Speech Recognition Techniques for a Sign Language Recognition System

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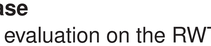
Introduction

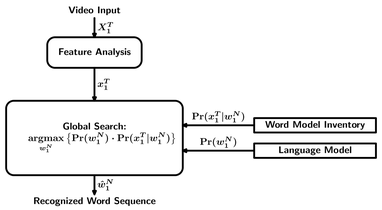
- automatic sign language recognition system
- necessary for communication between deaf and hearing people
- continuous sign language recognition, several speakers, vision-based approach, no special hardware
- large vocabulary speech recognition (LVSR) system to obtain a textual representation of the signed sentences
- evaluation of speech recognition techniques on publicly available sign language corpus

Automatic Sign Language Recognition (ASLR)

- similar to speech recognition: temporal sequences of images
- important features
  - hand-shapes, facial expressions, lip-patterns
  - orientation and movement of the hands, arms or body
- HMMs are used to compensate time and amplitude variations of the signers



- goal: find the model which best expresses the observation sequence



Experimental Setup

Database

- system evaluation on the RWTH-BOSTON-104 database
  - 201 sentences (161 training and 40 test sequences)
  - vocabulary size of 104 words
  - 3 speakers (2 female, 1 male)
  - corpus is annotated in glosses

Problems

- 26% of the training data are singletons
- simple sentence structure
- one out-of-vocabulary (OOV) words with whole-word models

Differences in Comparison to ASR

- simultaneousness
- signing space
- environment
- speakers and dialects
- coarticulation and movement epenthesis
- silence
- whole-word models and sub-word units

System Overview

Visual Modeling (VM)

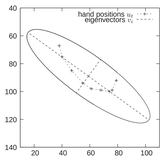
- related to the acoustic model in ASR
- HMM based, with separate GMMs, globally pooled diag. covariance matrix
- monophone whole-word models
- pronunciation handling

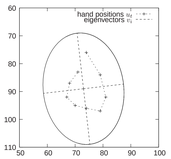
Language Modeling (LM)

- according to ASR: LM should have a greater weight than the VM
- trigram LM using the SRILM toolkit, with modified Kneser-Ney discounting with interpolation

Features

- appearance-based image features: for baseline system
  - thumbnails of video sequence frames (intensity images scaled to 32x32 pixels)
  - give a global description of all (manual and non-manual) features proposed in linguistic research
- manual features:
  - dominant hand tracking: hand position, hand velocity, and hand trajectory features

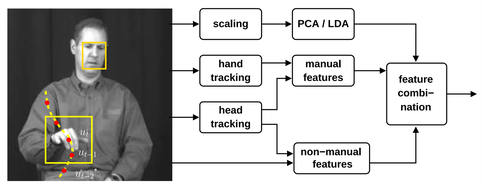




Feature Selection and Model Combination

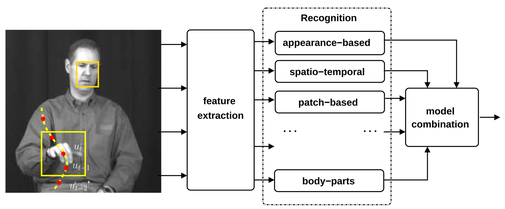
Feature Selection

- concatenation of appearance-based and manual features
- sliding window for context modeling
- dimensionality reduction by PCA and/or LDA

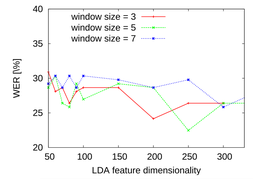


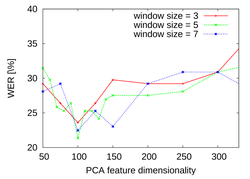
Model Combination

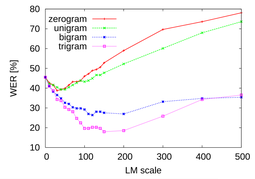
- log-linear combination of independently trained models
- profit from independent alignments (e.g. performing well for long and short words)
- profit from different feature extraction approaches



Experimental Results







Features	Dim.	[%WER]
frame intensity (w/o pronunciations)	1024	54.0
frame intensity (w/ pronunciations)	1024	37.0
frame intensity (w/ pronunciations + tangent distance)	1024	33.7
PCA-frame	110	27.5
PCA-frame, hand-position	112	25.3
PCA-frame, hand-velocity	112	24.2
PCA-frame, hand-trajectory	112	23.6
model-combination	2x100	17.9

Example Results

Correct Examples

IX-1P	FIND	SOMETHING-ONE	BOOK				
IX-1P	FIND	SOMETHING-ONE	BOOK				
JOHN	FISH	WONT	EAT	BUT	CAN	EAT	CHICKEN
LOVE	JOHN	WHO					
LOVE	JOHN	WHO					
JOHN	BUY	YESTERDAY	WHAT	BOOK			
JOHN	BUY	YESTERDAY	WHAT	BOOK			

Incorrect Examples

MARY	VEGETABLE	KNOW	IX	LIKE	CORN		
MARY	VEGETABLE	KNOW	IX	LIKE	MARY		
JOHN	IX	GIVE	MAN	IX	NEW	COAT	
JOHN	IX	WOMAN	____	__	NEW	COAT	
	LIKE	CHOCOLATE	WHO				
JOHN	LIKE	CHOCOLATE	WHO				
JOHN	[UNKNOWN]		BUY	HOUSE			
JOHN	FUTURE	NOT	BUY	HOUSE			

RWTH-BOSTON-104 Database

Corpus Statistics

	Training	Test
sentences	161	40
running words	710	178
frames	12422	3324
vocabulary	103	65
singletons	27	9
OOV	-	1

LM Perplexities

LM type	*PP*
zerogram	106.0
unigram	36.8
bigram	6.7
trigram	4.7

Database is publicly available

Conclusion

- LVSR system is suitable for vision-based continuous sign language recognition
- many of the principles known from ASR can directly be transfered
- important for ASLR: temporal contexts, pronunciation handling, language modelling, and model combination
- outlook: connection of recognizer output to a statistical machine translation system achieved promising translation results

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