ISSN 2186-7437

NII Shonan Meeting Report

No. 2014-15

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Ken Satoh
Yuji Matsumoto
Randy Goebel

November 27–30, 2014

National Institute of Informatics
2-1-2 Hitotsubashi, Chiyoda-Ku, Tokyo, Japan

Towards Explanation Production Combining Natural Language and Logical Reasoning

Organizers:
Ken Satoh (National Institute of Informatics, Japan)
Yuji Matsumoto (Nara Advanced Institute of Science and Technology, Japan)
Randy Goebel (University of Alberta, Canada)

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Meeting motivation and background

The recent application of high performance natural language processing (NLP) systems has shifted from general question answering to more targeted application domains (e.g., medical diagnosis, epidemiology, legal reasoning, intellectual property management). Examples include the WATSON project by IBM and the Todai Robot Project by NII. But these recent systems have focused more on engineering problem solutions, and less so on general architectures for building domain models that support more general representation and reasoning within the specific application domains. For example, the WATSON architect uses an associative pattern matching process which supports high performance, but is difficult to follow for humans, and thus prevents easy collaborative problem-solving with humans. Our workshop proposal is focused on the development and integration of modern natural language processing tools to support the development of systems with methods of hypothesis management and explanation. In this way, humans can collaborate with such systems to not only understand the use of representation to create answers, but also support incremental supervised machine learning. The purpose of the proposed meeting is to gather a group of researchers in related areas, such as natural language processing, information extraction, and logical reasoning, in order to formulate approaches to combining these areas to achieve the goal of machine-human collaboration in high-performance natural language-based domain interactive reasoning systems. A research agenda for such a meeting would include a variety of topics, including language-based information extraction (e.g., open information extraction), reasoning architectures based on abduction and hypothesis management, natural language entailment, and inductive learning. Specific challenges include the capture and use of legal documents, in order to answer legal questions. In this context, the creation of legal judgements involves not just answers (e.g., guilty, not guilty), but articulation of elaborate explanations supported by interpretation of legal statues and regulations. To construct such logical explanations, we need to identify information relevant to the questions, ensure that information is transformed to or directly represented in formal representations that support the contraction of explanations. In this phase, we need an NLP analysis of

question and information retrieval technique based on the analysis. Subsequent steps include the development of entailment testing methods, to decide whether and how (or how not) a question is entailed by the logical representation of the extracted domain information. The general development of NLP techniques for this kind of subsumption task involves ontological manipulation, relation extraction, and logical reasoning. Because of this diversity of requirements, our workshop will need to include researchers from information retrieval, information extraction, question-answer, general natural language processing, and logical representation and reasoning. With this context, the goal is to develop a basis for reliable system which produces an explanation of systems behaviour, and be incrementally constructed and improved to advance their level of performance in a variety of appellation domains. Possible topics of the meeting include, but are not limited to:

- Natural Language Processing for Information Retrieval
- Information Retrieval for Complex Logical Formulae
- Natural Language Processing for Textual Entailment
- Natural Language Processing for Subsumption Testing
- Ontology Research for Subsumption Testing
- Combining Logical Reasoning and Natural Language Processing
- Feedback from Logical Reasoning to Solve Disambiguation

Individual perspective on summary of workshop themes

The summary of individual perspectives of the workshop impact are included below, and summarized by a Wordle in Figure 1.

Overall, the workshop provided a good balance of theoretical and practical work, and discussions (as indicated below) are largely about continuing to discuss how to keep a balance in research that exploits computational linguistics and machine learning, from pragmatic system building to achieve a variety of information question answering and summary tasks.

The individual summaries here are presented in the order in which they where received.

Randy Goebel, University of Alberta

Our work on the entailment tasks of COLIEE and NTCIR has shown promising results, produced with a combination of modern NLP semantic parsing techniques, coupled with machine learning methods for knowledge extraction from large text corpora.

Future work will focus on at least two new themes: 1) identification of the language phenomena whose improper treatment explains the failure on some of the entailment tasks (e.g., faulty anaphoric reference resolution, no connection between legal terms buy and sell.), followed by elaboration of the entailment

Figure 1: Shonan Workshop Wordle Summary

process to handle such cases; and 2) further work on the development of abstract rules for domain specific knowledge (e.g., in the legal and medical domains), which can be used both to improve knowledge extraction in support of entailment, and guide abductive explanation of alternative entailments.

Chitta Baral, University of Arizona

This meeting has been very useful and gave me many ideas about future research directions in collaboration with other participants. I have already briefly discussed with some of the other participants but not all of them.

1. Developing a version of COLIEE with shorter text similar to text in Winograd Schema Challenge. The focus would be to test how well systems capture various logical intricacies in legal reasoning.

2. Randy mentioned some alternatives to the Winograd Schema Challenge. It would be worth pursuing this.

3. Ido, myself, and Kentaro Inui discussed collaborating and co-ordinating extraction of knowledge from text.

4. Yusuke Miyao and I discussed on collaborating on developing versions of NL2KR and kparser for the Japanese language.

5. I like the idea of developing a open-source Watson that was mentioned by Yuzuru Tanaka. Developing a multi-national effort on this would be a

good idea.

6. It would be interesting to use the math formula search work of Akiko Aizawa to solve numerical problems described in text by hunting and extracting the needed mathematical formulas from text (or text books). For example, it would be interesting to develop a system that can solve numerical Physics problems. The system will not be hardcoded with the Physics concepts but rather it (after it gets the problem) goes and finds the needed Physics formulas and concepts from text and then uses them to solve the problem that is asked.

Erich Schweighofer, University of Vienna

In law, the standard knowledge tool should become more supportive and intelligent. With the semantic legal knowledge system, a concept exists for major improvements. Research using knowledge representation and knowledge acquisition techniques would improve the tool box of knowledge engineering in the legal domain and would help to solve the present knowledge crisis in the legal system. Research aims: improve the semantic knowledge model of legal system, improve and update representation using tools of document categorisation, semi-automatic generation of thesaurus descriptors, automatic general of hypertext links, automatic generation of temporal relations, ranking, semi-automatic generation of summaries of documents and automatic translation of documents. International law (European law) is proposed as domain area.

Ido Dagan, Bar-Ilan University

I propose two types of practical next steps that can foster progress in this area, and possibly help bringing together researchers coming from different disciplines.

Inference and explanation benchmarks:

- Set up a benchmark dataset (or datasets) for relevant inference tasks over texts
- Desirably, the task should be taken from a real applied scenario (vs. a synthetic task like the Winograd schema challenge)
- In addition to the required inference decision, specify precisely also a task of providing explanations for the inference. Here substantial work should be done, since the notion of explanation is currently quite vague and non-consensual. This should include clear specifications of the required explanations, as well as a specification of an evaluation measure for explanations provided by systems

Promote work on knowledge acquisition and sharing of acquired knowledge resources:

- As was evident in the meeting, knowledge acquisition is a major bottleneck for robust inference
- Possibly specify novel benchmarks for knowledge acquisition tasks. This is quite challenging, as direct evaluations of knowledge effectiveness are

quite rare, and often depend on a particular non-standard system and are therefore hard to replicate.

An example of knowledge evaluation was given in Kentaro Inuis presentation, where the impact of acquired scripts knowledge was measured via an ablation test (measuring the marginal impact of the knowledge on the performance of the inference system).

Similarly, a benchmark could provide one or desirably several standard systems that rely on knowledge, and then asking benchmark participants to provide knowledge bases and measure their marginal impact on the provided systems.

- Encourage sharing of acquired knowledge resources, via standard repositories and formats
- Encourage projects, possibly joint ones, on acquisition of inference knowledge
- A far-fetching inspiration could be the Genome project, which has been a huge joint knowledge acquisition effort.

Günter Neumann, DFKI

Interactive exploratory search:

Our future research in the area of exploratory interactive search will exploit text inference for cross-sentential and space and time aware open relation extraction in order to identify more hidden relations and event structures. We will extend our multilingual open information extraction approach to cross-linguality by exploring Machine Translation and alignment-based strategies. Furthermore, we will investigate strategies that go beyond isolated topic graphs in order to support sharing topic graphs between different users, compare and merge topic graphs, and to monitor the development of topic graphs over time.

Bob Kowalski, Imperial College

The goal that I propose for future research is the generation of logical representations of natural language texts. The resulting logical forms can be used both for deductive and for abductive reasoning , as well as for input to inductive reasoning systems. Entailment and explanation would be two among many different applications. I believe that much of the work that has been done on NLP can be used to support this task. In particular, it can be help to identify predicate argument structure, which is the atomic building block of logical representations. I also believe that machine learning can be applied to this task. Experts can annotate a training set of natural language texts with the information needed to generate the logical representation of the text. The training set can then be used to learn how to generate the logical representation of new texts. The bottleneck in this proposal is the failure of logicians to agree upon a logic that is adequate for this task. However, I believe that there is overwhelming evidence that logic programming, with its focus on the distinction between simple conclusions and more complex conditions, provides a suitable formalism for this purpose. In this respect, it resembles the condition-action rules of production systems, which have been widely used a model of human thinking. Abductive

logic programming is a significant extension of ordinary logic programming, and it is especially well-suited for representing natural language meanings. Abductive logic programs combine ordinary logic programs for representing definitions of predicates, with (undefined) abducible predicates, which can have associated probabilities. Abducible predicates can be constrained by integrity constraints, which are similar to the obligations and prohibitions that are often be found in legal texts. There have been many applications of ordinary logic programming to the representation of legal texts, especially to legislation. I believe these applications can provide a sound foundation on which to build systems for understanding more informally written texts. I also believe that there is further evidence for the use of abductive logic programming, based on my analysis both of English language texts that are designed to be easy to understand, and on the advice given by English scholars about how to write English texts that are easy to understand. One feature of such advice, which can usefully be exploited when attempting to generate logical representation of texts, is that sentences should start with old, familiar information and end with new information. The new information at the end of one sentence can serve as the old information at the beginning of the next sentence. I believe that this feature of natural language texts can help a computer system to disambiguate text, by considering the logical representation of paragraphs instead of individual sentences.

Bart Verheij, University of Groningen

At this workshop, I hoped to learn about similarities and differences between two kinds of research:

- Research focusing on data-driven techniques, typically involving numeric estimates of what is relevant for a problem, e.g., in terms of statistics
- Research focusing on knowledge-modeling techniques, typically involving qualitative representations of what is relevant for a problem, e.g., in terms of logic

This hope was fulfilled, although it has been easier to see differences than similarities.

Differences

Data-driven research emphases:

1. Scalability
2. (Big) data/corpora
3. Simple structures and relations (e.g., correlations, triples)
4. Performance evaluation
5. Natural language
6. Approximate answers
7. Statistics

Correspondingly, knowledge-modeling research emphases:

1. Representational adequacy
2. Examples/cases
3. Complex structures and relations (e.g, arguments, logical models, scripts/schemes)
4. Normative evaluation
5. Formal language
6. Correct answers
7. Logic

Similarities

Both kinds of research had some version of the following:

- Construction of hypothetical answers, interpretations, explanations using background knowledge
- Testing of hypothetical answers, interpretations, explanations using evidence (sometimes supporting, sometimes attacking a hypothesis)
- Selection of hypothetical answers, interpretations, explanations using preferences

I like to think of these in terms of the language of argumentation, in which hypotheses are interactively constructed, tested and selected, much like in science (where argumentation is a tool for discovery) and in law (where argumentation is a tool for problem solving, and also for discovery). Argumentation approaches combine deductive, inductive and abductive reasoning techniques.

Future research

In my talk, I emphasized that there are questions with simple answers (e.g., What is Vincent van Gogh's country of birth?: The Netherlands) and with questions with complex answers (e.g., Is the suspect guilty of the crime, and why?: Some argument justifying a scenario that explains what has happened). IBM's Watson has focused on questions with simple answers. In the present state of the art of data-driven technology (such as Watson's) that is to be expected, as such technology has been focusing on simple structures and relations. In order to extend the state of the art to the answering of questions with complex answers (plans, explanations, arguments, interpretations, configurations), new technology must be developed that extends on what is now possible. The time is ripe for the incorporation of knowledge-modeling technology, which have been developed for the handling of complex structures and relations.

Hence, in future research, I would like to see the gradual integration of data-driven and knowledge-modeling technology. On the data-driven side, this requires a gradual extension of the complexity of the structures and relations. On the knowledge-modeling side, this requires a gradual change from being example-driven to (also) being data-driven. Intermediate representations (such

as parse trees, argument/rule schemes, scenario schemes) can help connect unstructured data with overstructured logic.

For me personally, the integration of data-driven and knowledge-modeling technology would be based on an argumentation perspective that combines probabilistic approaches (as relevant for data-driven research) with logical approaches (as relevant for knowledge-modeling approaches). Application domains of discovery in science and the law would be excellent test beds, and both would add social value, if successful.

Two kinds of input will lead to synergetic advantages:

- Theoretical research: the study of logic, probability theory and other relevant mathematics guarantees clarity, precision and normative correctness.
- Engineering research: the design and actual building of systems is necessary to establish what can and cannot be achieved, and why.

An important goal would be to develop a theoretically well-founded annotated data set (relevant for scientific and legal discovery) that can be used as a normatively correct golden standard for further research.

Yu Asano, Hitachi Central Research Labs

As future work, I would like to consider the following things:

1. How to build a lexicographic vocabulary automatically
2. Introduction of adverbs as a new word class. Probability or fuzzy logic may be used to defined adjective words, which is ambiguous words (e.g. gradually, rapidly)
3. Mapping natural language expressions to corresponding intermediate language, which we proposed.

Satoshi Tojo, JAIST

The complication of notation of modal logic is annoying. Especially in the case of dynamic epistemic logic (DEL), the description of revised model is further messy. Because DEL lies still in mathematical community, there should be a gap towards the pragmatic programming. My future tasks are:

1. to show more convincing examples; those which I have shown, e.g., three wise men, sum and product, and so on are solvable in other ways. In addition, they are purely logical puzzles far from real-world problems. We need to show the ones that are unique to DEL and more practical.
2. I myself have tried to be a bridge between math community and AI community. One method I recognized this time is to show DEL on computers, i.e., to visualize the accessibility to demonstrate how the belief revision works. I'm now considering to implement a comprehensible education system.

Yuzuru Tanaka, Hokkaido University

As a focused future research theme, I would like to propose the R&D on open source Watson-like systems through the intensive and international collaboration of natural language processing and logical reasoning research communities.

The current IBM Watson is still based on the shallow reasoning. Few details are available about reasoning architecture. It is focusing on business applications including the support of the negotiation between medical doctors and insurance companies, and the provision of alternative advices to medical doctors.

There are strong needs for open source Watson-like systems based on deeper reasoning. We need to establish an open innovation framework for the R&D of the required technologies. We should focus more on the support of academic R&D process and the support for patient empowerment.

The R&D toward this direction may have the following milestone subgoals.

1. Fact retrieval IBM Watson for Jeopardy challenge may corresponds to this stage.

2. Prediction of the research trend over the next decade This is practically useful for research policy making.

3. Finding a proof of $h \Rightarrow t$. The answer may be a proof process: $h \rightarrow t_1 \rightarrow t_2 \rightarrow \cdots \rightarrow t$, which explains this reasoning. Each $t_i \rightarrow t_j$ is extracted from some document in the document database.

4. Finding both requisites r and a proof of h, $r \Rightarrow t$, the answer may be a set: $\{r|h, r_1 \rightarrow t_1, t_1, r_2 \rightarrow t_2, t_2, r_3 \rightarrow t_3, t_3, \cdots t_{n-1}, r_n \rightarrow t_n\}$. Abductive inference will give those requisites.

Stages from (1) to (3) may work for hypothesis checking and its explanation, whereas the stage (4) may be necessary for the hypothesis making. They may support the whole research process consisting of the hypothesis making and the hypothesis checking.

Nguyen Le Minh, JAIST

1. I would like to focus on analyzing a sentence to a logical form representation and its application to textual entailment recognition (RTE) for the legal text. Recognizing temporal and event in the legal sentences will be considered in analyzing a legal sentence to its logical form representation.

2. Sentences in the legal domain are very long and complex, methods for dealing with those sentences are considered in our future works.

3. Graph knowledge is the one of the possibility for exploiting in my future work. This will be used for improving semantic parsing accuracy in the legal domain.

Akiko Aizawa, NII

In our work, we addressed several key issues to support users to retrieve, understand, and utilize mathematical information. Our approach is based on the

identification of links between mathematical expressions and their natural language descriptions in a document. Such associations enable us to semantically enrich math formulae and enhance conventional math retrieval and browsing systems. In my talk I also introduced our three-years struggle to establish an evaluation platform for math information retrieval in NTCIR-11 Math-2.

Although our current target is primarily focused on mathematical expressions, many of the techniques used in our system came from natural language processing. In addition to these conventional methods, we also developed a scalable indexing scheme suitable for large-size labeled trees (with variables). I hope such a math-specific method will be also useful for exploring semantic structure of text.

So far, I have been mainly working on math retrieval systems. However, through the discussions at this Shonan-meeting, I strongly recognized the necessity of moving forward and start thinking about extracting math-related knowledge from target documents. Just collecting and categorizing symbolized concepts in a specific field would reveal some domain knowledge. Another interesting viewpoint is to investigate in detail the difference of tree structures obtained from mathematical formulae and natural language sentences. This might help to learn the process of generalizing text into abstract rules.

Although converting mathematical formulae in a document into executable codes (for Mathematica or Maple) is a very hard task, it should be considered sometime in the future. As a starting point, translating natural language text into arithmetic calculation would be an interesting challenge, particularly when it is applied to tax law descriptions (suggested by Prof. Ken Sato).

Yuji Matsumoto, NAIST

Through the precise and deep analysis of (complex) sentences, I like to move forward to analyzing documents of several areas for extracting knowledge and valuable information. The targets will cover:

- Retrieval and summarizing technical documents, such as technical papers, from various perspectives, e.g., background, methodology, new results/findings, etc.
- Finding relationship between different documents/technical papers.
- classifying people's opinions and their reasons.
- Construction of lexicons that cover multi-word expressions, syntactic patterns, relationship between expression within a languages as well as cross-languages.
- Development of tools for handling lexicons and obtained knowledge for keeping and showing them.

Bernardo Magnini, FBK

In the seminar I have learnt interesting research activities carried on by several research groups, of which I was not fully aware. I have found particularly interesting the large-scale acquisition of resources for common-sense reasoning

(e.g. scripts) and the use of such resources for abductive reasoning for generating explanations.

As a general topic for future research I would focus on the relation between knowledge automatically extracted from text using open domain Information Extraction, typically represented as textual graphs, and background knowledge, typically represented with some formal language. While the current state-of-art in open domain IE does not allow to produce formal representations of enough quality and coverage, I can see interesting room in the next years for coupling the two representation levels. I think it would make sense to develop mixed query/retrieval schemas, where partially structured information (e.g. entailment graphs) is used together with structured knowledge (e.g. description logic) in order to provide more informative explanations of reasoning processes.

In this framework, I would be interested to pursue collaborations in the context of the CREST and EU research programs.

Kentaro Inui, Tohoku University, Japan

I share the view that intelligent computational systems must have the capability of explaining their outputs. Producing explanations is important not only for sophisticated applications which inherently need to provide the users with explanations but also for researchers' better understanding of how their computational models behave and what is required to make them better. This is also one of the motivations behind my group's exploration for the abduction-based approach.

One issue I think is important in this movement toward explanation production is how to evaluate the "goodness" of an explanation and how to compare different methods. Good explanations to a given situation may not be unique and different disciplines (or even different individual researchers) may have different models of explanations. This provisional problem reminds me of the issue of evaluating studies in language generation. In language generation, it is not as straightforward to evaluate outputs as it is in language analysis partly because language generation tasks sometimes have open-ended "appropriate" potential outputs for a given input and thus it is not easy to build "gold standard" datasets. Language analysis tasks, on the other hand, tend to be decomposable into tasks of label or structure prediction, where the correct answers are usually unique and not as arguable as in language generation. Research for explanation production involves the same issue in nature and may raise even more complex issues because it is more content-oriented and knowledge-dependent.

I think this is an intriguing issues for which researchers with different backgrounds can cooperate together. NLP, logic, knowledge modeling, argumentation theory and logic of thought are all indispensable pieces for addressing that issue. How describe and annotate explanations humans produce. How to collect humans' explanations. How to compare our systems' outputs with humans' explanations. I think these are important questions which drive our research forward.

Overview of Talks

Computational Logic, the Language of Thought and Natural Language

Robert Kowalski, Imperial College, United Kingdom

Formal Logic is a natural candidate for representing computer-intelligible knowledge extracted from natural language texts on the WWW. I will argue that the logic of natural language texts is normally not visible, but is hidden beneath the surface, and that it can be uncovered more easily by studying texts that are designed to be as clear and easy to understand as possible. I will support my argument in two ways: by giving examples of English language texts and their hidden logic, and by interpreting guidelines for English writing style in computational logic terms. I will also argue that kind of logic that is most useful for representing natural language is both simpler and richer than classical logic. It is simpler because it has a simpler syntax in the form of conditionals, and it is more powerful because it distinguishes between the logic of beliefs and the logic of goals.

Keywords: Computational Logic, English writing style, Knowledge representation.

Arguments for Structured Hypotheses: A Logico-Probabilistic Perspective

Bart Verheij, University of Groningen, The Netherlands

Some questions have answers with a simple structure. For instance, the question "What is Vincent van Gogh's country of birth?" has the answer "The Netherlands". Other questions require answers with a more elaborate structure. For instance, although the question "Is the suspect guilty of a crime?" can be answered with a simple "yes" or "no", additional structure in the form of arguments for and against the legally relevant scenarios is needed. Each scenario provides a hypothetical answer to the guilt question. Some scenarios are better supported by the evidence than others. In the talk, a theory of arguments for structured hypotheses is discussed that uses classical logic and probability theory as normative framework. Possible answers to questions take the form of structured hypotheses. The logico-probabilistic argumentation framework sheds new light on the formal semantics of argumentation, in a way that combines logic-based knowledge technology with probability-based data analysis.

Keywords: Argumentation, Inference to the Best Explanation, Artificial Intelligence and Law, Combining Logic and Probability Theory.

EXCITEMENT: EXploring Customer Interactions through Textual EntailMENT

Bernardo Magnini, Ido Dagan, Guenter Neumann, Sebastian Pado, Fondazione Bruno Kessler, Italy

EXCITEMENT (http://www.excitement-project.eu) is a 3-year research project funded by the European Commission. The main topic of the project is identi-

fying semantic inferences between text units, a major language processing task, needed in practically all text understanding applications. On the industrial side, EXCITEMENT is focused on the text analytics market and follows the increasing demand for automatically analyzing customer interactions. A major result of the project is the release of the EXCITEMENT Open Platform (EOP). The platform aims to automatically check for the pres-ence of entailment relations among texts. It is based on a modular architecture and provides support for the development of algorithms that are language independent to a high degree. The result is an ideal software environment for experimenting and testing innovative approaches for textual infer-ences. The EOP is distributed as open source software (http://hltfbk.github.io/Excitement-Open-Platform/).

Keywords: semantic inferences, textual entailment, inference platform.

Decomposing Semantic Inferences

Bernardo Magnini, Fondazione Bruno Kessler, Italy

Textual Entailment (TE) has been proposed as an applied framework to capture major semantic inference needs across applications in Computational Linguistics. We think that crucial progress may derive from a focus on decomposing the complexity of the TE task into basic phenomena and on their combination. In this talk, we carry out a deep analysis on TE data sets, investigating the relations among two relevant aspects of semantic inferences: the logical dimension, i.e. the capacity of the inference to prove the conclusion from its premises, and the linguistic dimension, i.e. the linguistic devices used to accomplish the goal of the inference. We propose a decomposition approach over TE pairs, where single linguistic phenomena are isolated in atomic inference pairs, and we show that at this granularity level the actual correlation between the linguistic and the logical dimensions of semantic inferences emerges and can be empirically observed.

Keywords: semantic inferences, textual entailment, linguistic phenomena

Natural Language Knowledge Graphs: Open-IE meets Knowledge Representation

Ido Dagan, Bar-Ilan University, Israel

Formal knowledge representation schemes are typically limited to pre-defined structures and predicates. Conversely, Open Information Extraction (Open-IE) represents arbitrary propositions occurring in text, but lacks a consolidating canonical structure and is limited to simple predicate-argument tuples. I will outline a proposal towards a more powerful knowledge open representation scheme, which could cover knowledge beyond the typical scope of pre-specified knowledge representation. First, we propose extracting complex and implied propositions and abstracting semantically-relevant information. Second, we propose adding a structure over the set of extracted propositions via relevant semantic relationships. We first focus on the textual entailment relation, which consolidates semantically equivalent propositions and induces a useful specific-to-general hierarchical structure. I will review initial research activities along the above mentioned goals.

Keywords: natural language processing, knowledge representation, textual inference, textual entailment, open information extraction

Identifying the Tradeoffs in Textual Entailment: Deep Representation versus Shallow Entailment

Randy Goebel, University of Alberta, Canada

Much research on natural language understanding and processing ("NLP") has focused on how to transform natural language to formal logics, in which case the problem of text entailment becomes that of logical entailment. Despite a variety of approaches to the transformation of language to logic, even the most sophisticated (e.g., Montague's higher order intensional logics or Steedman's combinatory categorial grammar) leave unresolved foundational challenges like context and dialogue. And though these transformations are tightly coupled with formal mechanisms for inference, those methods themselves are often difficult to implement. Current text entailment focuses on building or learning models of verb cases, concept identification, summarization, and information extraction. We consider consider some measure alternatives for the tradeoffs, and whether they are necessarily empirical, or can exploit some foundational principles of NLP representation theory.

Keywords: entailment,formal,representation,inference Slides Summary

Learning to Parse Legal Sentences to Logical Form Representations

Nguyen Le Minh and Akira Shimazu, Japan Advanced Institute of Science and Technology, Japan

In this talk, we would like to present our framework for dealing with the problems of understanding legal sentences. Our framework is divided into three major steps: logical parts recognition, logical part grouping, and semantic parsing. In the first phase, we model the problem of recognizing logical parts in law sentences as a multi-layer sequence-learning problem, and present a CRF-based model to recognize them. In the second phase, we propose a graph-based method to group logical parts into logical structures. We consider the problem of finding a subset of complete subgraphs in a weighted-edge complete graph, where each node corresponds to a logical part, and a complete subgraph corresponds to a logical structure. For the final step, we would like to report our recent works and the state of the art semantic parsing models for general domains. We also discuss the potential of exploiting current semantic parsing models for simple law sentences.

Keywords: Legal text processing, semantic parsing, logical parts recognition

Parsing Long and Complex Natural Language Sentences

Yuji Matsumoto, Nara Institute of Science and Technology, Japan

While syntactic analysis of natural language sentences has shown a remarkable progress in past decades, there are still some hindrances to further improvement. Sentences in scientific or legal areas often have very complex structures,

mainly due to long coordinate structures and/or complex sentence patterns. Although most of the current machine learning-based syntactic parsers use local features to decide phrase structures or word-to-word dependencies, global features or resources that make use of long distance dependencies are necessary to handle complicated linguistic phenomena. In this talk, I will introduce our on-going project to develop methods and linguistic resources for complex structures, such as coordination structures and complex syntactic patterns.

Keywords: natural language parsing, coordination structures, complex sentence patterns

Explanation Producing Combination of NLP and Logical Reasoning through Translation of Text to KR Formalisms

Chita Baral, University of Arizona, USA

Our approach to combine NLP and logical reasoning so that it can produce explanations is based on translating natural language text to appropriate knowledge representation formalisms. In this talk we will discuss two approaches. In the first approach, we will present our semantic parser, available at http://kparser.org , that translates English text to a knowledge graph that includes ontological and domain knowledge from various sources. The second approach addresses the concern that depending on applications one may want or need translations of natural language text to different knowledge representation formalisms. We will present our NL2KR platform (available at http://nl2kr.engineering.asu.edu) that allows the development of translation systems by giving examples of translations (i.e., a training set) and an initial dictionary of words and their meaning given as lambda calculus expressions. The work that will be presented is done by Chitta Baral and his students.

Keywords: Natural Language Processing, Semantic Parser, Lambda Calculus

Reading Between the Lines

Kentaro Inui, Tohoku University, Japan

Based on Scalable and Trainable Abduction and Large-scale Knowledge Acquisition The idea of modeling semantic and discourse analysis based on logical abduction goes back to Hobbs et al.(1993)'s influencing work: Interpretation as Abduction. While the approach has many potential advantages, no prior work has successfully built abductive models applicable to real-life problems chiefly due to the lack of knowledge and computational costs. However, the game is drastically changing. Recent advances in large-scale knowledge acquisition from the Web may resolve the knowledge bottleneck. We show that the computational cost of first-order abduction can be considerably reduced with the liner programming techniques, which then enables the supervised training of abduction. Given these movements, we believe that a number of intriguing issues will emerge from the resumption of the study for abduction-based modeling of NLP tasks with a fast reasoner and large-scale knowledge resources. We will present recent insights gained from experiments on the Winograd Schema Challenge.

Keywords: discourse analysis, abduction, knowledge acquisition, coreference resolution, Winograd Schema Challenge

Towards Explanation Production of Yes/No Questions in Multiple Choice Bar Exam

Ken Satoh, National Institute of Informatics, Japan

We will present an approach toward explanation production for multiple-choice bar exam where we give an explanation why a branch in multiple choices is followed by the articles or precedents in civil law. We use PROLEG (PROLOG-based LEGal reasoning system) for a reasoning part which we developed for reasoning about ultimate fact theory and try to make a connection between PROLEG predicate and an element in a parsed tree of bar exam sentences by NLP.

Keywords: Legal Reasoning, PROLEG, logic programming, parsed tree

How to Promote the R&D on Open Source Watson-like Systems based on the Combination of Natural Language Processing and Logical Reasoning?

Yuzuru Tanaka, Hokkaido University, Japan

In 2013, JST launched the CREST program on big data applications. It has picked up six projects during the first two years, and will pick up another couple of projects next year. As one of the focused research areas for the call for proposals next year, the program is now planning to pick up the NLP based knowledge acquisition from published research papers in logical representation, the construction of a large scale knowledge base, and the automatic reasoning with this knowledge base for knowledge discovery and question answering. This research area became stimulated by the success of IBM Watson in "Jeopardy!" This research direction may be considered a a scalable extension of the dreams of Japanese fifth generation computer project in 90s with NLP interface. As the program officer of the JST CREST program, I would like to ask a question on how to promote the R&D on open source Watson-like systems based on the combination of natural language processing and logical reasoning.

Keywords: big data applications, open-source Watson like systems, research promotion, knowledge discovery from published papers

Math Formula Search

Akiko Aizawa, National Institute of Informatics, Japan

Mathematical formulae in natural language text sometimes represent formalized concepts and relations that can be processed by computers. However, in actual documents, most formulae are expressed as noisy, ambiguous, and insufficient representations. In the past, we explored how to deal with such 'informality' of formalized and abstracted relations for efficient semantic search. This reveals to require elaborative analysis of surrounding natural language text as well as efficient approximate tree search enhanced with variable unification.

In this presentation, we briefly introduce up-to-date techniques for math formula search and also explore further research directions to connect such efforts to the manipulation of semantic structure embedded in natural language text.

Keywords:natural language processing, math formula search, description extraction, construction of dependency graph

Fact Validation by Recognizing Textual Entailment

Yusuke Miyao, National Institute of Informatics, Japan

We will introduce recent research activities on fact validation, which is also known as true-or-false question answering. Fact validation aims to prove whether or not a given statement is true, according to a prespecified set of texts, such as textbooks and Wikipedia, that are supposed to describe true facts. A shared task on fact validation has been organized in NTCIR, and its organization scheme and the results of participating systems are introduced. We will also describe experiments on applying a logic-based textual entailment system to fact validation, and discuss its advantages and difficulties.

Keywords: fact validation, true-or-false question answering, textual entailment recognition

Identifying Appropriate Concepts for Unknown Words with Formal Concept Analysis

Akihiro Yamamoto and Madori Ikeda, Kyoto University, Japan

In natural language processing, extending many thesauri is time-consuming. In order to overcome this problem, we propose a method with a corpus. We assume that extending thesauri should be inserting unknown words into them by finding accurate concepts. We regard the task as classification and use a concept lattice for it. The method enables us to decrease the time-cost by avoiding feature selection for each pair of a set of unknown words and a set of unknown words. More precisely, a concept lattice is generated from only a set of known words, and each formal concept is given a score with the set. By experiments using practical thesauri and corpora, we show that our methods can give more accurate concepts to unknown words than other the k-nearest algorithm.

Keywords: extending thesauri, classification, formal concept analysis

On the Way to Semantic Legal Knowledge Systems

Erich Schweighofer, University of Vienna, Austria

On the Way to Semantic Legal Knowledge Systems

Keywords: Semantics, Legal Ontologies, Logic

Knowledge-Intensive Structural NLP in the Era of Big Data

Sadao Kurohashi, Kyoto University, Japan

Texts are the basis of human knowledge representation, including data analysis results and interpretation by experts, criticism and opinions, procedures and instructions. We have been working on the realization of knowledge-intensive structural NLP which can extract truly valuable knowledge for human beings from an ever growing volume of texts, known recently as Big Data. This talk introduces several of our on-going projects concerning knowledge-intensive structural NLP: synonymous expression, case frame and event relation acquisition from 15G parsed sentences, ellipsis resolution considering exophora and author/reader information, an open search engine infrastructure TSUBAKI, and an information analysis system WISDOM.

Keywords: Knowledge-Intensive Structural NLP, Case Frame Acquisition, Event Relation Acquisition Slides

Interactive Text Exploration

Günter Neumann, German Research Centre for AI, Germany

Today's Web search is still dominated by a document perspective: a user enters keywords that represent the information of interest and receives a ranked list of documents. This technology has been shown to be very successful, because it very often delivers concrete web pages that contain the information the user is interested in. If the user only has a vague idea of the information in question or just wants to explore the information space, the current search engine paradigm does not provide enough assistance. The user has to read through the documents and eventually reformulate the query for finding new information. So seen, current search engines seem to be best suited for "one-shot search" and do not support content-oriented interaction. In my talk, I will present and discuss our efforts in building highly dynamic, scalable interactive intelligent text content exploration strategies which supports both, the computer and the human, to interactively "talking about something."

Keywords: information search, open information extraction, interactive text exploration

Agent Communication and Belief Change

Satoshi Tojo, Japan Advanced Institute of Science and Technology, Japan

Communication in agents is not a simple message passing. A rational agent should send logically consistent contents in the situation. Then, there must be a communication channel between agents, e.g., an address of the message recipient. Furthermore, the message can be publicly announced, i.e., there can be simultaneous multiple recipients; otherwise the message passing becomes a personal communication. Finally, the message recipient must adequately maintain the consistency of their belief, that is, as a result of message passing, the recipient must revise his/her belief to be logically consistent. In this talk, I overview the various researches concerning logical representation of communication and belief change, especially in terms of modal logic, where belief change is realized

by the restriction of accessibility to some possible worlds. Thereafter, I show some applications of the formalization, such as logical puzzles.

Keywords: agent, communication, belief, dynamic epistemic logic

Explanation Production with Open Data: Approach for Querying RDF Data by Using Natural Language

Yu Asanao, Hitachi Central Research Laboratory, Japan

The governments of many nations publish vast amount of open data, such as statistics and white paper. We introduce these activities of open data and discuss possibilities to produce explanations by using open data. For example, an answer on question and answering system "The population is growing" can be supported by showing observed statistical data. From this point of view, connecting a natural language expression to its evidence data is a key method of explanation production. As the first goal for the connection, we propose a method to inquiry structured data by using natural language like query expression.

Keywords: Open Data,Explanation Extraction, Resource Description Framework, Query Language, Natural Language

Workshop participants

- Akido Aizawa, NII, Japan
- Yu Asano, Hitachi Central Research Labs, Japan
- Chitta Baral, Unviersity of Arizona, USA
- Ido Dagan, Bar Ilan University, Israel
- Randy Goebel, University of Alberta, Canada
- Kentaro Inui, Tohoku University, Japan
- Robert Kowalski, Imperial College, United Kingdom
- Sadao Kurohashi, Kyoto University, Japan
- Bernardo Magnini, FBK, Italy
- Yuji Matsumoto, NAIST, Japan
- Günter Neumann, DFKI, Germany
- Minh Le Nguyen, JAIST, Japan
- Ken Satoh, NII, Japan
- Erich Schweighofer, University of Vienna, Austria
- Satoshi Tojo, JAIST, Japan
- Bart Verheij, University of Groningen, The Netherlands
- Akihiro Yamamoto, Kyoto University, Japan
- Miyao Yusuke, NII, Japan

Workshop schedule

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November 26 (Wed)
15:00 check-in
19:00-21:00 Welcome Reception
21:00-23:00 Night Session

November 27 (Thu)
07:30-09:00 Breakfast
09:00-09:10 Introduction movie of NII Shonan Meeting
09:10-10:30 Brief Introduction of Your Presentation (in 3 minutes)
10:30-11:00 Break

11:00-12:00
Robert Kowalski
Computational Logic and its Relationship with Guidelines for English Writing Style

Bart Verheij
Arguments for Structured Hypotheses: A Logico-Probabilistic Perspective

12:00-13:30 Lunch

13:30-15:30
Bernardo Magnini, Ido Dagan, Guenter Neumann, Sebastian Pado
EXCITEMENT: EXploring Customer Interactions through Textual EntailMENT

Bernardo Magnini
ecomposing Semantic Inferences

Ido Dagan
Natural Language Knowledge Graphs: Open-IE meets Knowledge Representation

Randy Goebel
Identifying the Tradeoffs in Textual Entailment: Deep Representation versus Shallow Entailment

15:30-16:00 Break
16:00-17:00
Nguyen Le Minh (joint work with Akira Shimazu)
Learning to Parse Legal Sentences to Logical Form Representations

Yuji Matsumoto
Parsing Long and Complex Natural Language Sentences

17:00-18:00 Discussion
Discussion Question: Can you please note your immediate observations about

your original expectations for the workshop, and how they have so far been changed or adjusted?

18:00-19:30 Dinner
21:00-23:00 Night Session

November 28 (Fri)
07:30-09:00 Breakfast
09:00-10:30
Chitta Baral
Explanation Producing Combination of NLP and Logical Reasoning through Translation of Text to KR Formalisms

Kentaro Inui
Modeling Reading between the Lines Based on Scalable and Trainable Abduction and Large-scale Knowledge Acquisition

Ken Satoh
Towards Explanation Production of Yes/No Questions in Multiple Choice Bar Exam

10:30-11:00 Break
11:00-12:00 Discussion
Discussion Questions: From discussions and presentations so far, what are the measures that could be used to guide the pursuit of the engineering of systems that provide natural language explanations? Are there underlying scientific challenges which delimit possible scientific measures?

12:00-13:30 Lunch
13:30-15:30
Yuzuru Tanaka
How to Promote the R&D on Open Source Watson-like Systems based on the Combination of Natural Language Processing and Logical Reasoning?

Akiko Aizawa
A Linguistic Approach to Math Formula Search

Yusuke Miyao
Fact Validation by Textual Entailment Recognition

Akihiro Yamamoto (Joint work with Madori Ikeda)
Identifying Appropriate Concepts for Unknown Words with Formal Concept Analysis

15:30-16:00 Break
16:00-18:00 Discussion
Discussion Question: Now at the end of the second day, what concepts have emerged to be most important so far?

18:00-19:30 Dinner

21:00-23:00 Night Session

November 29 (Sat)
07:30-09:00 Breakfast
09:30-10:30
Erich Schweighofer
Logic and Semantics in Legal Text Corpora: The Dynamic Legal Electronic Commentary

Sadao Kurohashi
Knowledge-Intensive Structural NLP in the Era of Big Data

10:30-11:00 Break
11:00-12:00 Discussion
Discussion Question: What major themes have emerged as a result of the meeting?

12:00-13:30 Lunch
13:30-19:00 Excursion
19:00-21:30 Banquet

November 30 (Sun)
07:30-09:00 Breakfast
09:00-10:30
Günter Neumann
Interactive Text Exploration

Satoshi Tojo
Agent Communication and Belief Change

Yu Asano
Explanation Production with Open Data: Approach for Querying RDF Data by Using Natural Language

10:30-11:00 Break
11:10-12:00 Wrapping-up
Discussion Question: What are the major themes developed during the meeting that will impact your future research trajectories (if any)?

12:00-13:30 Lunch
1330-1400 Good-bye(Farewell)
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