Report on Natural Language Understanding

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INTRODUCTION

NLU is a subset of the wider world of NLP.

Natural Language Understanding (NLU) encompasses one of the narrow but especially complex challenges of AI: how to best handle unstructured inputs that are governed by poorly defined and flexible rules and convert them into a structured form that a machine can understand and act upon?

While humans are able to handle mispronunciations, swapped words, contradictions, and other quirks, machines are less adept at handling unpredictable inputs.

To build machines that understand natural language, we must distill speech into a structured ontology using a combination of rules, statistical modeling, or other techniques.

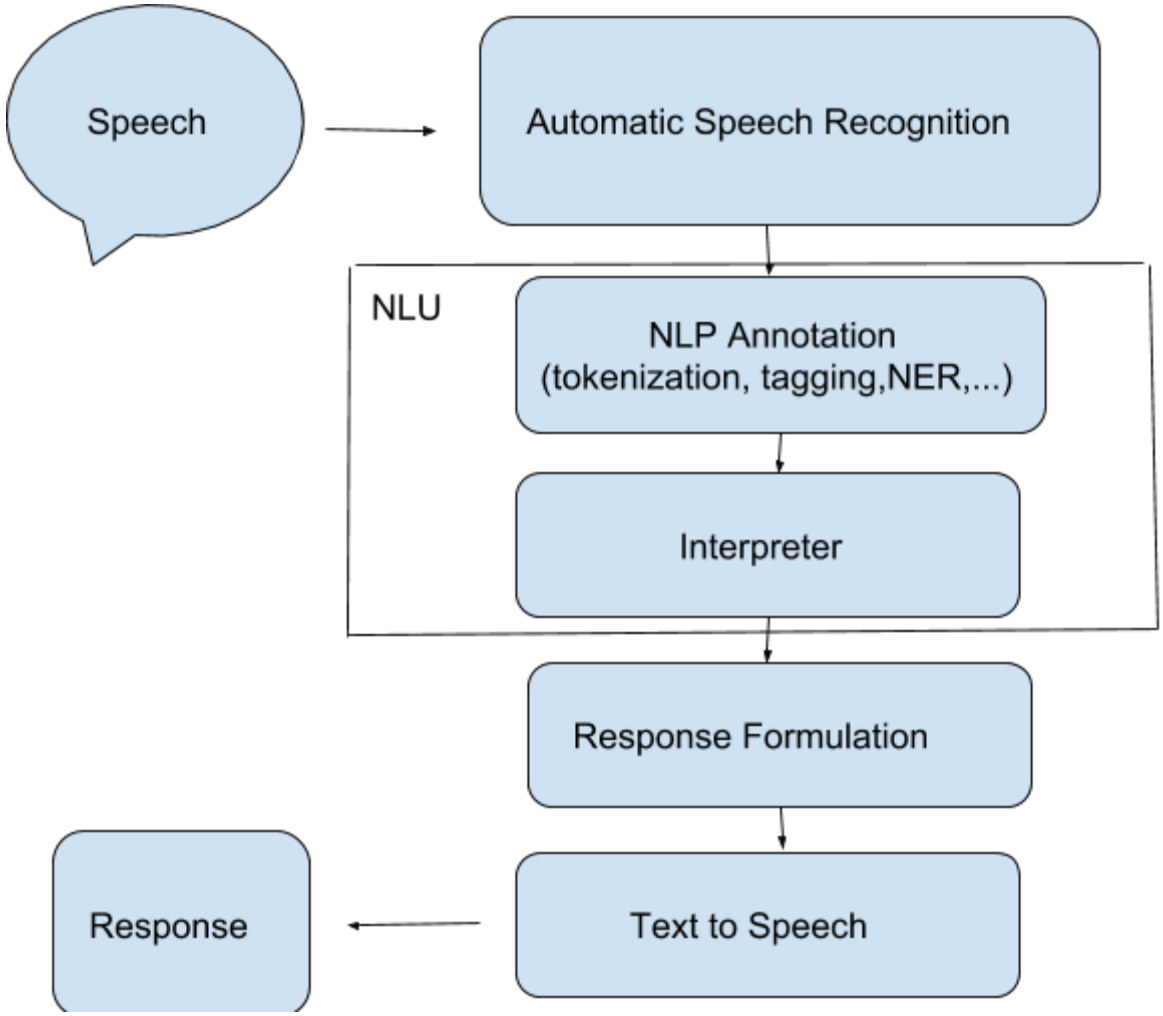
Entities must be extracted, identified, and resolved, and semantic meaning must be derived within context, and be used for identifying intents.

For example, a simple phrase such as: “I need a flight and hotel in Delhi from August 4 to 10” must be parsed and given structure:

need:flight {intent} / need:hotel {intent} / Delhi {city} / Aug 4 {date} / Aug 10 {date} / sentiment: 0.5723 (neutral)

Essentially, NLU allows a more unstructured communication between humans and machines.

HOW DO CONVERSATIONAL AGENTS WORK ?



NATURAL LANGUAGE UNDERSTANDING VS NATURAL LANGUAGE GENERATION

Natural Language Understanding is a part of Natural Language Processing. It undertakes the analysis of content, text-based metadata and generates summarized content in natural, human language.

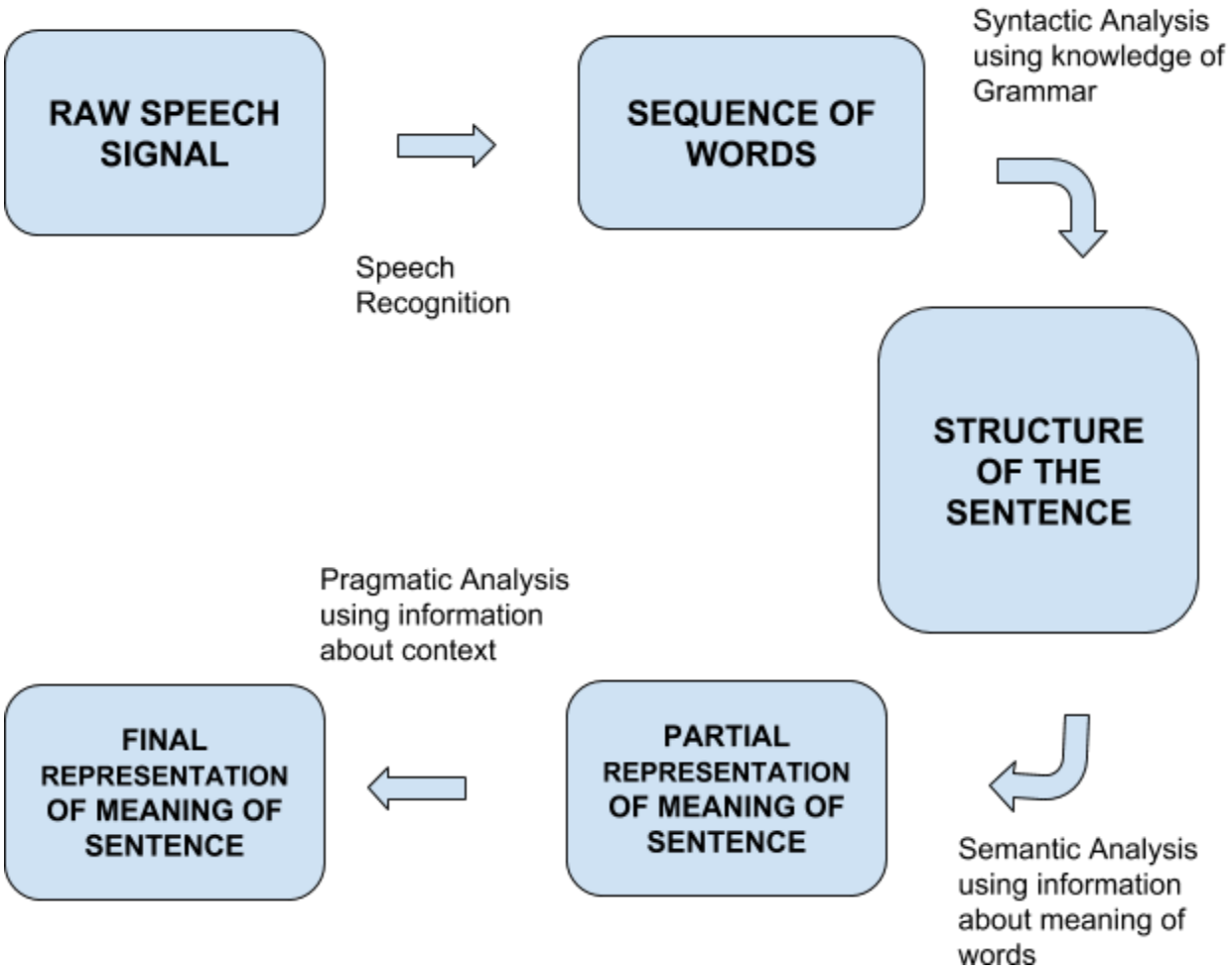
It is opposite to the process of Natural Language Generation. NLG deals with input in the form of data and generates output in the form of plain text while Natural Language Understanding tools process text or voice that is in natural language and generates appropriate responses by summarizing, editing or creating vocal responses.

NLU: UNSTRUCTURED DATA ----------> STRUCTURED RESPONSE

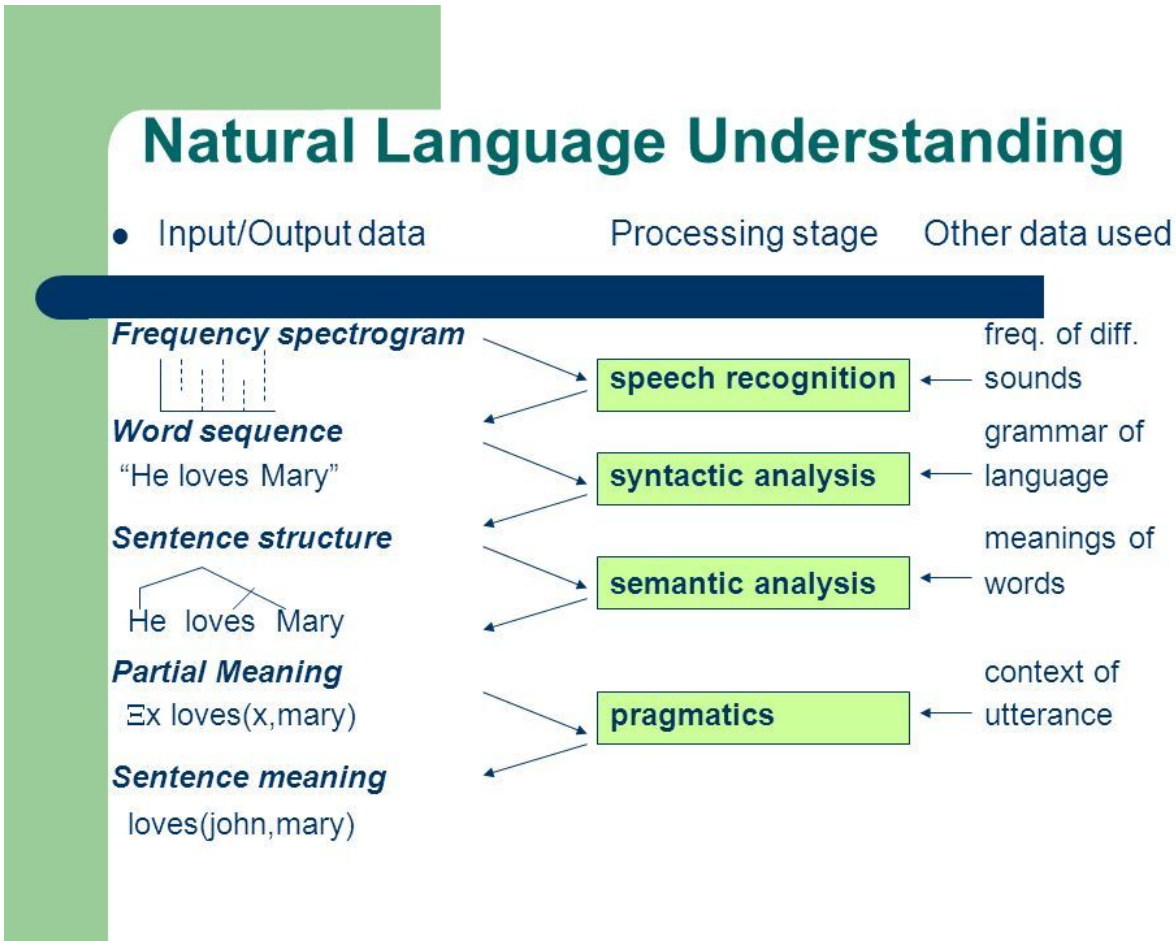
NLG: STRUCTURED DATA ----------> UNSTRUCTURED RESPONSE

Data could be either text or speech.

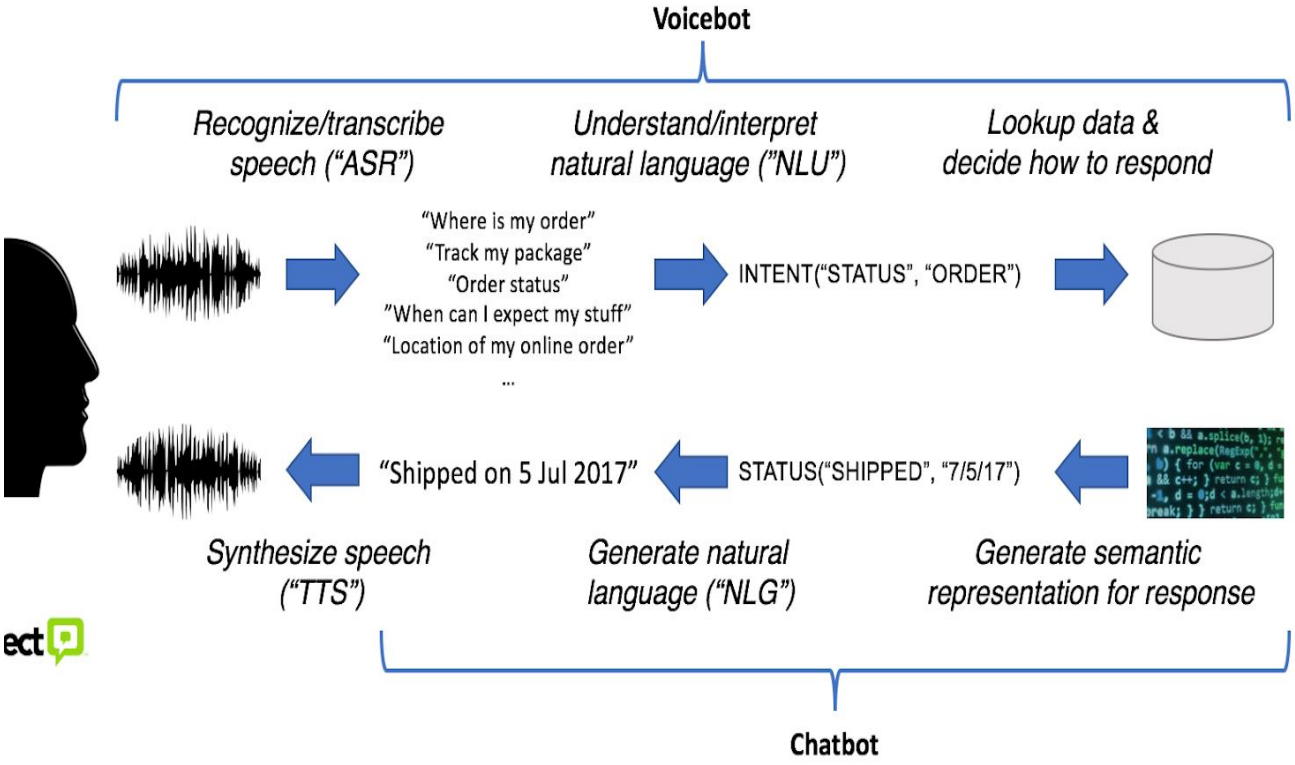
ARCHITECTURE



EXAMPLE OF NLU


Natural Language Understanding
Input/Output data
Processing stage
Other data used
Frequency spectrogram
Word sequence
"He loves Mary"
Sentence structure
He loves Mary
Partial Meaning
Ξx loves(x,mary)
Sentence meaning
loves(john,mary)
speech recognition
syntactic analysis
semantic analysis
pragmatics
freq. of diff. sounds
grammar of language
meanings of words
context of utterance

NLU + NLG



APPLICATIONS OF NATURAL LANGUAGE UNDERSTANDING

1. **Collecting data and data analysis** – To be able to serve well, a

business must know what is expected out of them. Data on customer feedback is not numeric data like sales or financial statements. It is open-ended and text heavy. For companies to identify patterns and trends throughout, this data and taking action as per identified gaps or insights, is crucial for survival and growth. More and more companies are realizing that implementing a natural language understanding solution provides strong benefits to analysing metadata like customer feedback and product reviews.

2. **Reputation monitoring** – Most of the real customer sentiments hence are trapped in unstructured data. News, blog posts, chats, and social media updates contain huge amounts of such data which is more natural and can be used to know the 'real' feelings of customers about the product or service. Natural language understanding software products help businesses to scan through such scattered data and draw practical inferences.

3. **Automated trading** – Capital market trading automation is not a new phenomenon anymore. Multiple software products and platforms are now available that analyse market movements, the profile of industries and financial strength of a company and based on technical analysis design the trading patterns. Advanced Natural Language Understanding tools which scan through various sources like financial statements, reports, market news are the basis of automated trading systems.

PAPERS ON NLU AND RELATED TOPICS:

- Expanding the horizons of Natural Language

Interfaces

Link: http://aclweb.org/anthology/P/P80/P80-1019.pdf

This paper stresses on the importance of non-literal aspects of communication in human-machine interaction. This allows a user to express himself naturally. Non-literal aspects include knowledge of the speaker's intentions, utterances and sometimes contradictions. But the paper stresses that in order to master communication between humans and machines, the most effective way is not for the machines to speak exactly like humans. It says that there are more effective ways of commmunication.

The paper proposes a full-duplex mode of communication in which there are two seperate channels for input and output. So it does not need to be a "Question-Answer" kind of interaction.

The paper also suggest multiple channels of information flow that can allow the machines to handle shifting of focus of the human since human beings dont tend to stick with one line of communication.

- ## Prospects for Practical Natural Language Systems

Link: http://aclweb.org/anthology/P/P80/P80-1033.pdf

The paper stresses that NL systems can be built with existing technologies. It says that although we are yet to completely understand the problems with such NL systems, it is very much possible to build a NL system of practical value.

The paper says that NL sytems must focus on being extremely robust within well-defined limitations rather than having a wider coverage system which is less robust.

- Issues in Parsing and NLU

  Link: http://aclweb.org/anthology/P/P81/P81-1021.pdf

  This paper stresses on the importance of a well defined architecture to NLU. There must be well defined modules starting with a syntactic analysis of the input data using knowledge of the grammar of the language. This will allow the machine to recover the meaning, intention and goals of the input data.

  There are two beliefs: Firstly, there needs to be a syntactic analysis of the data. ‘Parsing’ can be used to perform synactic analysis. Secondly, there also needs to be semantic and pragmatic analysis of the parsed data.

  The paper proposes there needs to be a parallelism between the processes such that after each module does its work, there is always an ouput. This increases the capability and efficiency of the overall NLU process. Thus, for example, if the syntactic module makes its intermediate decisions available to semantics and/or pragmatlcs, then those processors can evaluate those decisions, guide syntax's future behavior and, in addition, develop in parallel their own analyses.

- A Knowledge Engineering approach to NLU

  Link: http://aclweb.org/anthology/P/P82/P82-1031.pdf

  This paper describes how a rule-based system which uses a semantic network can facilitate interaction between an user and the system.

  Knowledge of various types like semantic and syntactic rules is needed and can be entered. This new approach claims that new knowledge can be entered into the system when required and this alows flexibility for the users.

  The Knowledge Engg. system the paper suggests using is a Semantic Network Processing System. This system includes a semantic network system in which all knowledge, including rules is represented as nodes in a semantic network.

  This proposed NL system has two logical components:

  Firstly, there needs to be a facility for the input of linguistic knowledge into the semantic network in natural language.

  Secondly, there needs to a facility for sentence generation and question answering via rules in the network.

- The Syntax and Semantics of User-defined modifiers in a NL Processor

Link: http://aclweb.org/anthology/P/P84/P84-1013.pdf

This paper describes a Layered Domain Class system which is an experimental NL Processor. It is made up of two primary components: Firstly, is the knowledge side or database side, whose job is to find out about the vocabulary and semantics of the language. Secondly, there is the user-phase processor, which enables the user to obtain reductions on the typed input.

The User-Phase processor involves a sequence of models for scanning the input, looking up in a dictionary, syntactically parsing it and then finally semantic parsing.

The processor works by identifying the noun-phrase modifiers in the input data. These noun-phrases are connected by verbs which are categorized by the prcessor. These nouns and verbs are used by the processor to obtain reductions from the user-input data.

- A Technological Simplification Transformation for NL Question Answering Systems

Link: http://aclweb.org/anthology/P/P86/P86-1036.pdf

This paper intoduces us to a new method for simplifying the input data entered by the users and produce adequate responses. The solution is to map expression of the reduced senetences to a database and retrieve actual responses.

A common strategy for constructing natural language interface

systems is to divide the processing of input into 2 stages:

Firstly, the sentence needs to be mapped to short logical expression representing its meaning.

Secondly, from this reduced expression, an appropriate response needs to be generated.

The module first interprets the meaning of the sentence and reduces it using semantic knowledge of the language. Then, the module maps the logical expression to a database query and obtains a short reduced response. This response is then expanded and an appropriate response is generated in natural language.

- Conceptual Revision for Natural Language Generation

  Link: http://aclweb.org/anthology/P/P91/P91-1051.pdf

  In order to get a clear view of the process of NLU, it is important to get a clear view of Natural Language Generation. The task of NLG is to convert the ouput of NLU into human spoken voice or text.

  This paper sheds light on the pipeline of NLG. The reduced text produced after semantic, syntactic and contextual analysis during NLU is used as input. The input is mapped to the database and after lexical and syntactic analysis, final output in human readable form is produced.

This paper proposes a revision-in-generation system that would conceptually and stylistically keep adding natural elements to the output. This revision keeps adding lexical and contextual meaning to the output sentence until there is no ambiguity in the meaning of the sentence.

- A NL system for Spoken-Language Understanding

  Link: http://aclweb.org/anthology/P/P93/P93-1008.pdf

  This paper takes the example of a NLU system called Gemini and describes its size, efficieny and performance of each of ts components. It says that while designing a system, there always needs to be a balance between the robustness and correctess of the system. Robustness always allows the system to take care of errors in the input and find a sensible interpretation. On the other hand, this could reduce the correctness of systems.

  There are 4 steps followed in the Gemini processing system:

  Firstly, a set of syntatic, semantic, and lexical rules are applied by a constituent parser to make sense of the input data.

  Secondly, a second uttetrance parser is used to arrive at a contextual understanding of the input.

  Third, when an acceptable interpretation is found, a set of parse preferences are used to get the single best interpretation to be used for subsequent processing.

  Fourth, Quantifier scoping rules are applied to produce the final

logical form which are then used as an input for a query-answering system.

- Semantic Information Preprocessing for Natural Language Interfaces to Databses

  Link: http://aclweb.org/anthology/P/P95/P95-1048.pdf

  This paper describes how automated procedures for semantic parsing of the input data can reduce processing time and also improve correctness.

  An approach is described for supplying selectional restrictions to parsers in NLU systems. The work is based on Linguistic Domain Theories. LDT is a system where the input is a logical formula and after lexical parsing, the output is a logical formula, consisting of meaningful predicates.

  Automating the process of finding selectional restrictions reduces NLI development time and may avoid errors introduced by manual selectional restrictions.

- Integration of Large-Scale Linguistic Resources in a NLU System

  Link: http://aclweb.org/anthology/P/P98/P98-2161.pdf

  This paper describes how large scaled linguistic resources can

be compiled and integrated into a NLY system. Client-server architecture has been used to make a large knowledge database available to the system.

Firstly, the NLU system folllows the architectural pipeline: Lexical parsing->Syntactic parsing->Semantic Analysis-> Pragmatic Analysis.

Secondly, the linguistic servers provide the lexical, semantical and syntactical knowledge available to the different modules. The linguistic servers store the database consisting of more than 3000 words, classes like nouns, verbs, adjectives, etc.

The paper proved that large scale linguistic resources can be successfully integrated with the core pipeline architecture of the NL engine.

- Other Papers on NLU and related topics

  Link: http://aclweb.org/anthology/P/P83/P83-1023.pdf

  Link: http://aclweb.org/anthology/P/P85/P85-1022.pdf

  Link: http://aclweb.org/anthology/P/P97/P97-1022.pdf

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