Challenges of Computational Processing of Code-Switching

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Mixing Languages

(Photo: Craig Morey/Flickr)

- Acting multilingual, that is, mixing languages is commonly observed among multilingual speakers [Auer and Wei 2007]

Mixing Languages

- Extensively studied from social and linguistic perspectives
  [Poplack 1980, Myers-Scotton 1993, Muysken 2000, Auer and Wei 2007, Bullock and Toribio 2012]

- Different use of terminology
  - inter-sentential vs. intra-sentential
  - *code-mixing* for intra-sentential alternations
  - either *code-mixing* or *code-switching* for all types of mixing
  - borrowing vs. code-mixing

- Code-switching for all types of mixing

Computational Processing

Normalisation

Language Modelling

Language Identification

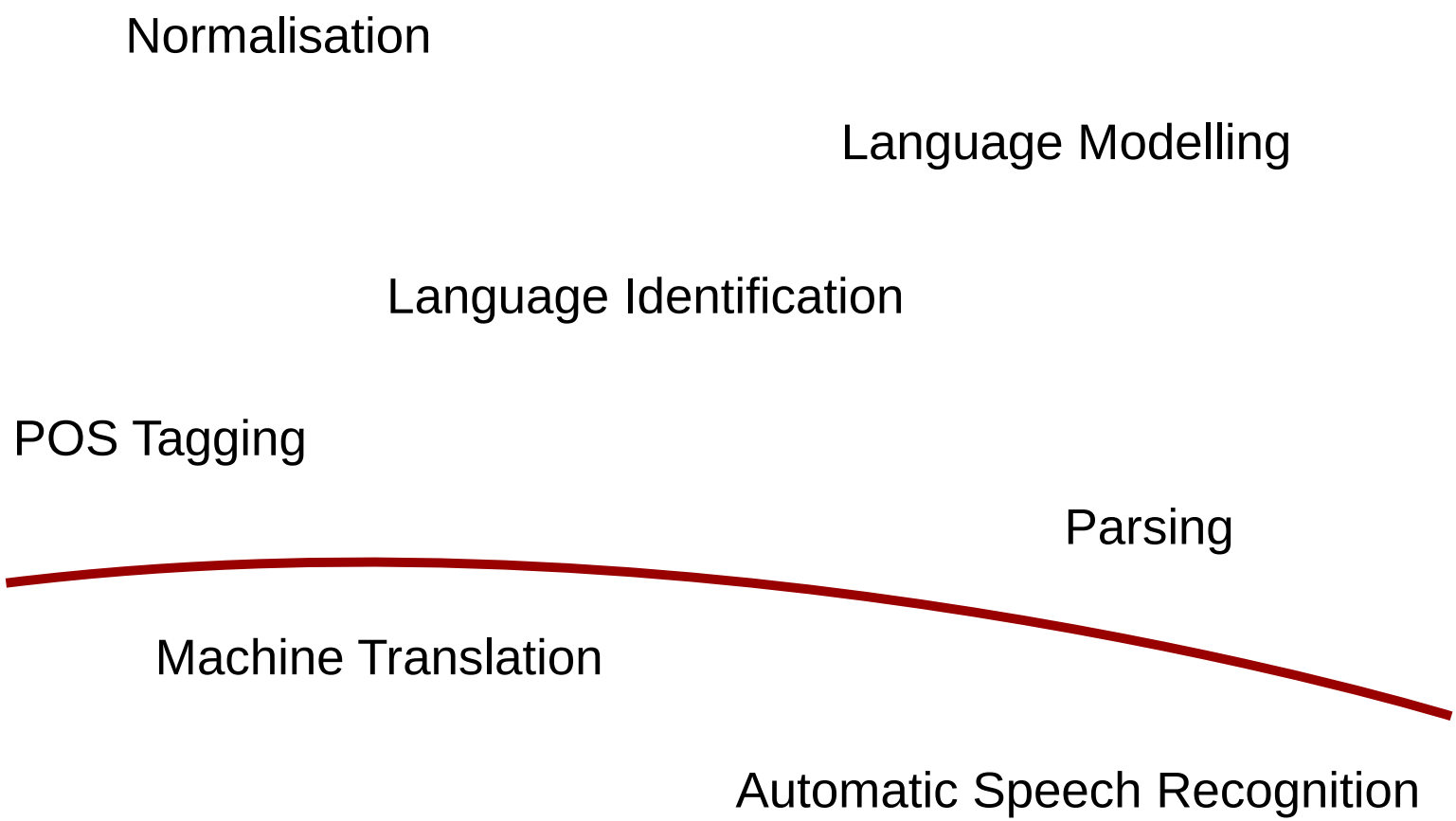
POS Tagging

Parsing

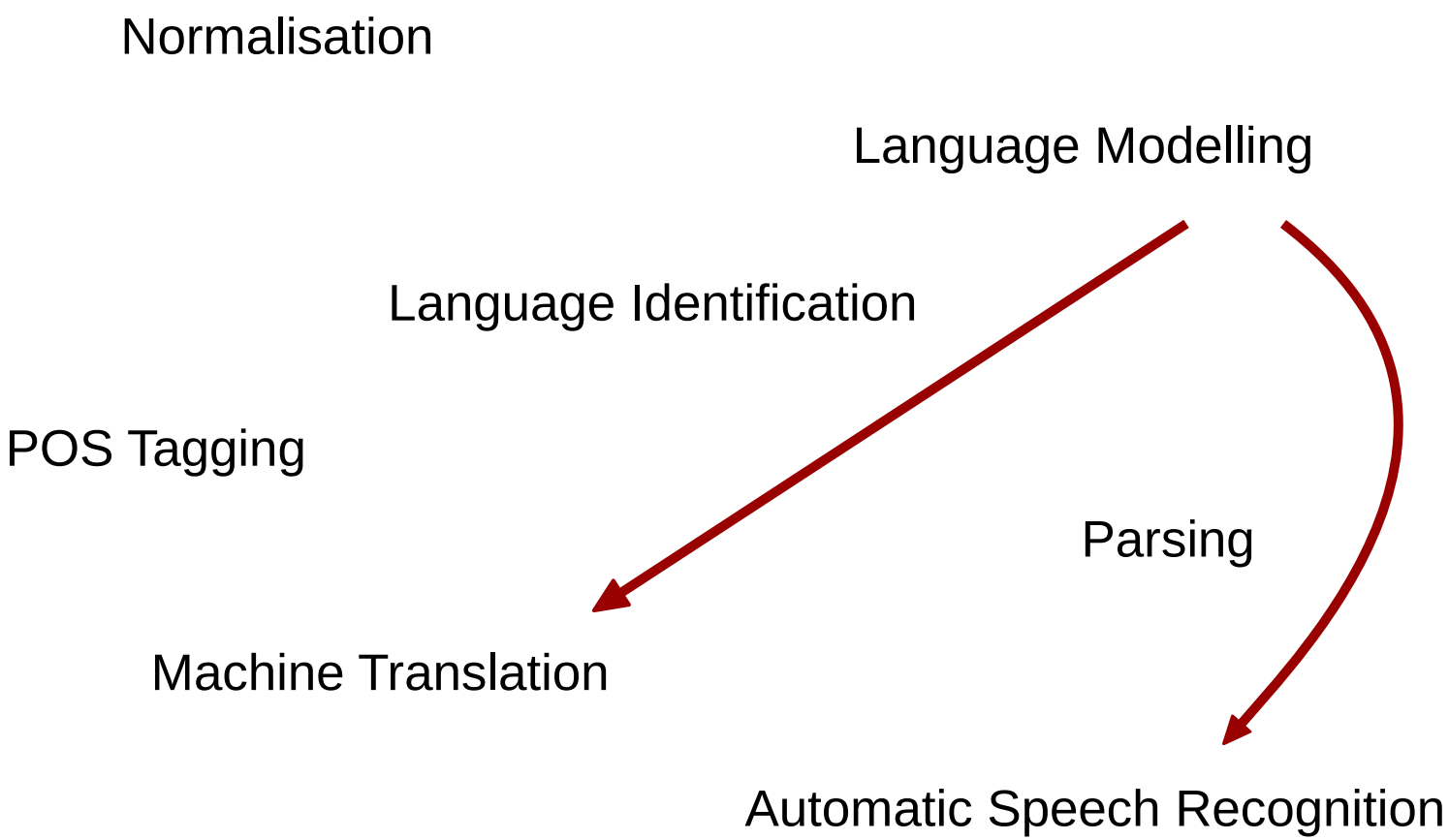
Machine Translation

Automatic Speech Recognition

Computational Processing



Computational Processing



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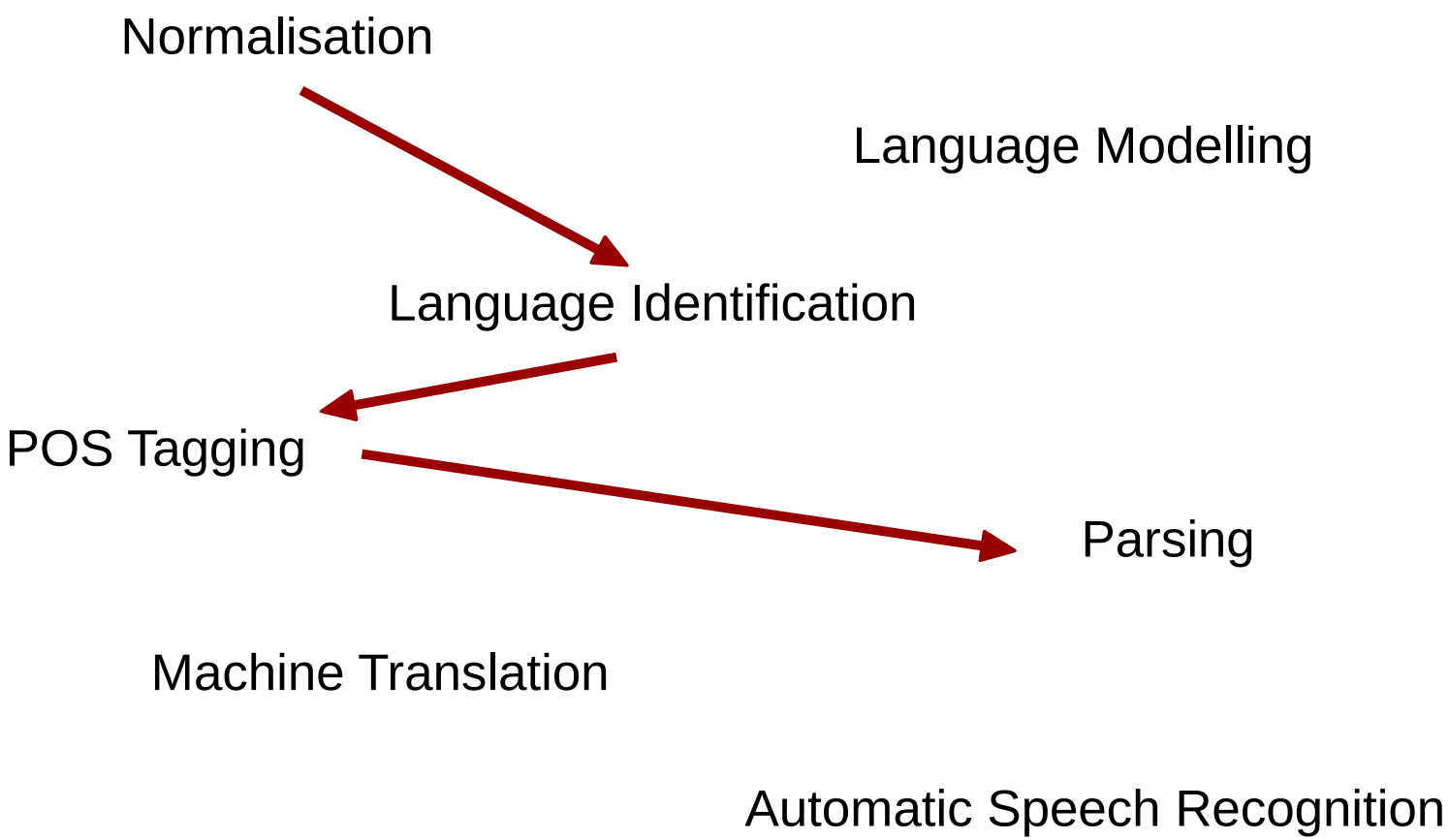

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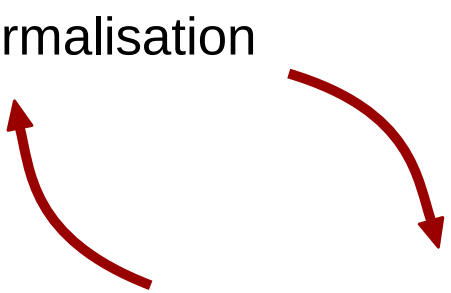

Language Modelling

POS Tagging

Parsing

Machine Translation

Automatic Speech Recognition

Nature of the Data

- Spoken data [Solorio and Liu 2008, Lyu et al. 2015, Yılmaz et al. 2016]
- Historical text [Schulz and Keller 2016]
- Social media [Nguyen and Doğruöz 2013, Barman et al. 2014, Vyas et al. 2014] [Solorio et al. 2014, Choudhury et al. 2014, Jamatia et al. 2015] [Çetinoğlu 2016, Samih and Maier 2016]

(1) *vette spellllllllll* bir girdimmi cikamiyomm
fat game once enter.Past.1Sg leave.Neg.Prog.1Sg
'Awesome game, once I enter I cannot leave.'

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Accessing the Data

- Spoken Data
  - Prior consent from sources
  - Natural language usage
  - Self-awareness
- Social Media Data
  - Post consent from sources
  - License issues
  - Noisier environment?

! How to collect big sizes of data?

! How to share?

Normalisation

this workshop IS gr8!!!! $\rightarrow$ This workshop is great!

- Standardising text that deviates from some agreed-upon (or canonical) form
  - not a valid word
  - valid word, but a wrong one in context

Normalisation

- Highly relevant to CS due to the nature of the data
- ! Additional challenge: context according to the language

(3) ***meisten*** *kıyımıza* *vurmuş* *olmasi*
Meis.Abl(TR)/mostly(DE) shore.P1pl.Dat hit.EvidPast be.Inf
muhtemel :)
possible

'It is possible that it hit our shore from Meis.'/'Mostly it is possible that it hit our shore.'

- meisten → Meis'ten (from Meis)
  meisten → Meistens (Mostly)

Normalisation

- Neural net-based translation architecture [Zhang et al. 2014]
- Monolingual language models with context depending on neighbouring language [Dutta et al. 2015]

- Text in Roman script, resources in another script
  - Punjabi-English [Kaur and Singh 2015]
  - Hindi-English and Bengali-English [Sarkar 2016]
- Different approaches
  - Use training set as a resource [Barman et al. 2014]
  - Romanise the resources [Das and Gambäck 2014]
  - Transliterate back to the other script [Vyas et al. 2014]

Language Modelling

$$
\begin{gathered}
\ldots \\
P(\text{is} \mid \text{this, workshop}) \\
P(\text{great} \mid \text{workshop, is}) \\
\ldots
\end{gathered}
$$

- Consider mixed text as an individual language, use existing methods
  - Tokenisation and normalisation as preprocessing
- Inter-sentential CS:
  - Monolingual models from CS language pair
  - Model interpolation

Language Modelling

- Intra-sentential CS: only CS data
  - ! When do people code-switch?
  - ! How to incorporate this information?

- Language ID and POS information [Adel et al. 2013a, 2015, 2013b]
  - Mandarin and English POS tags that trigger a code-switching point [Adel et al. 2013a]
  - Man $\rightarrow$ En: DT 40.44%
  - En $\rightarrow$ Man: NN 49.07% , NNS 40.82%
- Functional head constraints [Li and Fung 2012, 2014]

- ! Intra-word CS: Additional out-of-vocabulary problem

Language Identification

This workshop is great → EN
Dieser Workshop ist großartig → DE

- Highly accurate on monolingual data
  - Up to 100%
  - Harder to discriminate similar languages [Zampieri et al. 2014]
- ! Mixed text: More than one languages in input, one ID is not enough
  - 💡 Token level identification

Language Identification

- Most well-studied task among computational CS approaches:
  - Relatively more annotated data
  - A preprocessing step for more complex tasks
  - Shared tasks [Solorio et al. 2014, Choudhury et al. 2014]

- High accuracy language identifiers has lower performance on CS data [Nguyen and Doğruöz 2013, Volk and Clematide 2014]

- Approaches tailored to mixed data
  - Utilising monolingual dictionaries
  - Machine learning on annotated CS data [Lignos and Marcus 2013, Nguyen and Doğruöz 2013, Voss et al. 2014, Das and Gambäck 2014, Barman et al. 2014, Solorio et al. 2014]
  - Accuracies in mid-90s; lower F1 (80-85%) for some language pairs

Language Identification

- Closely related languages – linguistically or historically
  - Modern Standard Arabic and dialects [Elfardy and Diab 2012, Samih and Maier 2016]
  - Frisian-Dutch [Yılmaz et al. 2016]
  - English-Hindi, English-Bengali [Das and Gambäck 2014, Vyas et al. 2014, Barman et al. 2014]
- Hard to find a clear distinction between CS and borrowing
  - ! Resources and annotation guidelines might conflict
  - ! Annotators agreement is low
  - ! Also observed when a third language has influence on one or both of CS languages

- ! Intra-word CS: How to annotate?
  - 💡 No special tag (no or very infrequent occurence)
  - 💡 `Mixed` tag [Maharjan et al. 2015, Barman et al. 2014, Çetinoğlu 2016]
  - 💡 Fine-grained tag set [Das and Gambäck 2014]

POS Tagging

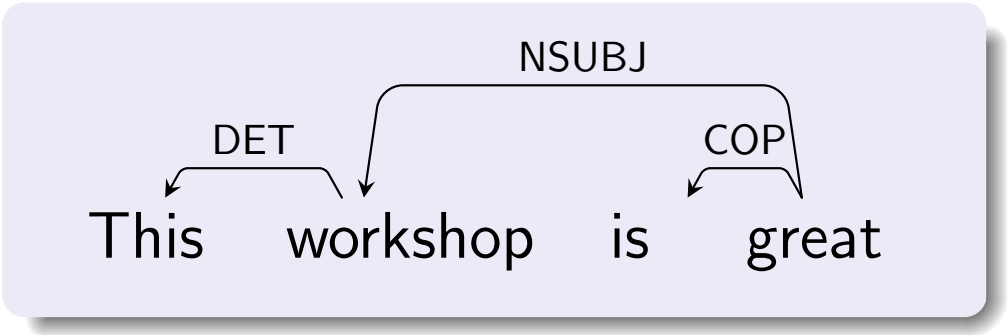
This	workshop	is	great
DET	NOUN	VERB	ADJ

- State-of-the-art on monolingual data: 97% accuracy
- POS-annotated CS corpora
  - Languages: En-Es, En-Hi(x4), En-Bn, En-Ta, De-Tr, midEn-La
  - Tokens: 3k-38k
  - Tag Sets: 1 language-specific, others: universal tag sets
    [Solorio and Liu 2008, Vyas et al. 2014, Jamatia et al. 2015, Çetinoğlu and Çöltekin 2016, Sharma et al. 2016, Schulz and Keller 2016]

POS Tagging

- Monolingual off-the-shelf taggers are not suitable
  - En tagger 54% Es tagger 26% accuracy on En-Es [Solorio and Liu 2008]
- Approaches tailored to mixed data
  - Choosing between monolingual tagger outputs based on probabilities
  - Utilising monolingual dictionaries and language models
  - Machine learning on annotated CS data
    [Solorio and Liu 2008, Vyas et al. 2014, Jamatia et al. 2015, Sharma et al. 2016, Schulz and Keller 2016]
- Language ID as useful feature
  - Language identification as a preprocessing step
- Accuracies in the 65-75% range
  - Exception: 93.48% on En-Es [Solorio and Liu 2008], partly due to 62.5% monolingual English sentences

Parsing



- Advanced substantially over the last decade
  - e.g. English dependency parsing above 93% UAS [Kiperwasser and Goldberg 2016]

Parsing

- Parsing CS text
  - Theoretical framework [Joshi 1982]
  - Rule-based HPSG prototype [Goyal et al. 2003]
  - But no statistical parsers $\leftarrow$ no CS treebanks
- Chunking for Hindi-English social media [Sharma et al. 2016]
- Parsing 10 English-Spanish tweets [Vilares et al. 2016]
  - English and Spanish data are combined to train the POS tagger and parser

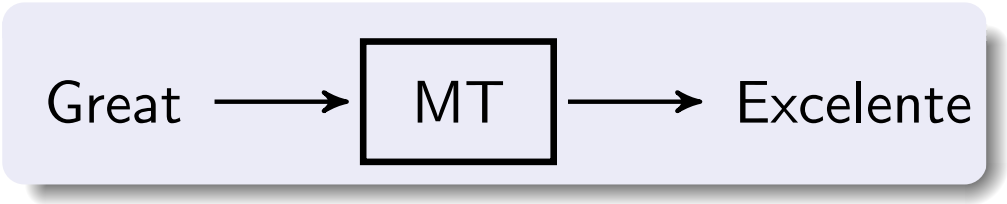
Parsing

- ! Error propogation from previous steps
- ! Syntactic constructions that are not native to monolingual languages

(4) birkaç *Aufgabe*ler yaptık arkadaşla
a few assignment(DE).Pl(TR) make.Past.1Pl friend.Sg.Ins
'We made a few assignments with a friend.'

- *birkaç Aufgabeler* does not follow Turkish syntax
- Turkish syntax: singular noun in NP, German syntax: plural

Machine Translation



- Parallel text for phrase tables and translation probabilities, monolingual data for language models
  - ! Mixed text: high number of unknowns, low probabilities for translations

Machine Translation

- Foreign word translation into the source language before translation into the target language [Sinha and Thakur 2005]
  - ! Foreign word detection, language identification, normalisation

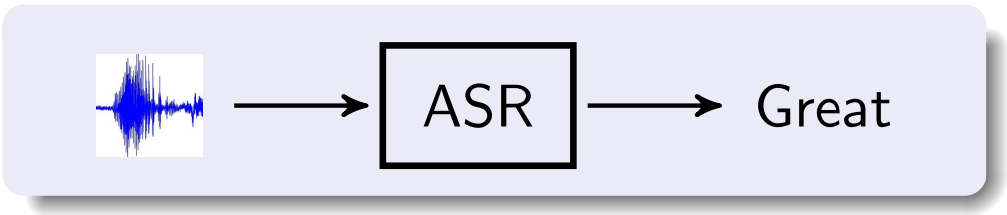
- Intra-word CS: Morphological analysis to separate the stem from suffixes, then a dictionary lookup [Manandise and Gdaniec 2011]

(5)

anticooldad →	anticool: dad	
	cooldad : anti	
	cool: anti, dad	→ anti-coolness

- ! What about syntax of the monolingualised source language?

Automatic Speech Recognition

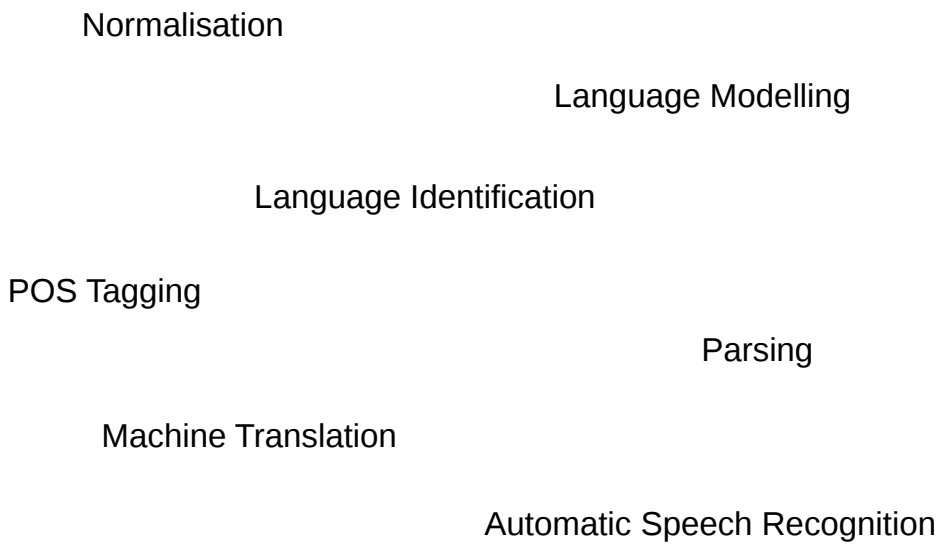


- Three major components
  - A pronunciation dictionary, a language model and an acoustic model
- Dealing with CS speech [Vu et al. 2012]
- Split input into monolingual parts, apply monolingual recognisers
  - Language identification mistakes if segments are short (e.g. < 3s)
  - Lost context information
  - Intra-word CS
- Multilingual components

Automatic Speech Recognition

- Pronunciation dictionary
  - Collection of words and phoneme sequences which describe how a word is pronounced
  - ! CS changes pronunciation due to articulation effect
  - ! Pronunciation of intra-word CS
- Acoustic modelling
  - Estimating the probability of a sound state given a speech frame
  - ! Phonetic transfer phenomenon
- Merging phoneme sets for bilingual sound state models [Vu et al. 2012]
- Creating phone clusters and linear interpolation of their sound state models [Li and Fung 2013]
- Integrating language identification into ASR in the speech frame level [Weiner et al. 2012]

Overview



- Need for more data
  - New lexical and syntactic structures
- Few resources
  - Language ID, POS tagging, ASR
- Artificial data
- Linguistic insights
- Joint approaches

Thanks!

Questions?

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