July 16th - August 10th, 2007 - Istanbul, Turkey

eNTERFACE '07

The SIMILAR NoE Summer Workshop on Multimodal Interfaces

Project 3
A Multimodal Framework for the Communication of Disabled

Part 2
Retrieval from Hearing Impaired News Videos

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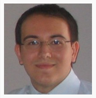
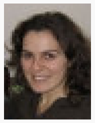
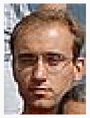
hosted by Boğaziçi University, Multimedia Group

Retrieval from Hearing Impaired News Videos

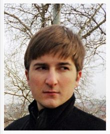
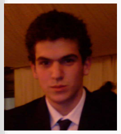
- Modalities



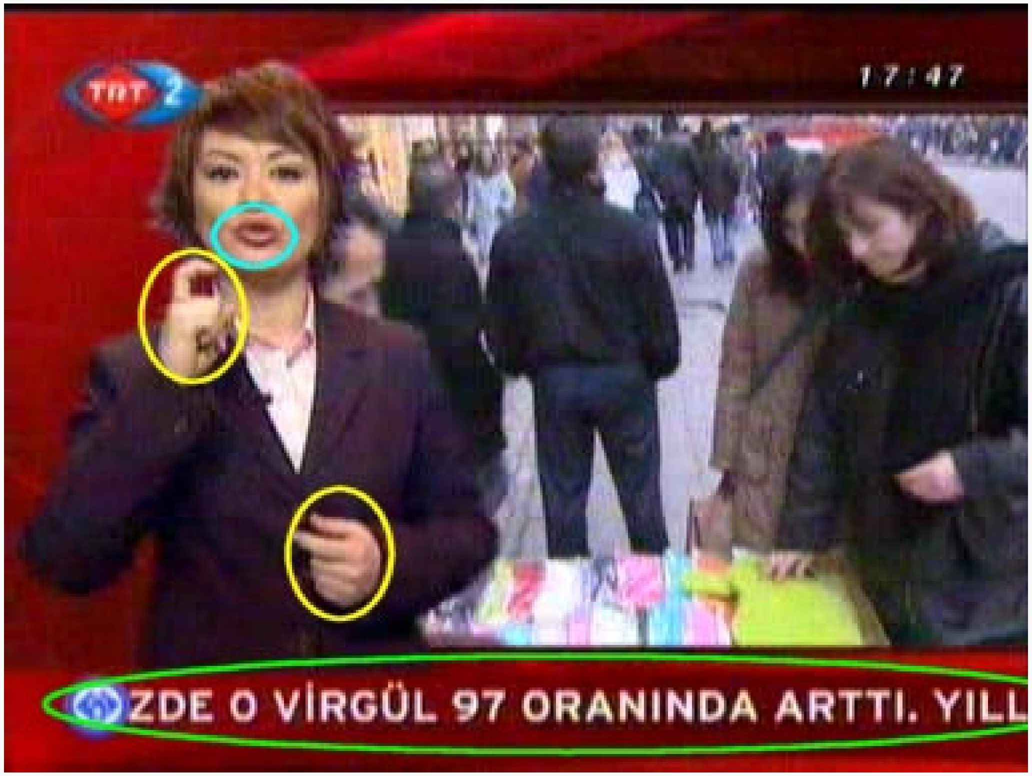
  - Speech
  - Lips
  - Text
  - Sign

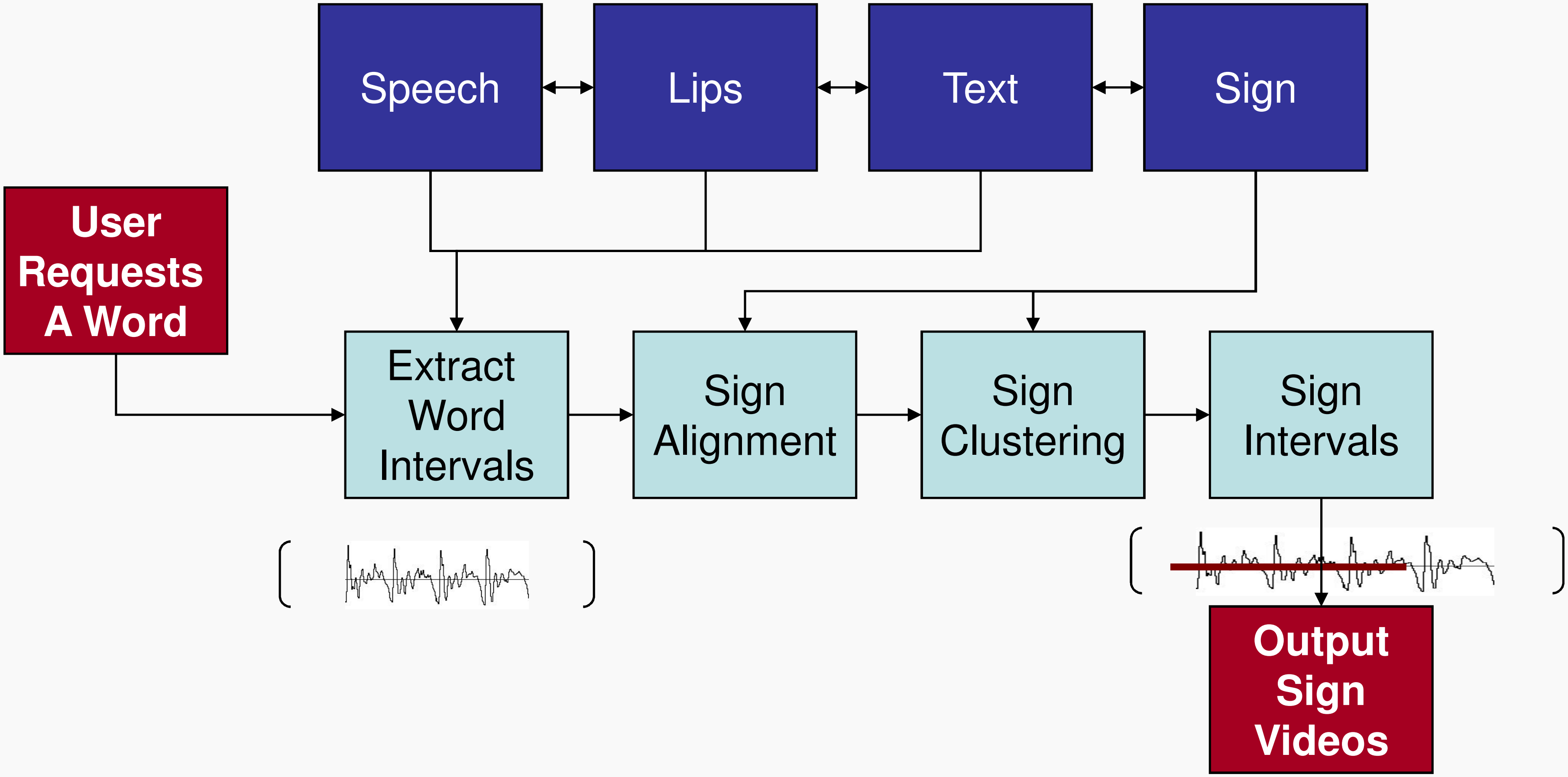
- GUI

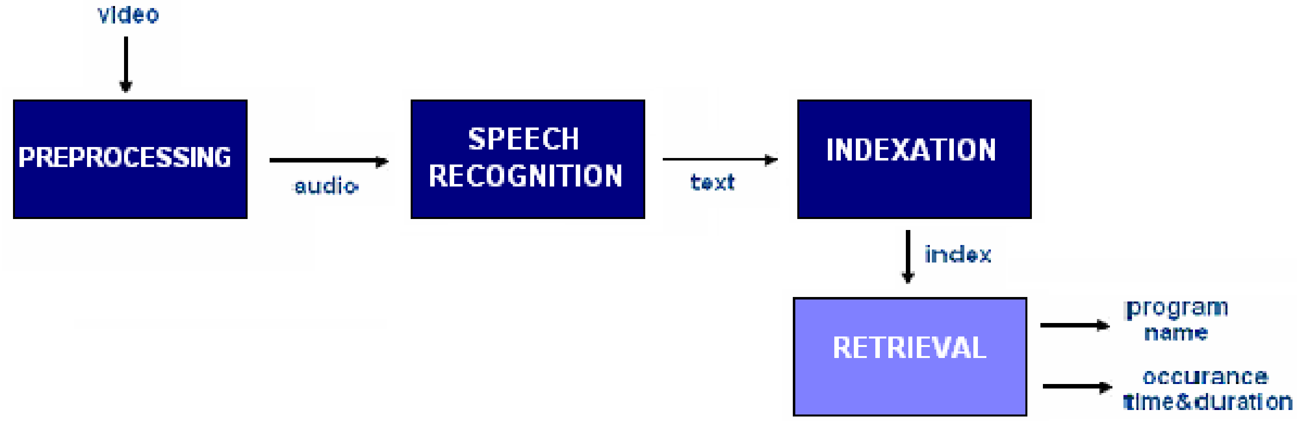
  - Stand alone application
  - Web site



Retrieval Application



SpokenTerm Detection(STD)



video

PREPROCESSING

audio

SPEECH RECOGNITION

text

INDEXATION

index

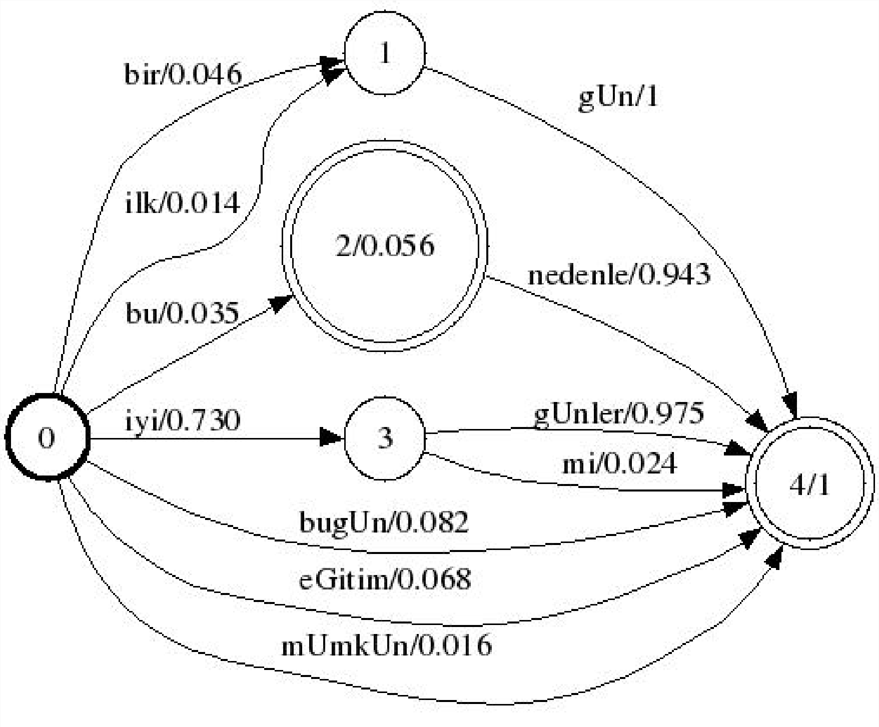
RETRIEVAL

program name

occurance time&duration

- **Speech Recognition**
  - Automatic segmentation based on energy
  - HMM-based LVCSR system
  - ASR output is a weighted finite state automata in form of lattice.
- **Indexation**
  - a weighted finite-state transducer mapping each factor of each utterance to the indices of the automata where it appears and the expected count of the factor.
  - WFST index is beneficial since ASR output is uncertain. It is also optimizes search time.
- **Retrieval**
  - Query is composed with the index FSM, resulting in utterance indices.
  - Forced alignment to find the beginning and duration of query.
- **Server Application**
  - Socket connection is established between client and server. After the query is received from client, server searches for it in the database and returns the results back to client.

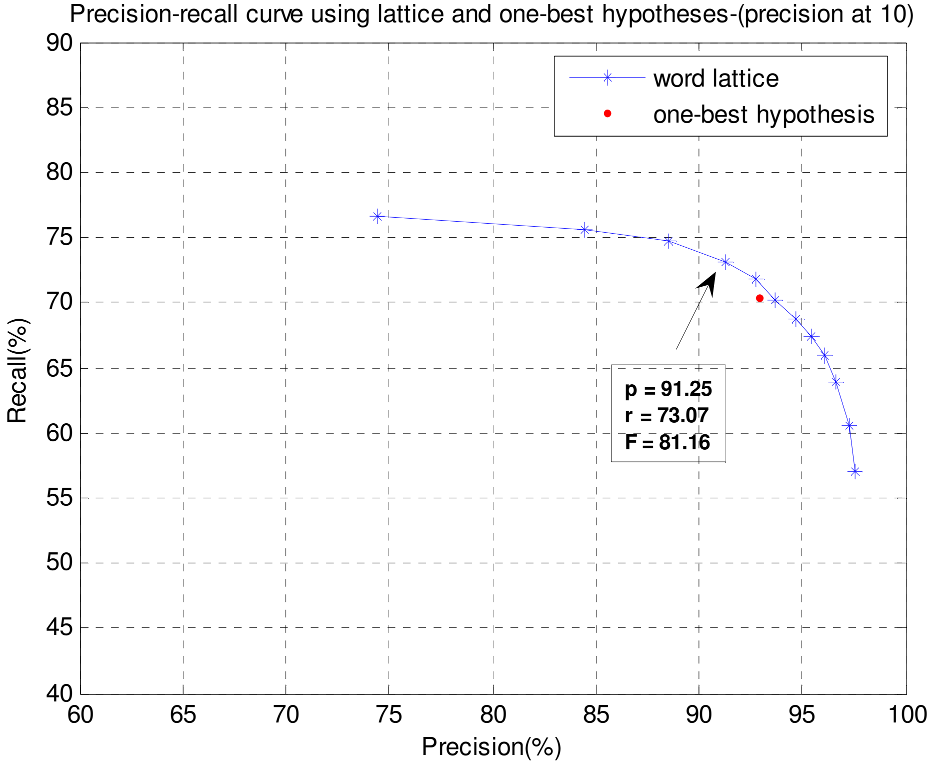
Lattices: Usage&Benefits

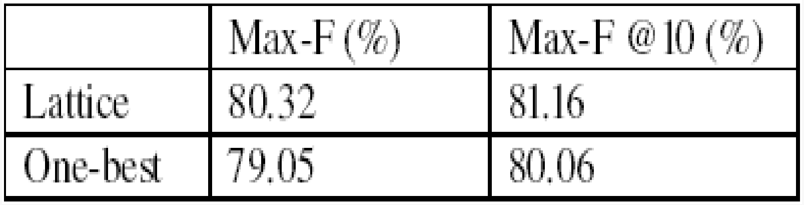


- Arc labels are word hypotheses.

  Arc weights are path probabilities.
- Indexation process estimates expected counts from path probabilities.
- By setting a threshold on expected counts, different precision-recall points can be obtained.
- This corresponds to a curve, while one-best output results in only one point.
- FLEXIBILITY:
  - If precision is more important→ increase the threshold (recall falls)
  - If recall is more important → decrease the threshold (precision falls)

STD RESULTS



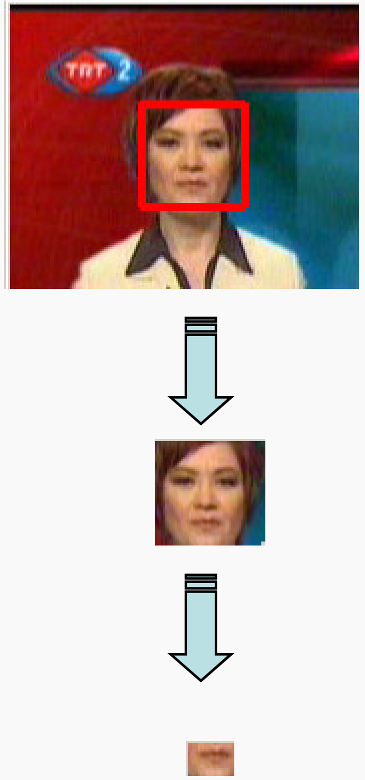


	Max-F (%)	Max-F @10 (%)
Lattice	80.32	81.16
One-best	79.05	80.06

- Metrics:
  - Precision-Recall
  - F-measure
- Evaluation corpora includes 15 of the videos.
- Maximum F-measure (81.16%) is achieved at P=91.25%, R=73.07% point.
- One-best point, indicated with red, is below the lattice curve.
- Use of lattice introduces 1-1.5% improvement on max-F.
- For the sign language tutor application, it may be desirable to operate on high-precision regions.

Lip Reading
Detection & Feature extraction

- Viola and Jones' method for detecting face
- Correlation of each frame with a lip template to extract the lip region with size 24x16
- Future work
    - Use DCT coefficients extracted from the lip region as the visual features to be combined with the audio features



Sliding Text Retrieval

Baseline Method

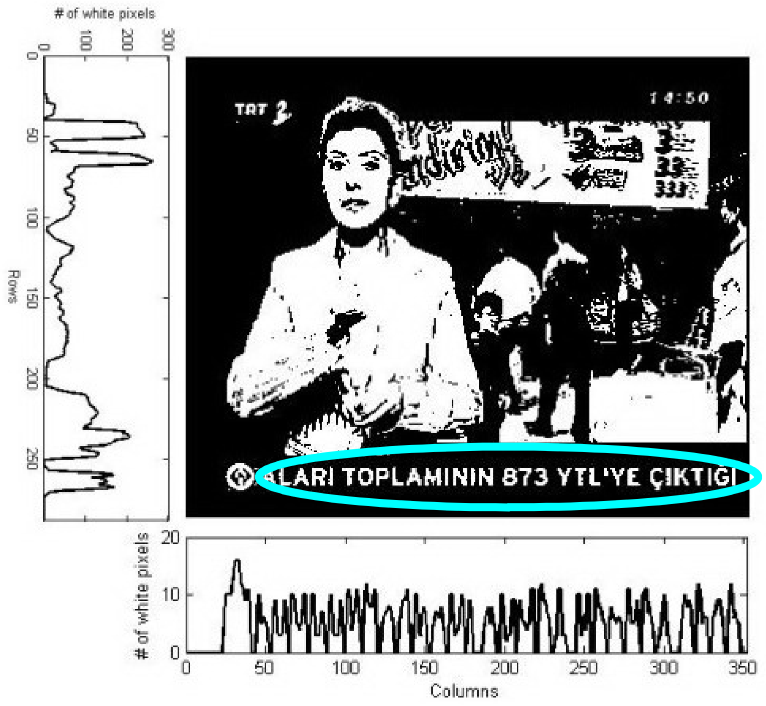
- Text band extraction
- Determination of word and space positions
- Template matching
- Text alignment in every 10 frames
- Noise removal
  - Averaging / Smoothing
  - Morphological operations

Improvements

- Jaccard's binary template match score

$$d_J = \frac{n_{11}}{n_{11} + n_{10} + n_{01}}$$

- Integrating heuristics
- Incorporating language model



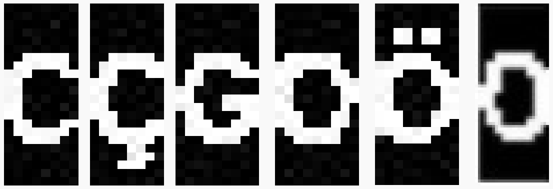
TOPLAMININ 873 YTL'YE ÇIKTIĞI

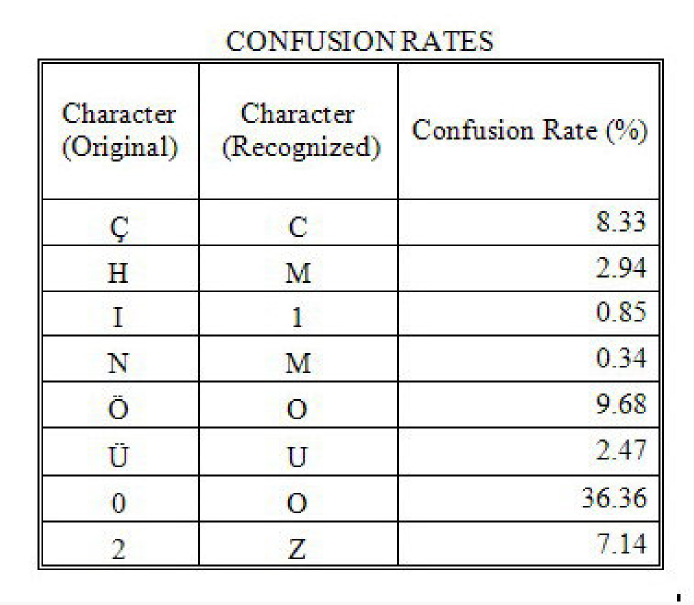
248 253 254 261 263 271 274 282 284 290 294 302 305 314 ...

Sliding Text Retrieval (II)

Problems

- **Low resolution and noise**
  - Distorted images
  - Losing distinctive parts of some Turkish characters
- **Temporal alignment between successive frames**
  - Merged / divided characters
  - Pixel shifts





CONFUSION RATES

Character (Original)	Character (Recognized)	Confusion Rate (%)
Ç	C	8.33
H	M	2.94
I	1	0.85
N	M	0.34
Ö	O	9.68
Ü	U	2.47
0	O	36.36
2	Z	7.14

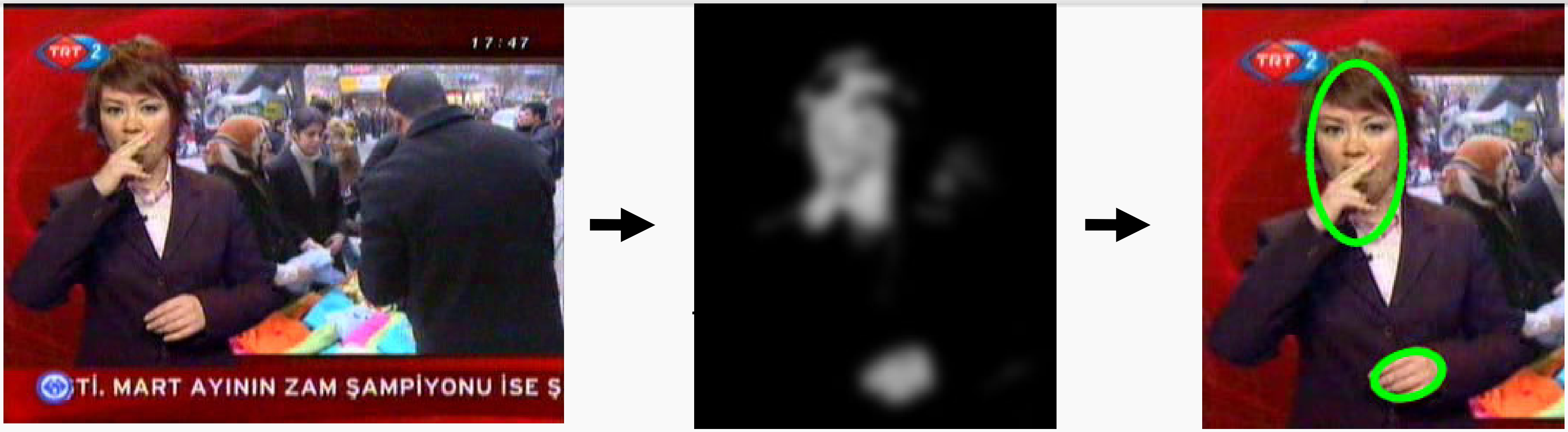
Performance

- Character Recognition Accuracy

  94.0% ➔ 98.5%
- Word Recognition Accuracy

  70% ➔ 90%

Image segmentation by using skin color model



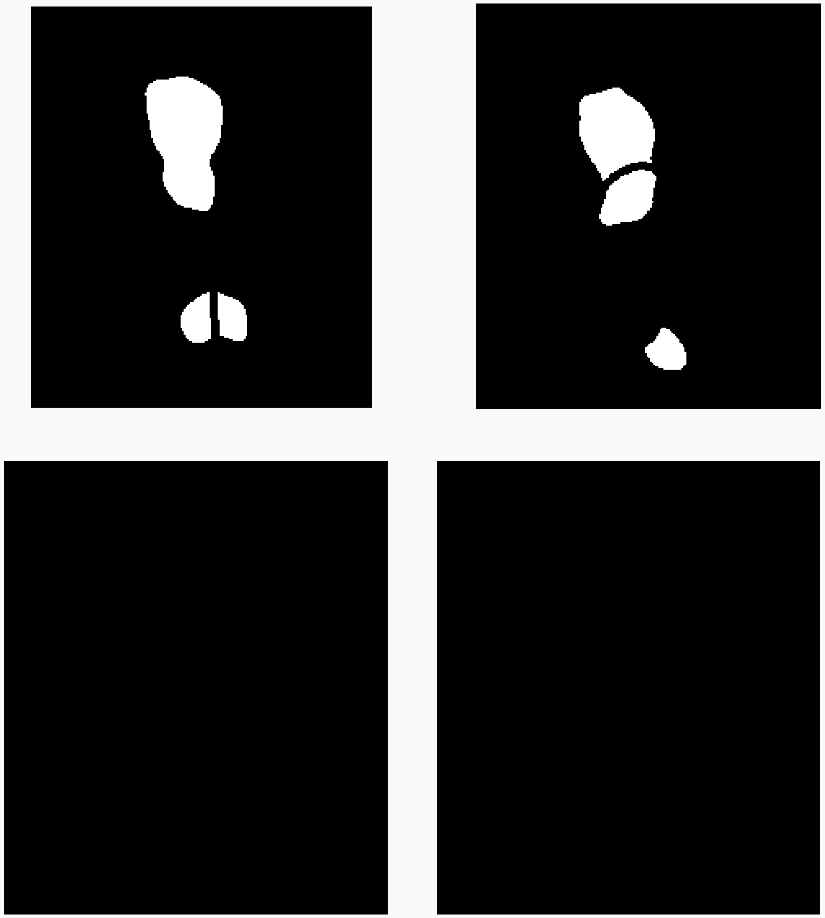
Input: Single frame from TV news

Output: Segmented blobs (head and hands of speaker and people in background)

- GMM of skin color distribution in RGB space
- Adaptation for each speaker
- Connected Components Labeling

Tracking Face and Hands

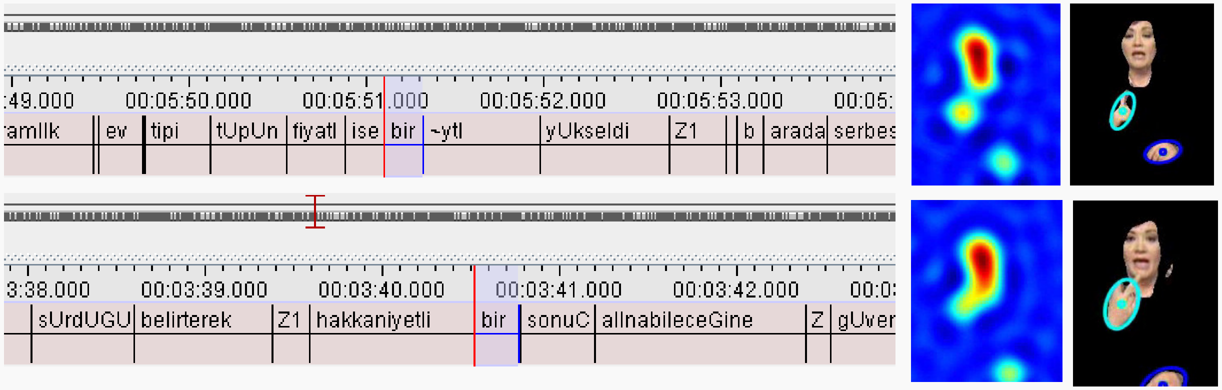
- Handling blobs
  - Blob filters
  - Template acquisition
  - Occlusion prediction & detection
  - Separation of blobs
- Blob tracking
  - Rule based blob classification



Feature extraction

- Tracking algorithm
  - Five features for every blob
  - Position, size and angle of bounding ellipse
- DCT
  - DCT of hand template
  - DCT of whole image
- Together 258 features
  - 15 tracking features
  - 243 DCT features (108 for hands and 135 for image)

Clustering of signs



```
:49.000    00:05:50.000    00:05:51.000    00:05:52.000    00:05:53.000    00:05:
amlIk | ev | tipi | tUpUn | fiyatl | ise | bir | ~ytl | yUkseldi | Z1 | b | arada | serbes

3:38.000    00:03:39.000    00:03:40.000    00:03:41.000    00:03:42.000    00:0
sUrdUGU | belirterek | Z1 | hakkaniyetli | bir | sonuC | allnabileceGine | Z | gUver
```

? → same signs in sequences

? → different signs

Input:

- Two (or more) short video sequences, in which same word was pronounced and where same sign is expected to occur (cca 0.4 seconds each sequence)
- Features extracted from image data for each sequence

Our task:

Cluster the sequences, i.e. determine whether they contain same sign.

(homonyms – same pronouncing in speech but different sign and meaning)

Clustering of signs: Sequences distance estimation

1) Subtraction + Sum

subtract calculated features of two sequences, sum this difference

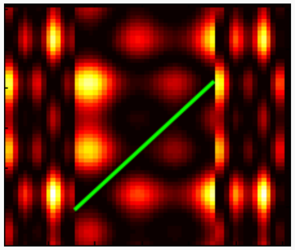
- borders of signs aren‘t accurate, sequences can contain part of previous / following sign -> the distance increases
- time warped data -> the distance increases

2) DTW (multidimensional), in progress…

- possibility to detect borders of same signs, align them and cut previous / following sign
- problems: short sequences, hard to estimate the borders of signs

3) HMM – another possibility, future work…

- could detect borders of signs too



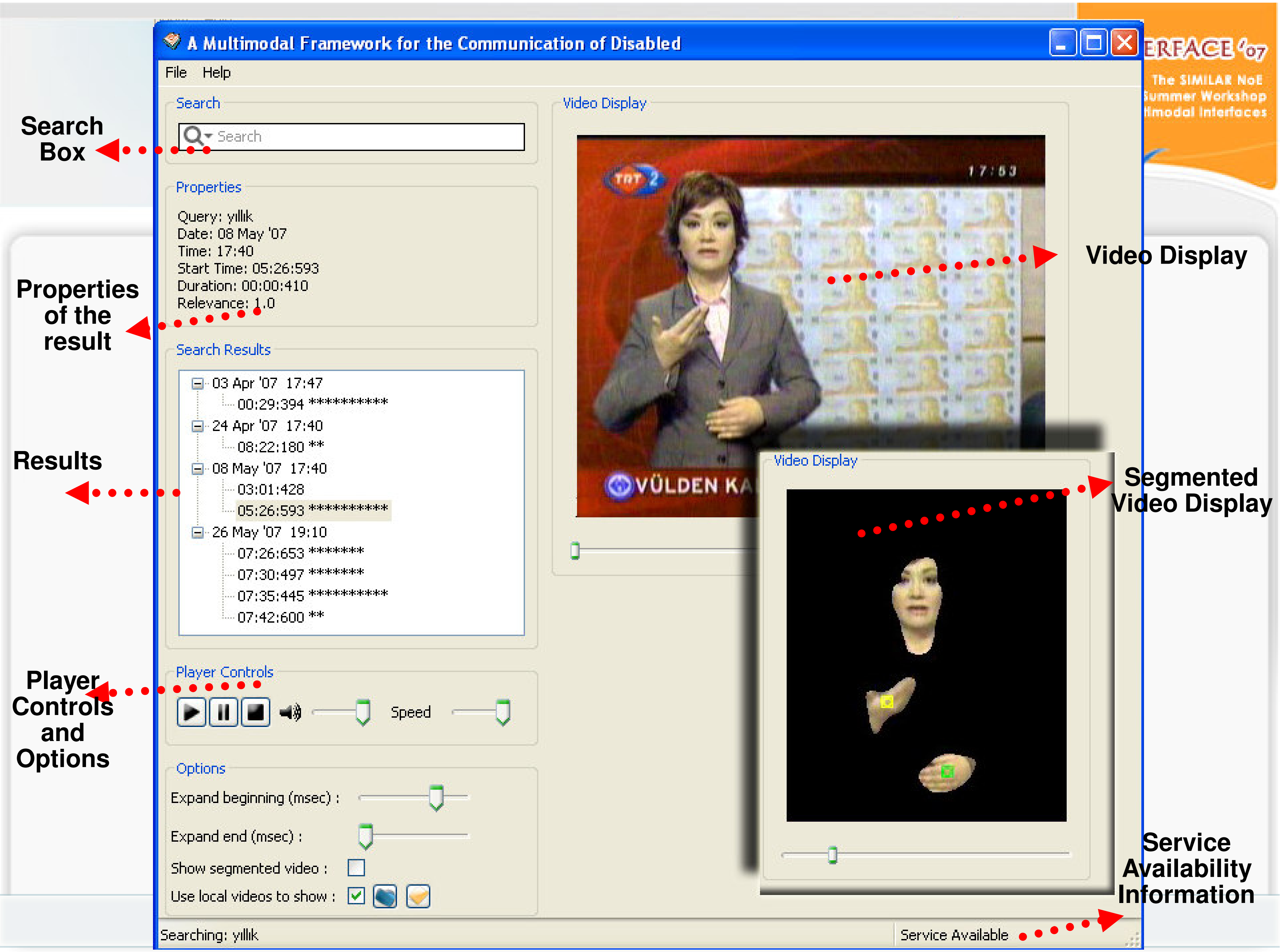
DTW cost matrix

green line: mapping one sign to another

Ideal case

Retrieval Application & GUI

- Seperate GUI and core program:
  - Search engine is on the server
  - Connection via TCP/IP socket
- Used tools:
  - wxPython (GUI widgets)
  - wxFolmBuilder (Separate UI files)
  - py2exe (creating exe from python code)
  - nsis (standalone program setup)



Search Box

Properties of the result

Results

Player Controls and Options

Video Display

Segmented Video Display

Service Availability Information

Properties

Query: yıllık
Date: 08 May '07
Time: 17:40
Start Time: 05:26:593
Duration: 00:00:410
Relevance: 1.0

Search Results

- 03 Apr '07 17:47
  - 00:29:394 **********
- 24 Apr '07 17:40
  - 08:22:180 **
- 08 May '07 17:40
  - 03:01:428
  - 05:26:593 **********
- 26 May '07 19:10
  - 07:26:653 *******
  - 07:30:497 *******
  - 07:35:445 **********
  - 07:42:600 **

Expand beginning (msec) :

Expand end (msec) :

Show segmented video : □

Use local videos to show : ☑

Searching: yıllık

Service Available

DEMO