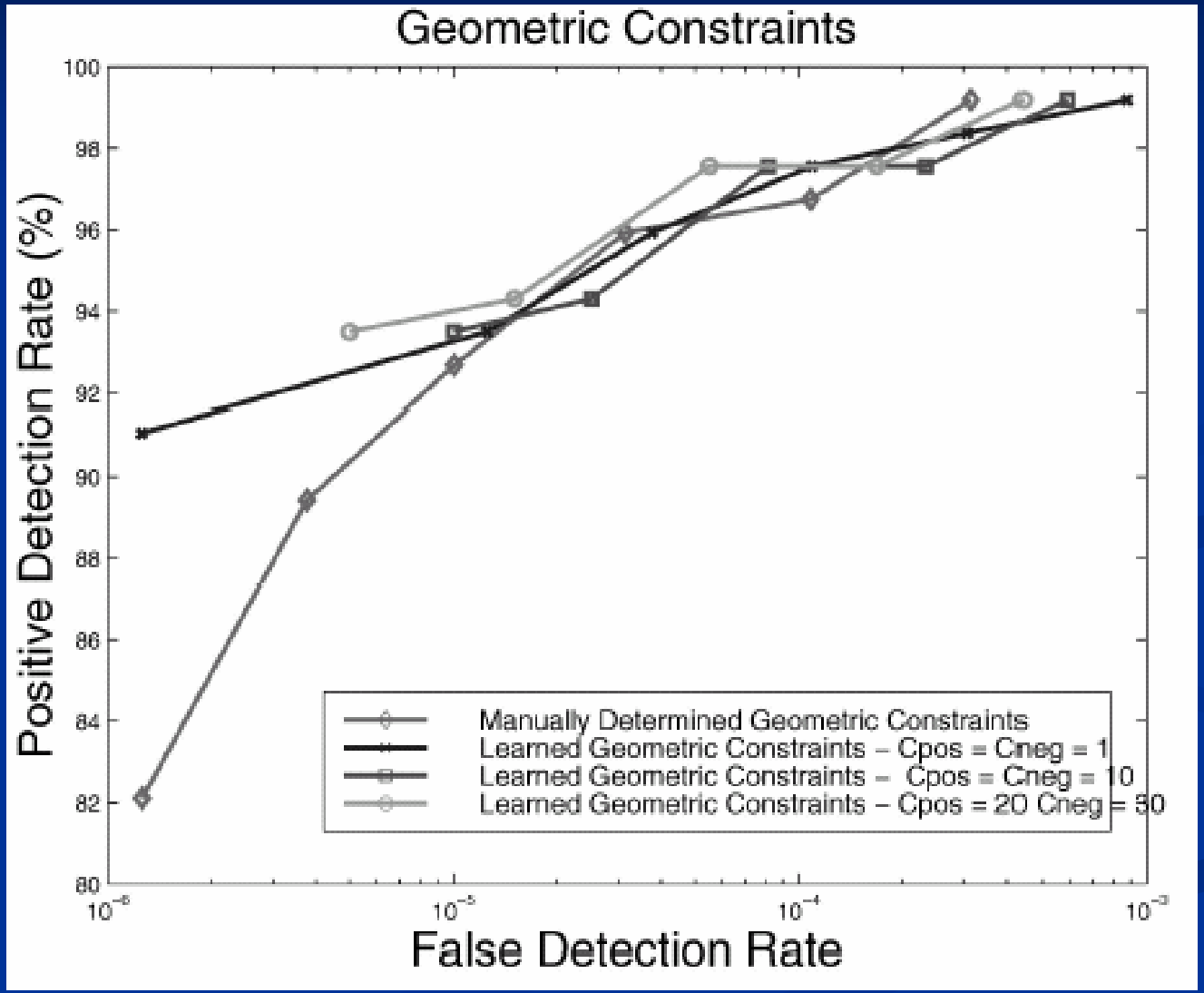


Learned Geometric Constraints



Conclusions

- Component–based person detection
  - Better than full-body person detector
  - Hierarchical Classifiers or Adaptive Combination of Classifiers (ACC)

Future Work

- Face detection: Heisele et al. CVPR'01
- Face recognition: Heisele et al. CVIU'03
- Car detection: Bileschi, Leung and Rifkin ECCV 04 Workshop
- Arbitrary viewpoints?
  - How appearance and geometric configuration change

Questions

- Lighting
- Videos
  - Space-time component based detection, recognition and tracking
- Other applications
  - Insect
- What are meaningful components?
- Object detection/recognition/tracking if cameras intrinsic and extrinsic parameters may change

Thank You!