Model-based Integrated Approaches for Remote Identification of Humans

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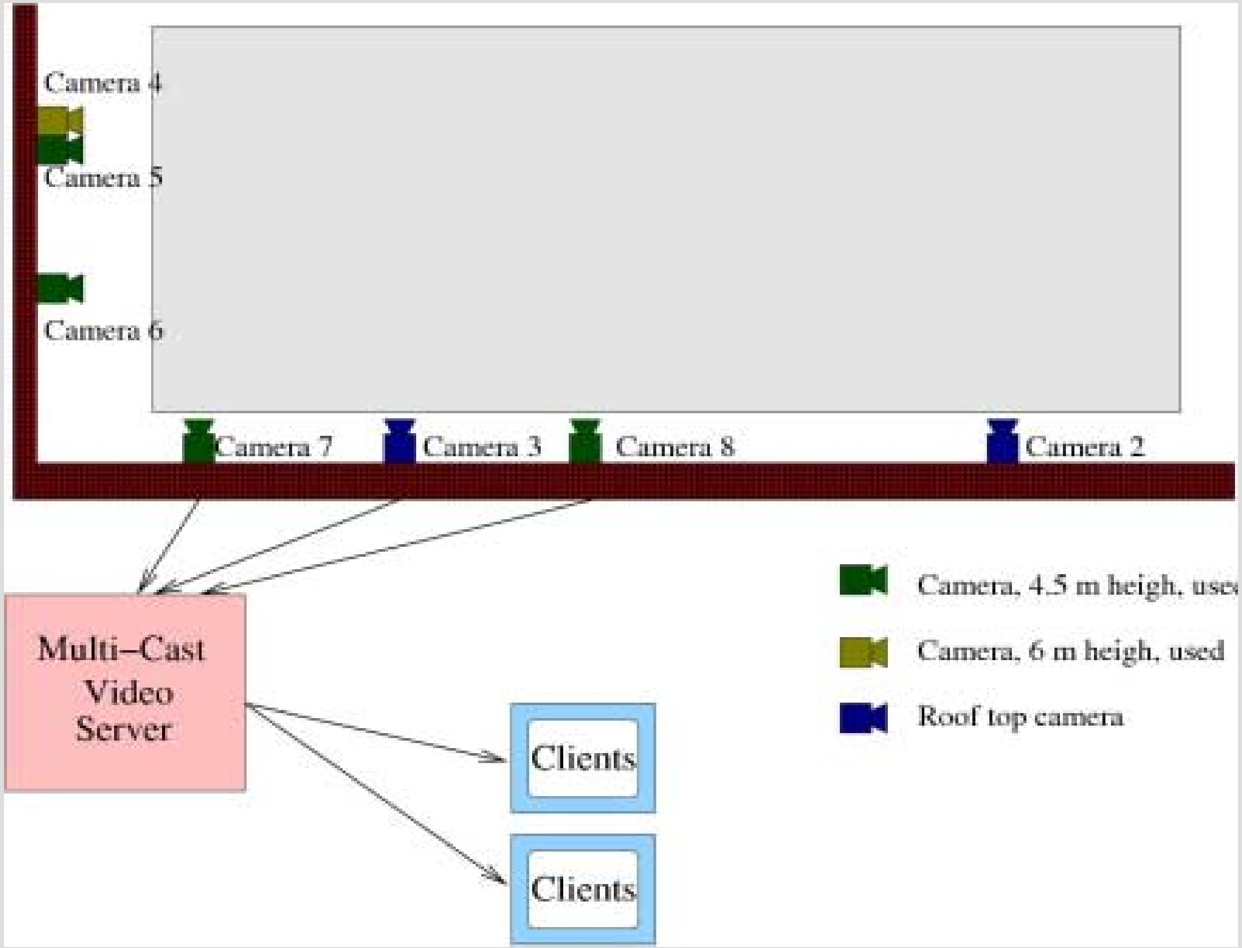
Objectives

- Development of Algorithms for Human ID using Gait and Face
- Integration of Software and Hardware for End-to-End System Realization
- Facility for Data Collection
- Systematic Evaluation and Performance Characterization

Infrastructure

Installation of the **Outdoor Video Lab (OVL)**



4 Cameras, 4.5m
1 Camera, 6m
1 Camera, roof

1 Video server
N clients

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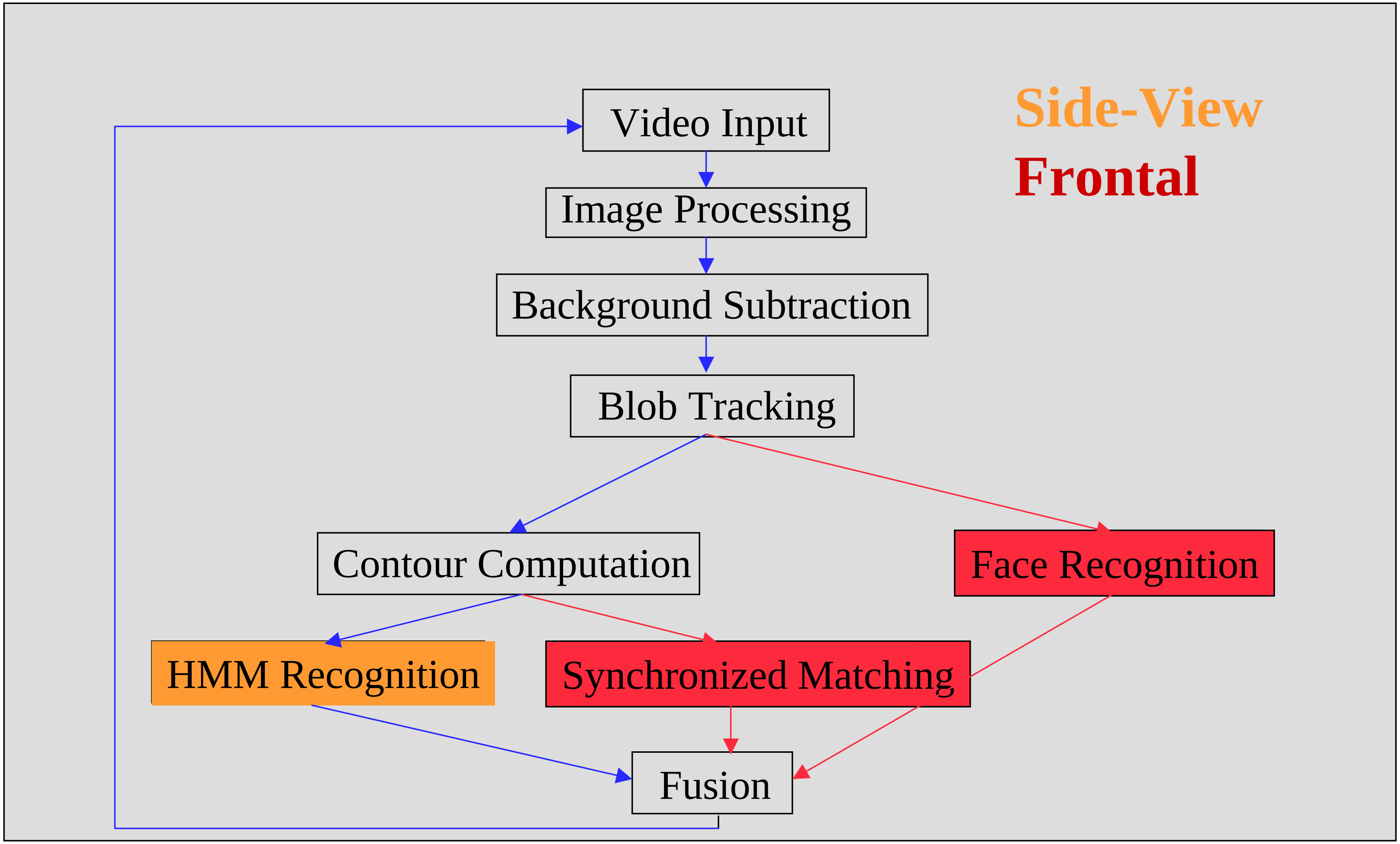
Integrated Software System



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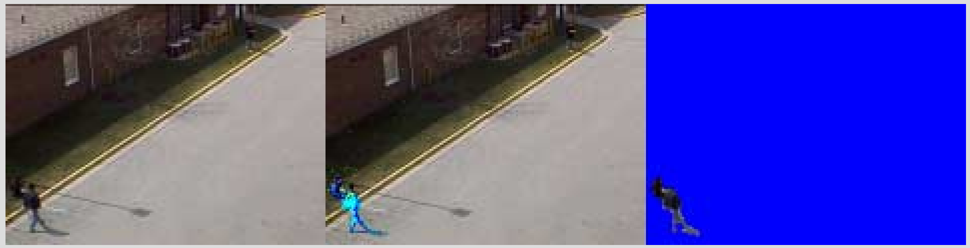
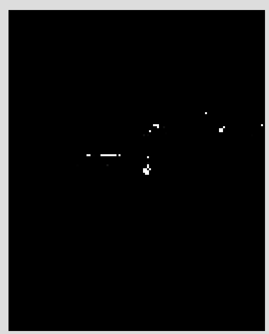
Preprocessing Videos

- Background Subtraction



- Mean Shift Blob Tracking

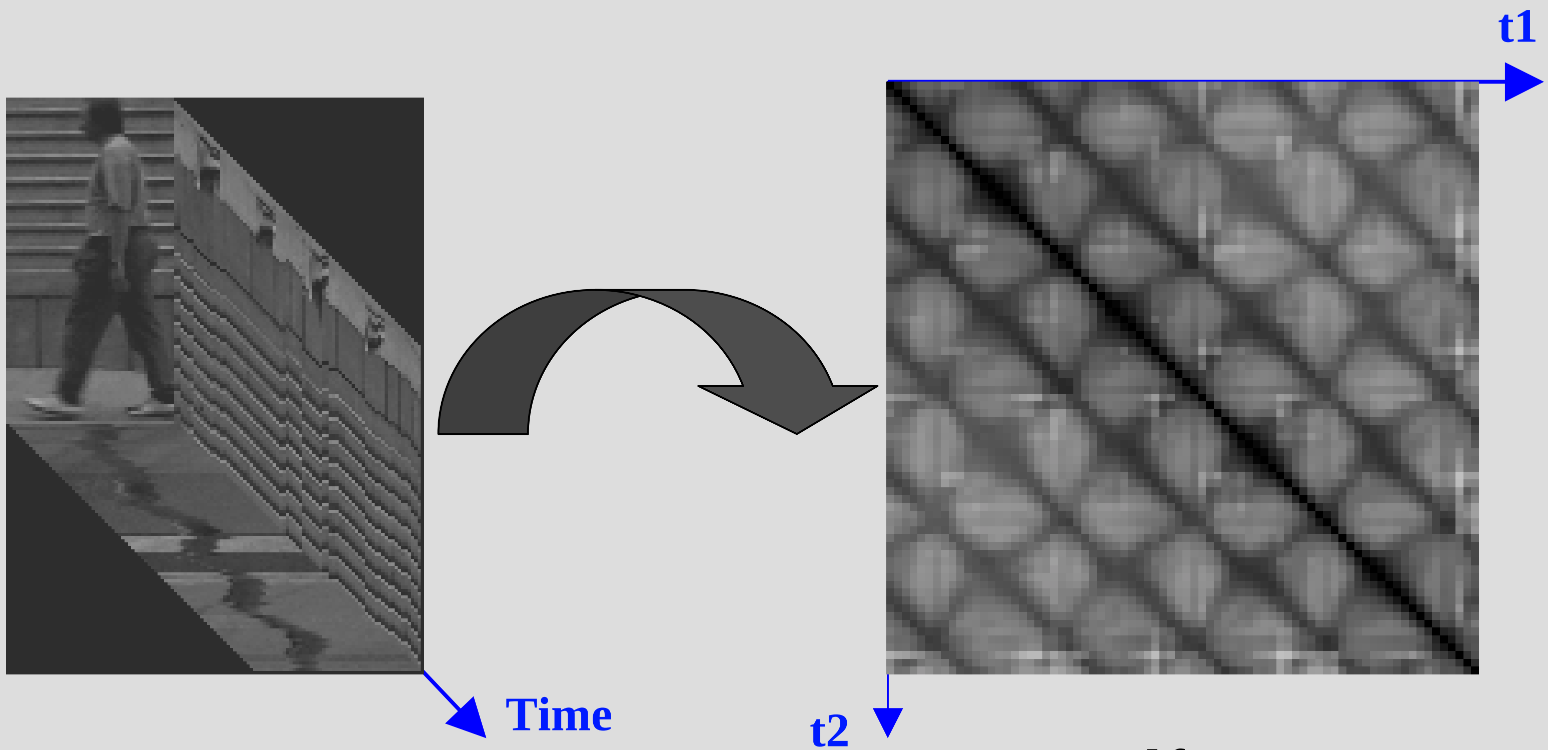


Gait Algorithm Development

- Developed and Evaluated three Algorithms for Gait-based Recognition

1. Eigengait
2. HMM
3. Synchronized Matching (using Dynamic Time Warping)
4. Fusion
    1. Leg-dynamics + physical attributes
    2. Frontal + side gait

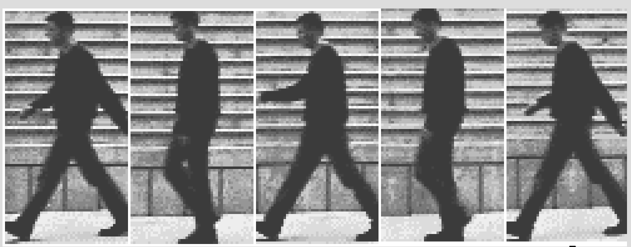
Eigengait-based Approach



Spatio-temporal Cube

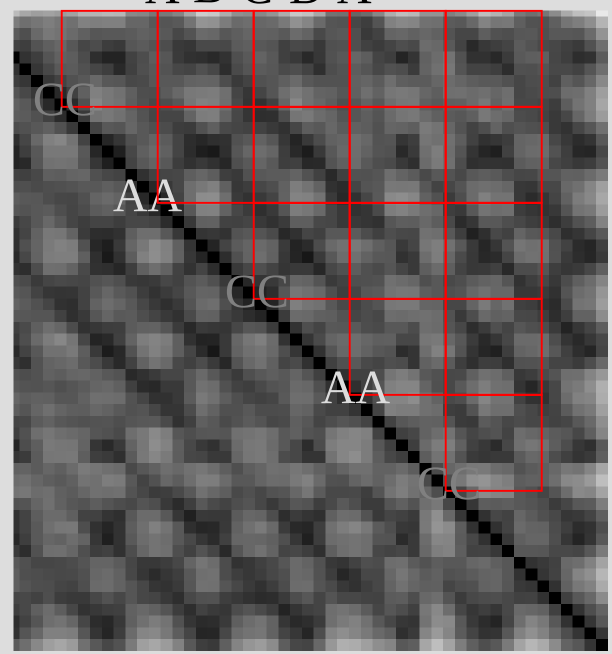
Self-similarity Plot S(t1,t2)

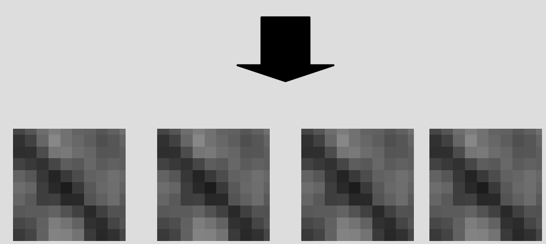
Eigengait-based Approach



A B C D A

Key Poses of Gait

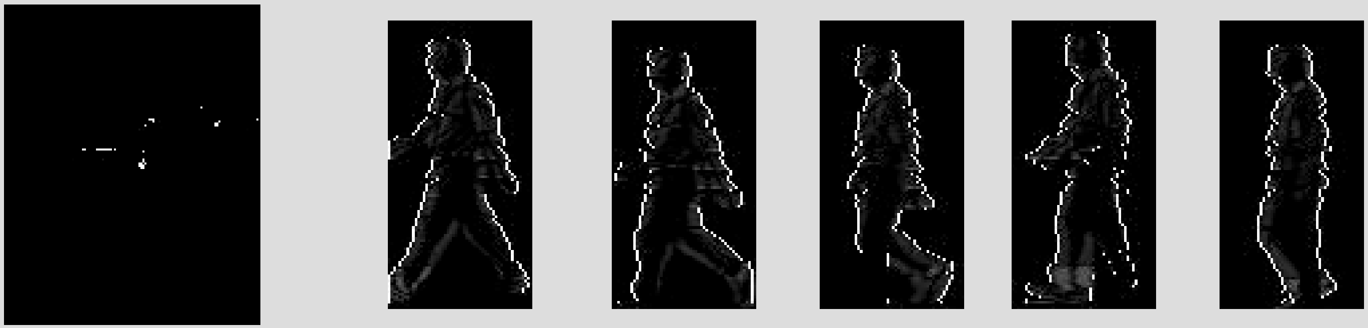




Normalized Feature Vectors

HMM-based Approach

Automatic Extraction of *Stances* from training video



These five *stances* are associated with HMM states

Two distance measures were used to compute feature vector:

•Chamfer metric (distance transform)

•Integral metric (Kanade)

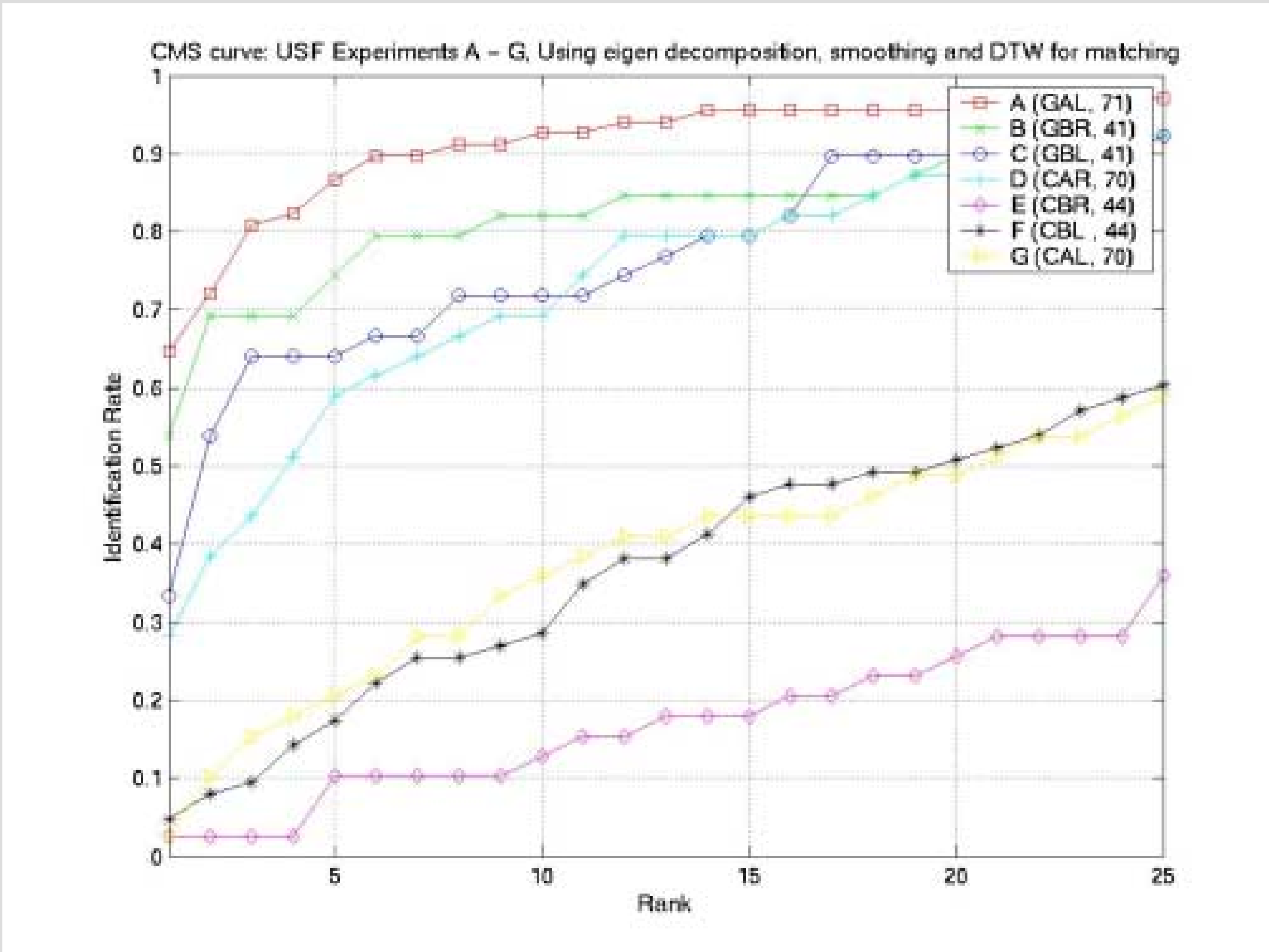
Synchronized Matching

- Advantages:
  - Similar to the Baseline Algorithm
  - Enhances the Baseline Algorithm with DTW
  - Simple
  - No training is required
- Disadvantages:
  - No training is required
  - Inadequate generalization

Performance Evaluation

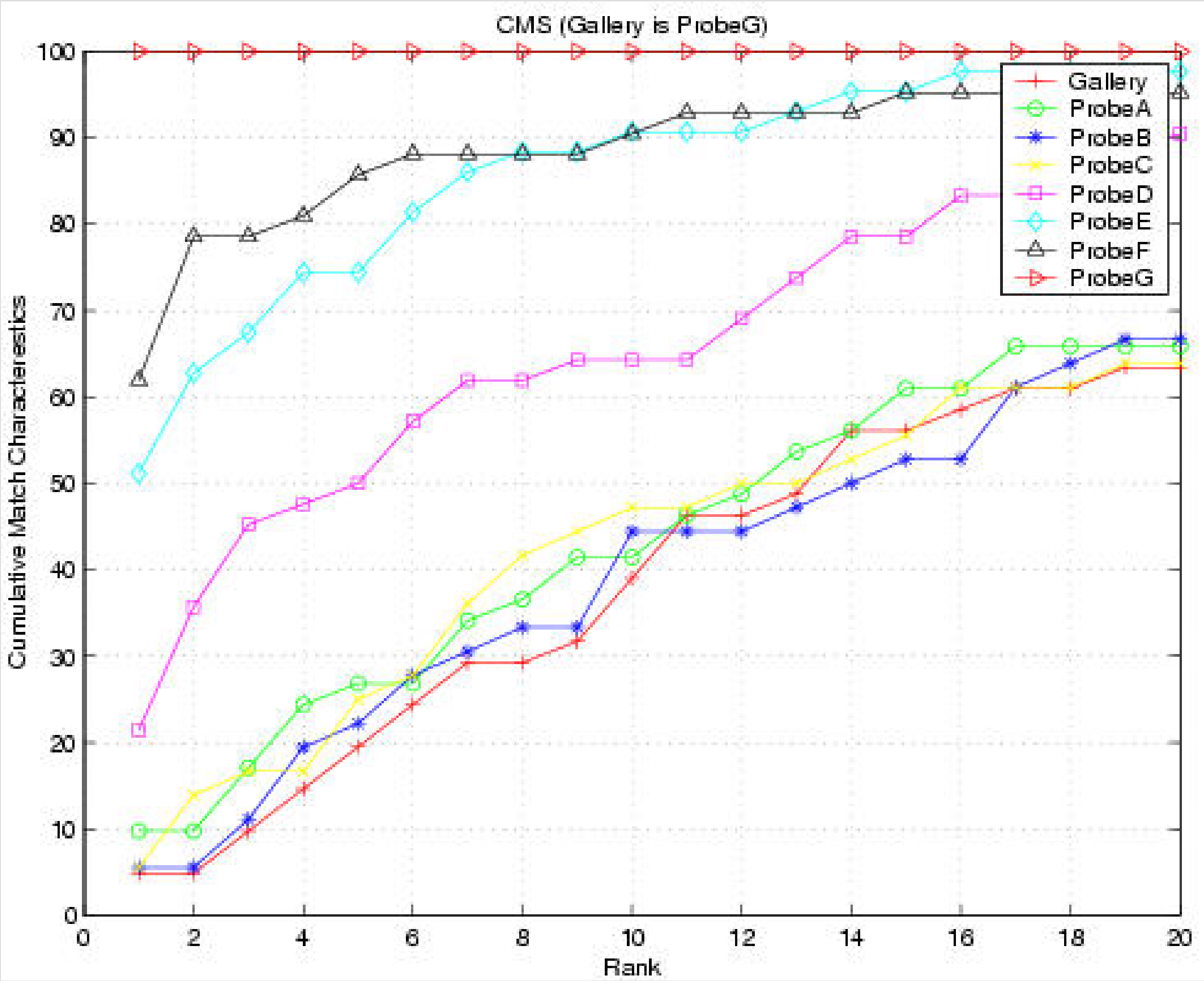
	CMU	UMD2	MIT	USF
HMM	✓	✓	✓	✓
DTW	✓	✓	✓	✓
EigenG	✓	✓	✓	
Fusion		✓	✓	

UMD Gait Recognition on USF Dataset: Results



UMD HMM Results on USF Dataset

Gallery: GAR
Probe A: GAL
Probe B: GBR
Probe C: GBL
Probe D: CAR
Probe E: CBR
Probe F: CAL
Probe G: CBL



Summary of Round Robin Expts.

- Generalization across surface type poor
- Graceful degradation with variations in camera look and shoe type.

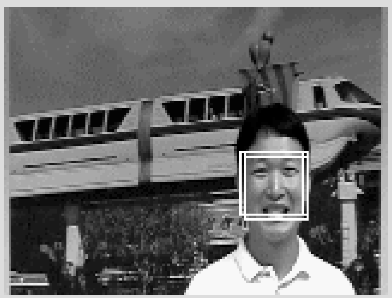
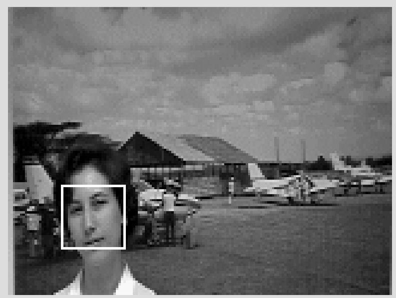
Gallery	GAL	GBR	GBL	CAR	CBR	CAL	CBL
Probe	GBL	GBL	GAL	CBR	CAR	CBL	CAL
Probe	GAR	GAR	GBR	CAL	CBL	CAR	CAR
Probe	GBR	GAL	GAR	CBL	CAL	CBR	CAR

Face Recognition

- Developed and evaluated three Algorithms for Face recognition
  - Still-to-still in complex background
  - Still-to-video, using Sequential Importance Sampling (SIS)
  - Video-to-video, using exemplar learning and SIS
- "Smiling" faces are better for recognition!

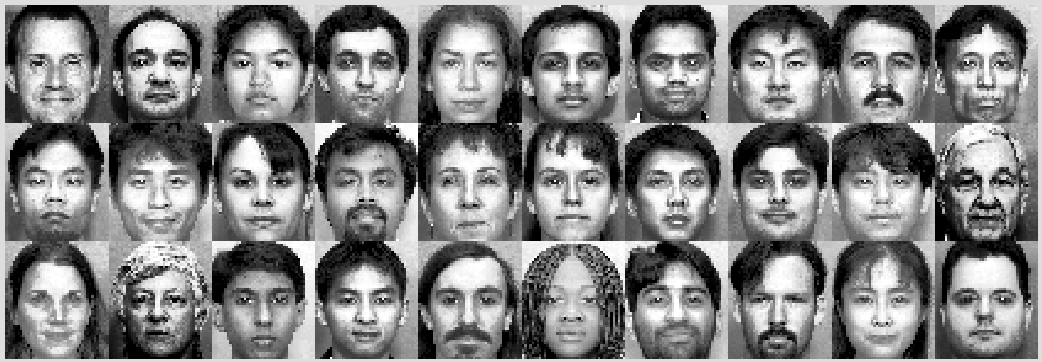
Face Recognition and Detection in Complex Backgrounds




- Preliminary tests using 50 persons dataset and 400 images give 95% detection rate with one false alarm. Recognition accuracy is typical of eigenfaces method.

Still-to-Video-based Recognition



Still-to-Video-based Recognition

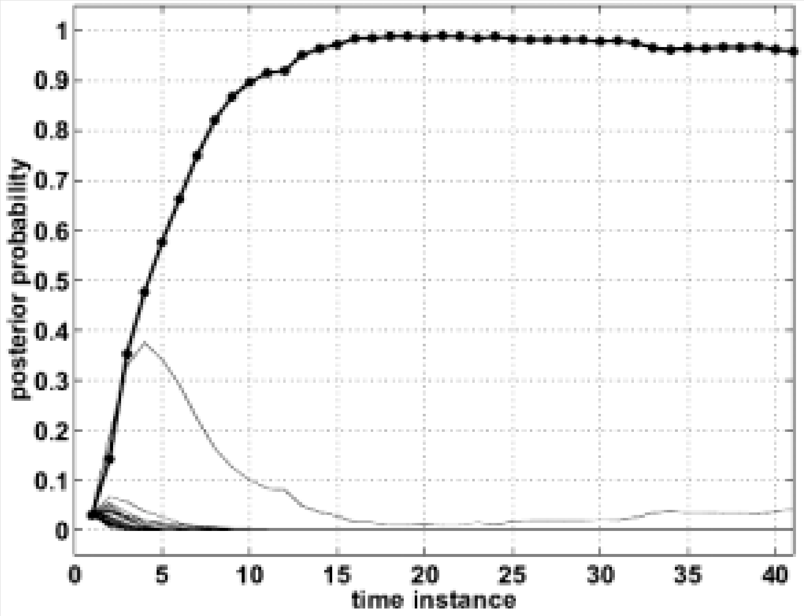
Still-to-video uses classical Bayesian propagation

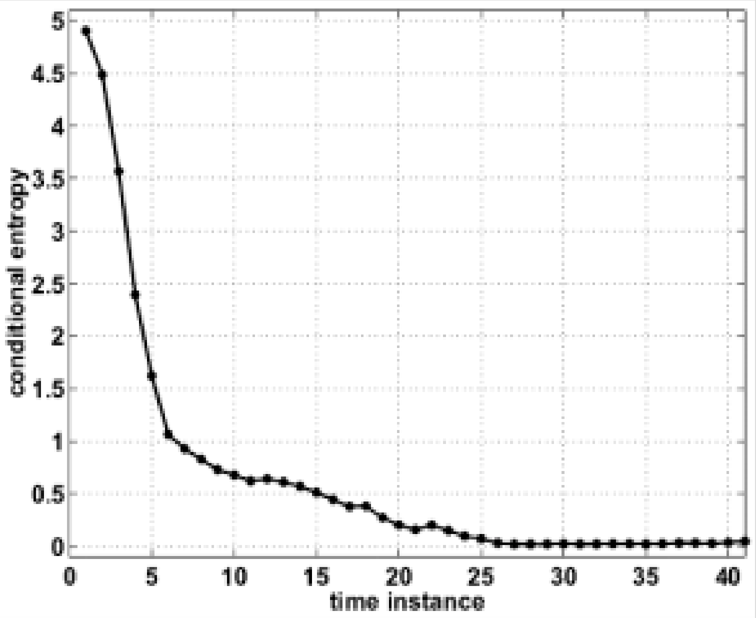
$$p\left(X_t \mid Z_1 .. Z_t\right) \equiv p_t(\alpha_t, i_t)$$

$$= \sum_{i_{t-1}} \int_{\alpha_{t-1}} p_t(Z_t \mid \alpha_t, i_t)\, p_t(\alpha_t, i_t \mid \alpha_{t-1}, i_{t-1})\, p_{t-1}(\alpha_{t-1}, i_{t-1})\, d\alpha$$

A Monte Carlo Markov Chain method is used to approximate the probability density function

Still-to-Video-based Recognition





Posterior Probability

$$p\left(X_t \mid Z_1 \ldots Z_t\right)$$

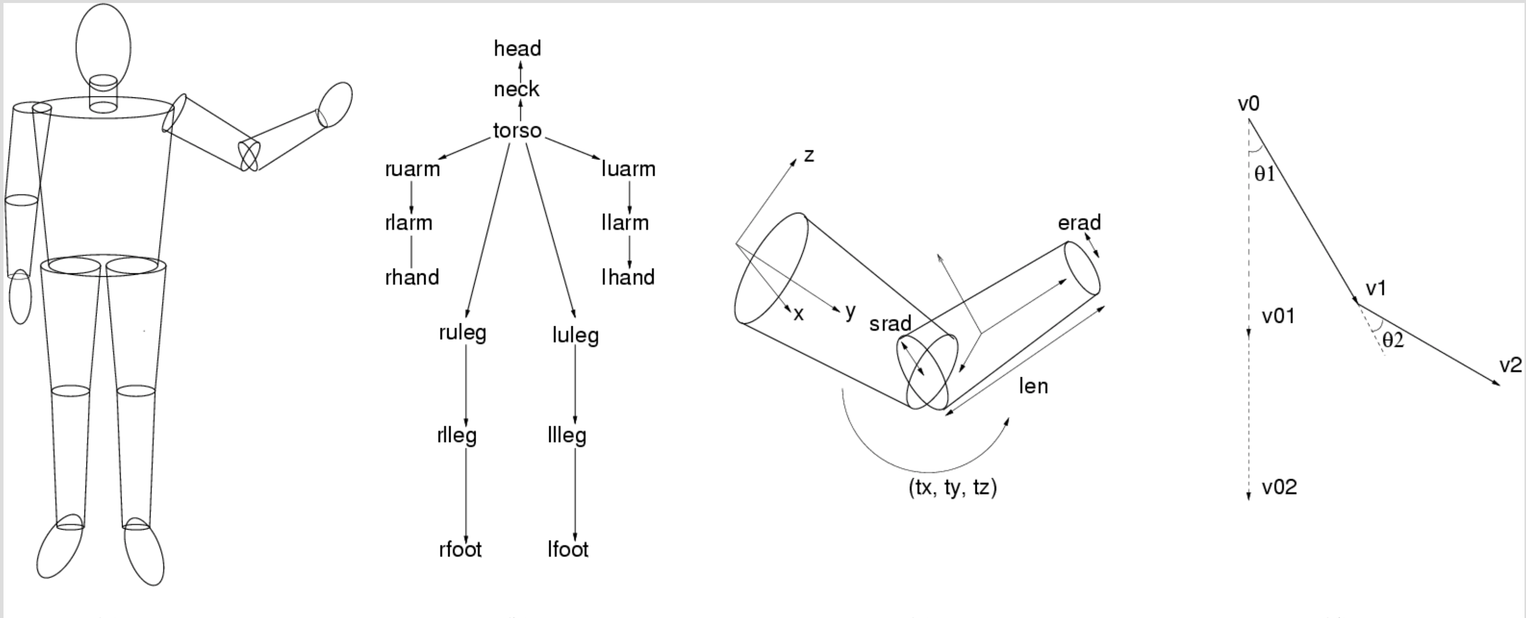
Conditional Entropy

$$h(X_t \mid Z_{1:t}) = \sum p(X_t, Z_{1:t}) \log_2 \frac{1}{p(X_t \mid Z_{1:t})}$$

Future Plans

1. Rotation-Invariant Gait Recognition
2. 3D Face Recognition
3. 3D Gait Recognition
4. Fusion of Face + Gait
5. Extensions to Multi-Camera systems

3D Gait Recognition



(a) (b) (c) (d)

3D Gait Recognition

Application of Monte Carlo Markov Chain for parameter estimation.
29-d parameter space

Fusion of Face and Gait

- Frontal face, side gait
- Frontal face, frontal gait
- Needs special camera setup (face too small on gait images)