Extreme Data Streaming Using Image Database

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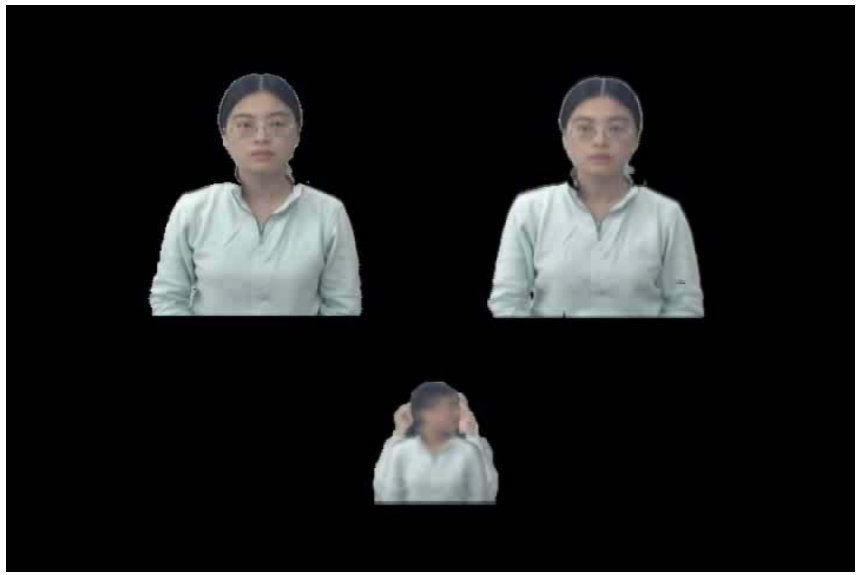
Problem

- Current limitation in bandwidth for large data communication
- We want to achieve real time interactive communication under low bandwidth network

Key Insights

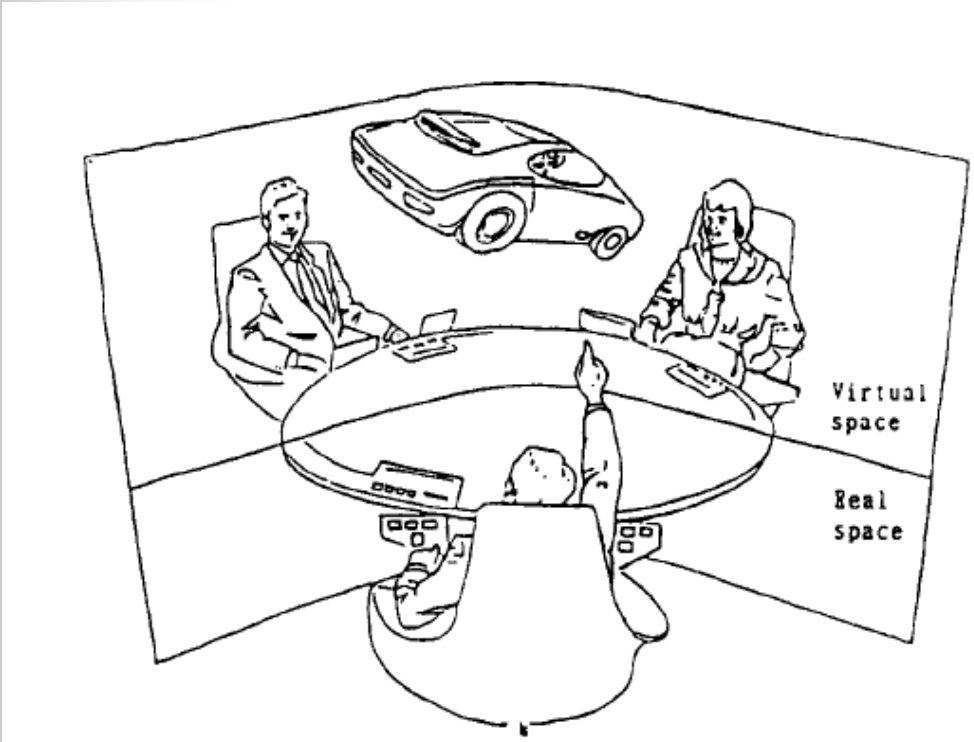
- Limited body motion
  - Pre-record the motion sequence
  - Send the processed movie in the beginning
- Live video captured from webcam is matched with the frames in image database, only the index of the matched frame is sent



Possible application

Distance Learning Classroom System

Another example



Virtual office

Aizawa, Kiyoharu. “Model-Based Image Coding: Advanced Video Coding Techniques for Very Low Bit-Rate Applications”. Proceedings of the IEEE, Vol. 83, No. 2, February 1995

Contribution

- Extreme bit-rate reduction (35kbps -> 480 bps for 30 fps)
- Independent resolution
- Less overhead – no need to build a 3D model
- Low computational complexity: based purely on image comparison

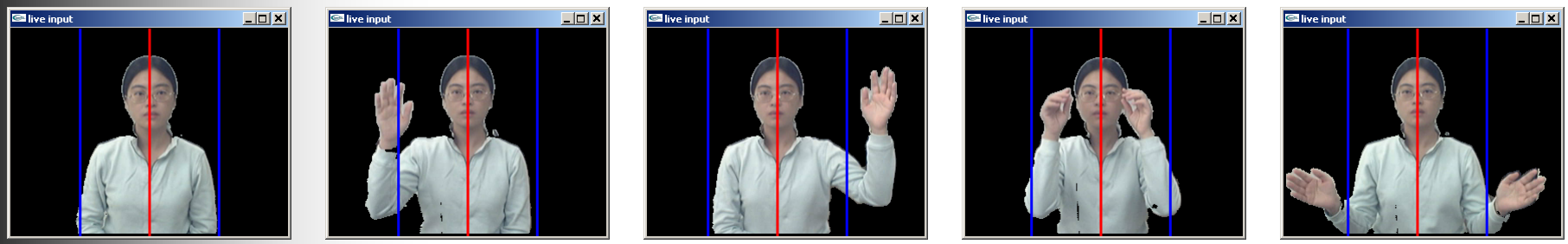
Data Acquisition

- A movie sequence consists of various upper body gestures.
- Natural pausing between sequence.
- Guiding audio instruction.

Data Registration

- Background subtraction
- Frame Segmentation
- Shape Analysis
  - Noise removal
  - Silhouette

Frame Segmentation

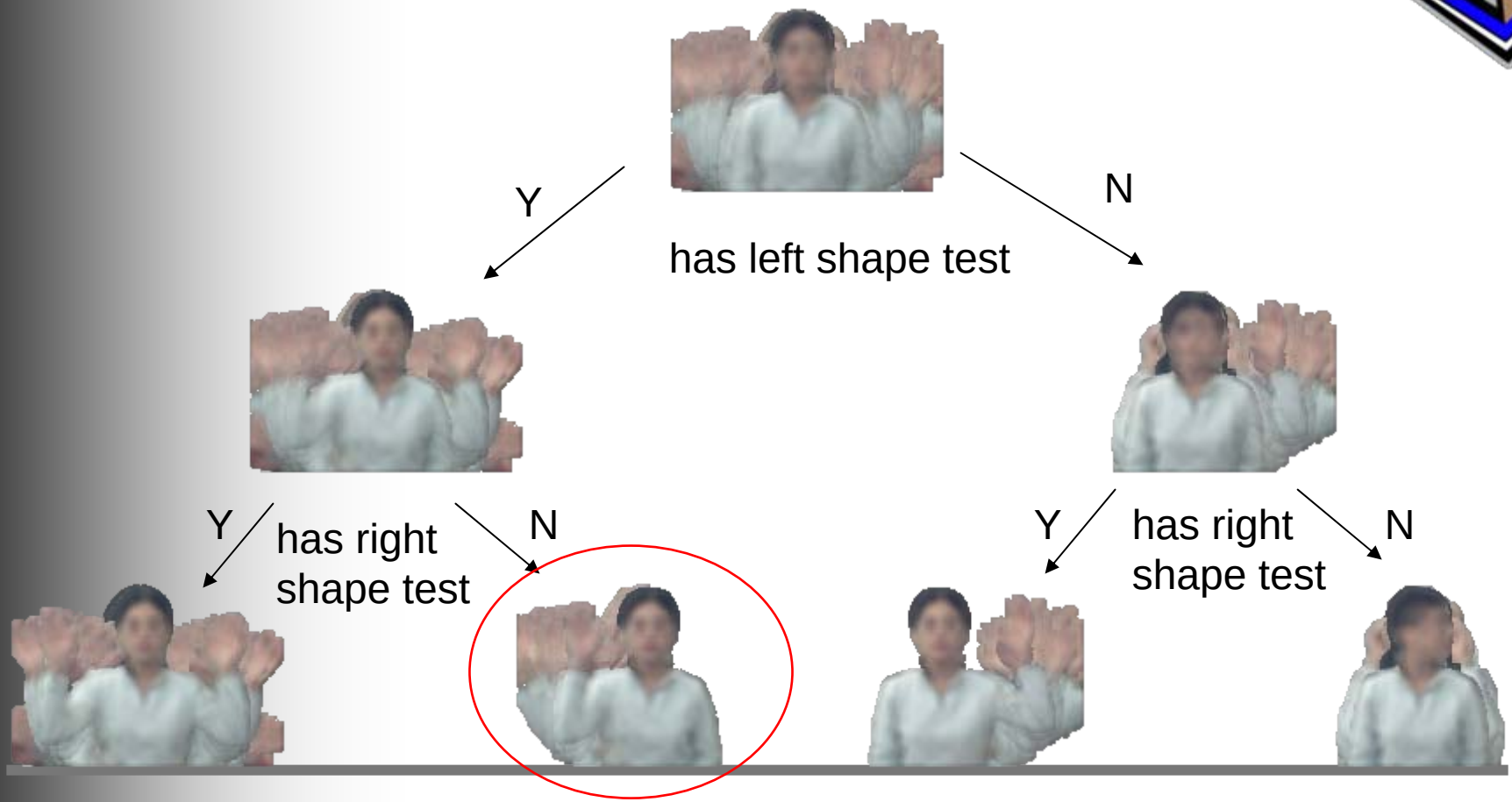


- Central line (red) and shoulder line (blue) defines the stationary region without shape variation

Model Segmentation

- Group division based on pausing
- Skipping redundant frames
- Merging group based on similar shape
- Binary tree built based on shape variation w.r.t. the stationary region

Tree Visualization



Tree Leaves

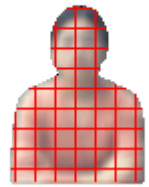
- Leaf node 5: left side only shape

Image-based Matching

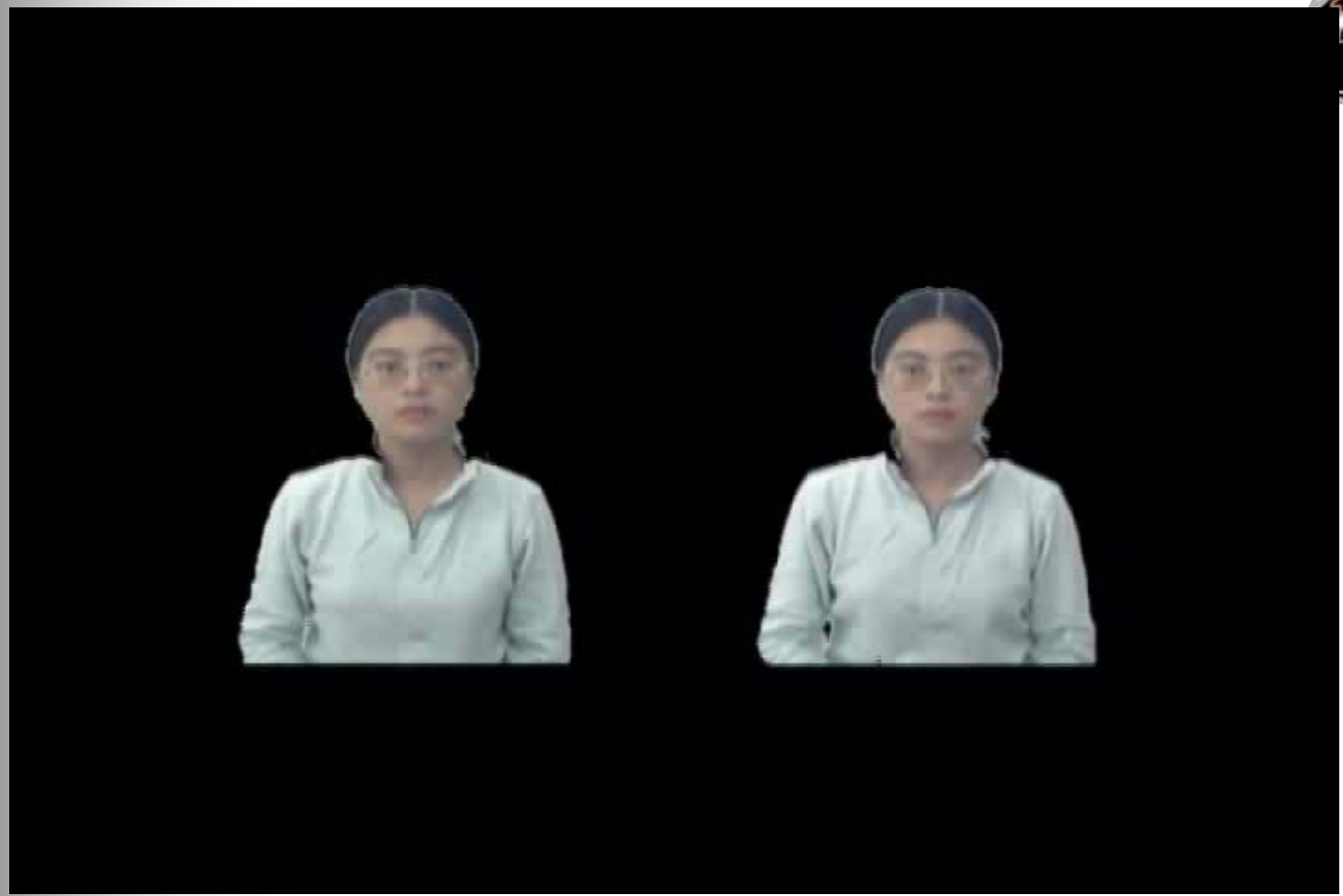
- Linear searching on all images
- Linear searching on selected tree leaves
- Linear searching on groups
- Binary searching on groups

Linear Searching On All Images

- Use segments in database images with the input image



- Optimization
  - Skip frame if bbox not match
  - Use coherence to reduce popping



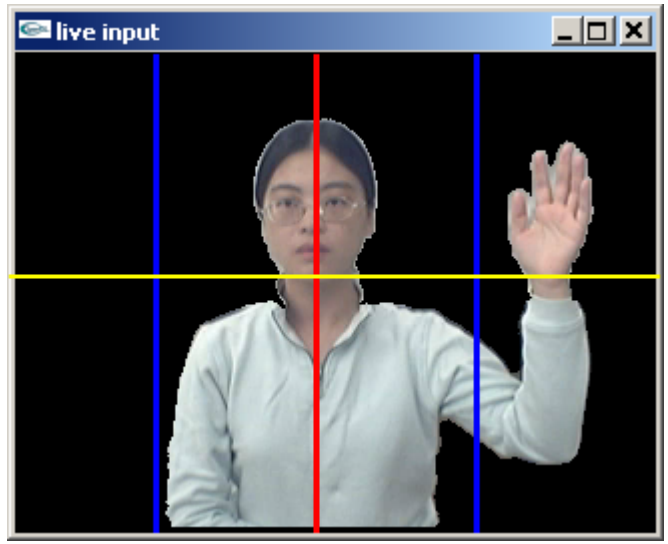
Linear searching on all images

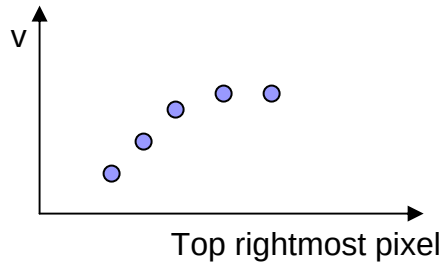
Linear Searching On Selected Tree Leaves

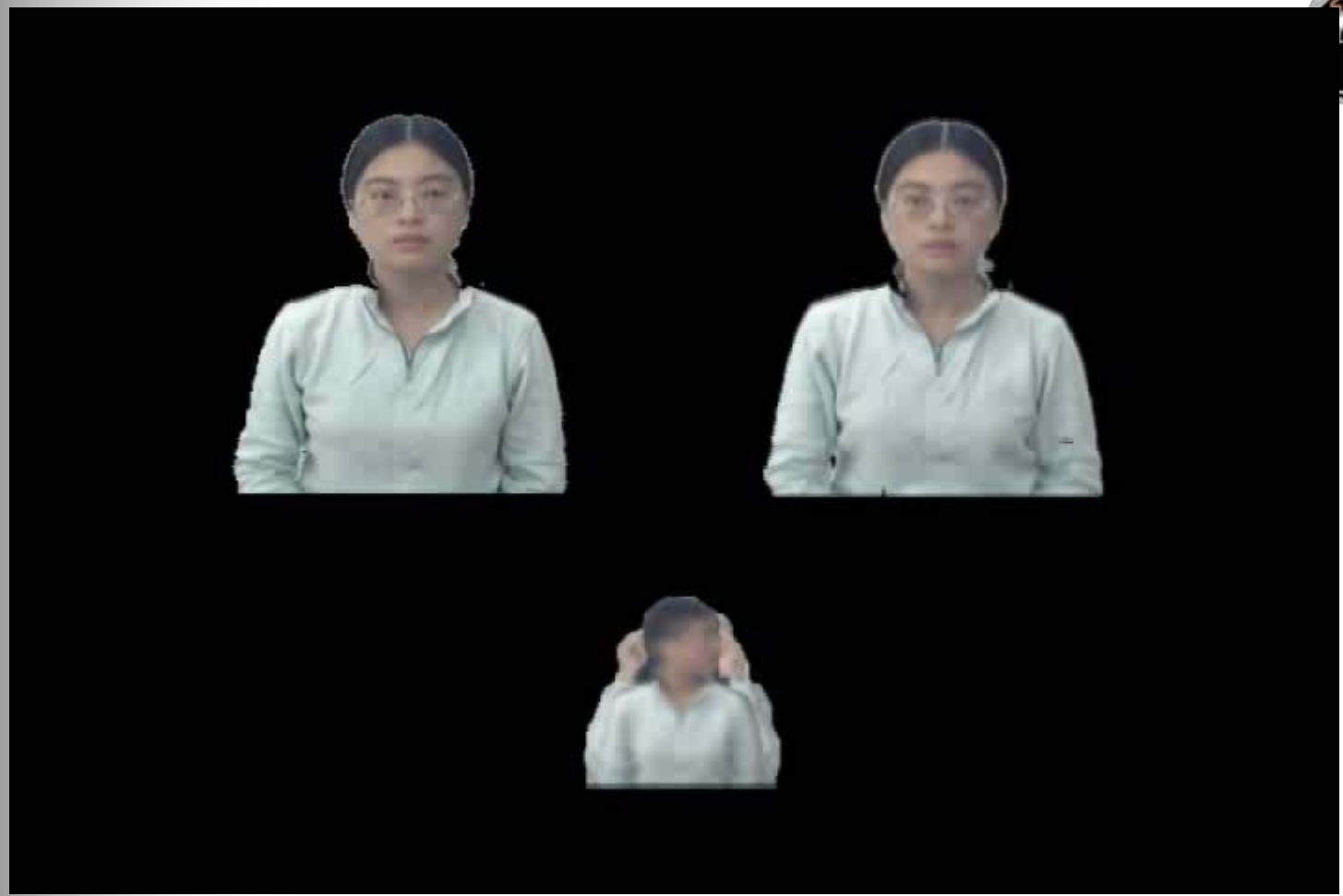
- Walk down the binary tree and find the matched leaf based on shape
- Searching all images under the matched leaf
  - Can do better if using more efficient matching algorithm in linear searching for all images
  - Further divide the frame into top, left, right region w.r.t. the shoulder line

Subdivision

- Find the discrete curve of the top-, left-,right-most pixel position in each group
- Match the input frame needs only 1D searching







Linear searching on selected tree leaves

Performance

- Current database
  - 1300 frames, captured at 10 fps
  - 500 stored frames, 52 groups, 24 merged groups

Performance Comparison

- Linear searching on all images
  - 68.12 ms per input frame, or 14 fps, use coherence
  - One input frame needs 312 ms, or 0.23 ms computation time for each database image
- Linear searching on selected tree leaves
  - 123 ms per input frame, or 8 fps, no coherence
  - One input frame takes 219 ms computation time

Future Work

- Acquire data using higher resolution
- Capture facial expression
- Build database using multiple people and do matching