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SEKI - REPORT

Goals, Issues and Directions in Machine-learning of Natural Language and Ontology

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in
Machine Learning of Natural Language and Ontology

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Information additional to 'Call for Participation'
AAAI Spring Symposium - March 26-28 1991, Stanford
(Includes mini-bibliographies by symposia subarea)

1. INTRODUCTION

The call for participation for the symposium on Machine Learning of Natural Language and Ontology noted that the papers on this topic, over the last thirty years, have tended to take drastically different practical and theoretical approaches, and have drawn in varying degrees on fields outside Computer Science and Artificial Intelligence. Contributions should thus be made as generally relevant to the topic of machine learning of natural language and ontology as possible, and the potential contributor or participant should seek to make this relevance clear to the quite broad audience which will be approaching the area from many different backgrounds and perspectives.

The following seeks to expand on the perceived extent of the field, to clarify and encourage the possibility for participation from those with potentially relevant research, and to indicate some of the areas in which research is, can be or should be focussed. Researchers who have not been active in Machine Learning of Natural Language, but can make contributions in one (or more) of these areas should also contact the author or another member of the symposium committee.

Our descriptions are intended to be totally independent of application, whether Database Retrieval, Machine Translation, Modelling (Linguistic, Psychological or Neurological), or Robotic Speech and Vision systems.

The symposium will address all aspects of the relationship between Machine Learning and Natural Language. We not only expect input from researchers in Computer Science and Artificial Intelligence (Machine Learning, Natural Language, Robotics, Vision, Neural Nets, Parallelism, etc.) but wish particularly to encourage relevant contributions from other fields (Linguistics, Psycholinguistics, Philosophy, Neurology, Mathematics, etc.)

Note that contributions should clearly indicate assumed background in the introduction - where appropriate we will seek to allow a limited amount of

extra time for session chairmen or presenters to present essential tutorial material, and/or space for the same in the working papers of the symposium. We intend to avoid holding parallel sessions, as we feel all contributions should have relevance to all participants. Thus talks should be presented at a level accessible to all participants. Full working papers will be required by 1st February and advice and instructions concerning preparation will be given upon acceptance of your paper.

Specific areas of interest mentioned in the call will now be reviewed and elaborated, clarifying the intentions and goals behind the headings. Representative or exhaustive references will be included under each major heading. Notification of errors and omissions will be welcomed. The purpose of this document is to stimulate interaction and expand our perceptions of the field, and here 'our' includes most definitely the author and the rest of the committee.

Note that the last of the six major headings, System Development, represents the practical outworking of our field and aims to be exhaustive, and where possible comparative. The preceding sections refer to work which has proven useful, or has been proposed as useful, in relation to this ultimate aim of building an effective system. Emphasis is on the roots of these other fields rather than the modern breadth they all encompass.

2. TRADITIONAL APPROACHES

2.1 Applicability of traditional machine learning.

Here we particularly have in mind work in concept learning - clearly related to semantics potentially to syntax and pragmatics - and on the role of teacher and critic, including automatic generation of examples, implicit criticism, unsupervised learning etc. Application of traditional techniques to facits of language are fundamental in that they are immediately accessible and connect with a considerable body of previous work.

2.2 Applicability of traditional parsing techniques.

Some approaches are based on traditional theories from linguistics and elsewhere. Learnability provides a very practical test for a linguistic theory. A good approach to parsing should relate to a good approach to learning syntax. Many approaches however are based on non-linguistic traditions, notably neural nets. Contributions connecting different disciplinary approaches, and showing the relationship with traditional approaches are especially solicited.

2.3 Goals and Issues

GOAL: Theories of language (grammar, semantics, representation) and learning (reasoning, understanding cognition) which allow effective language learning and use.

ISSUE: Will traditional approaches to language and learning be effective in some combination? Or will language learning require / lead to new theories of language and learning?

2.4 References

The traditional natural language work has been based in varying degrees on linguistic theories and models. Machine learning has largely been focussed on concept learning, heuristic evaluation with signature tables, information theoretic discrimination learning, etc. This bibliography summarizes the roots of both natural language and machine learning work. The many modern texts are not referenced, but could be referred to for up-to-date detail.

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3. COMPLEXITY THEORY

3.1 Formal results on learning and language constraints.

Results and proposals based on complexity theory have been driving forces in some schools of linguistics and psycholingustics - notably the contributions of Gold and Chomsky. New approaches, algorithms and claims need to be considered in the light of such results, and appropriate new analyses should be developed.

3.2 Development of effective classifications of language.

Part of the problem with formal theory is the lack of evidence that the theoretical classification of language relates to the actual human languages and cognitive restrictions. Some basic assumptions are clearly suspect or at least oversimplications. Do we need to develop new ways of formally characterizing language in terms of the restrictions and heuristics which shape human learning of language?

3.3 Goals and Issues

GOAL: Theoretical analysis is need to determine and characterize the relation between supervision level, computational constraints, formal language class and base level knowledge.

ISSUE: The positive effect of negative constraints on the computational capacity has been neglected. Such constraints effectively define new subclasses of languages learnable by a given algorithm. The languages humans encounter are not arbitrary but are shaped by our algorithms, limitations and environmental (including supervisory) conditions, being limited to what can be learned (or, stronger still, invented) under these conditions.

3.4 References

Rigourous mathematical analysis is an important source of criticism for Cognitive Science research. Publication of results can shape the whole future of a field, firmly closing off former paths of attack, and opening up others. Unfortunately, the effect has not always been positive. In some noteworthy cases, the wider Cognitive Science community has taken a result at face value, applied it far outside the applicable conditions (spelled out by the original author), and interpreted it without commonsense reflection on and reinterpretation of the natural world correlates of the analyzed system. This list includes a number of such examples. It pays to consider these results first hand!

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4. COGNITIVE SCIENCE

4.1 Psychological results on language and restrictions.

This is seen as an important aspect of the symposium, with the hope that old and new results and critiques from Psycholinguistics will inspire those who are looking for solutions to problems and ideas they can implement. It is not necessary that the particpant has himself worked on learning programs, but the relevance of his work to such efforts should be made clear.

4.2 Linguistic results on the nature of natural language.

Similar considerations apply here. Comparative advice about linguistic theories or formalisms, with critical evaluation on the basis of computability, are particularly encouraged. Implementers who have adopted a particular linguistic heritage are particularly asked to comment on the reasons for the choice plus the appropriateness in retrospect.

4.3 Goals and Issues

GOALS: To provide the empirical evidence for the roles of innate knowledge and specific and general learning mechanisms, as well as for environmental conditions including parents and other human supervisors and critics plus the physical laws and feedback deriving from physiological constraints.

ISSUE: How much is (necessarily) innate? From how minimal a base state can learning be effective in bootstrapping?

ISSUE: How much supervision, teaching and criticism is necessary for effective learning? To what extent can a reactive environment

substitute? What cognitive constraints shape our languages?

4.4 References

The emergence of Cognitive Science in the 80s as the interdisciplinary counterpart of Artificial Intelligence represents a huge increase in interest in the potential interdisciplinary contributions to understanding and modeling intelligence, learning and language. This is reflected here in only token form, allowing the reference to the older expositions which preempted the universalist approach and the debates which ensued and lead directly to the recognition of Cognitive Science. The linguistic and philosophical traditions have been to a greater or lesser extent reflected in the last section; whilst the new age neural developments are reflected in the next section to the extent that they are treated at all. This leaves, in the main, Psycholinguistics.

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5. PARALLEL NETWORKS

5.1 Neural models of parsing and learning.

There is a separate symposium on "Connectionist Natural Language Processing". For information contact Charles Dolan: cpd@aic.hrl.hac.com and consider which forum is most appropriate to your interests and research. Both committees are open to the idea of a joint session. If you apply to participate in both, please let us know, and do be aware of the impossibility of participating in both.

In relation to this symposium, we would be particularly interested in presentations EITHER with conclusions concerning the advantages of neural approaches over conventional machine learning OR with deep modelling of neurolinguistic processes.

5.2 Parallel models of parsing and learning.

Implementations on parallel hardware are of interest, as are parallel or parallelized algorithms and theoretical contributions on the role, parallelism, backtracking etc. in language and learning processes.

5.3 Goals and Issues

GOAL: Neural investigations need to determine and characterize the nature and role of the human (animal) wetware, as well as stretching the limits of neural inspired models.

ISSUE: What are the limits of genetic determination, boundary conditions and self-organzational determination?

ISSUE: Neural simulations to date tend to be passive recognizers reacting to the sensory-motor input. Does there exist some sort of active learning which is different, which is not just a feedback control system, but capable of initiating behaviour?

ISSUE: How does all of this relate to language? Is language just a consequence of our neural capacities in combination? Or are language specific neural level mechanisms to be found?

5.4 References

This very short list points to both the old school and the new age of associative and neural networks, as well as the only parallel language learning proposals I am aware of.

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6. SYMBOL GROUNDING

6.1 Grounding of Natural Language Systems.

Where is the border between syntax and semantics? When can a system be said to know something as opposed to just churning out a pat response? Does learning provide an answer to these old chesnuts? How far can you get with an ungrounded system?

6.2 Interaction between Modalities and Learning of Ontology.

We particularly solicit contributions in which aspects of language are learnt and used in a context, where language input and output are supplemented by (or indeed supplement) other forms of interaction between the language system and the envirnoment in which it is embedded. The system could be a robot, simulated or actual; the environment could be provided by a vision system; or we could have a humbler interface to a database, an operating system or other application.

6.3 Goals and Issues

FALSE ISSUE: What is the difference between a chinese room and a chinese in a room? (Complexion?!)

NOTE:	NONE	= Turing	=	Outside room	=	Black Box
	MIND	= Searle	=	Inside room	=	Glass Box
	SKIN	= Harnard	=	Essence	=	Colored Box

Turing says that intelligence and thought is totally captured in language and can be totally expressed and communicated through arbitrary symbols.

Searle says that intelligence and thought is totally equivalent to mind and can't be totally expressed and communicated through any symbols.

Harnard says that intelligence and thought is equivalent to human-ness and can't be totally expressed and communicated through any symbols, but can be expressed and communicated through the right set of 'symbols' (which must include icons, the intrinsic counterpart of symbols).

ULTIMATE GOAL: To have language used effectively by the computer for the purpose we intend.

REAL ISSUE: When are we just translating from one language to another? When are we doing more: understanding, communicating, intending? Where does a computer derive its motivation from? Its programmer? Where do we derive our motivation from?

TOY SUB GOAL: To provide a toy environment in which the above is achieved.

REAL SUB GOAL: To achieve this in an actual application environment.

CRUCIAL ISSUE: How similar a sensory-motor environment and perceptual interface to ours is needed to allow learning of language? And what criterion do we learn to?

6.4 References

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7. SYSTEM DEVELOPMENT

7.1 Computable hypotheses and heuristics for language learning.

Proposals of how to build a language learning system will be received with interest, as will more limited argument about the significance of various hypotheses, heuristics or methodologies for language learning implementations.

7.2 Experimental language learning systems and their rationale.

Reports on successfully implemented language learning systems will be received with amazement! Characterizations of what can be learnt by the system, or any precursor thereof, should be included, along with explanations of the methodology used.

7.3 Goals and Issues

GOAL: The HAL of 2001, or Bridging the Communication Gap?

ISSUE: Most systems, and natural language learning experiments, are in danger of just translating from one representation to another. While this is appropriate for specific applications (database, machine translation, etc.), there is little merit in learning a one to one correspondence, or somethings close to it. Implementors need to make clear they are doing more than that.

ISSUE: Humans learn their language in parallel with their ontology! That is humans have to learn about their world too! A language learning system which cannot learn about its world is not adaptable, and has impaired language learning capability.

ISSUE: Most systems, and natural language learning experiments, start with simple examples of sentences (and/or meanings) and work up (if they're lucky) to complicated examples. Children learn primarily from full blown adult conversation. There is

relatively little (machine readable) graded material. There is little advantage in constructing examples by rule. Learning is only possible of "what we almost already know". To use material which is beyond this "next grade" level, we need "filtering" - heuristic elimination of unprocessable input.

ISSUE: Some "field" systems provide mechanisms for accommodating to overly complex or new input, and optimizing to user variation and development. But the "too hard basket" is discarded. This, however, is precisely where learning systems should focus their effort, what is beyond the range of "acceptable" but nonetheless still "understandable". The excess baggage is never gratuitous!

ISSUE: What is the relationship between learning for recognition and learning for production? Children's generation capability seems to lag their understanding. Computers often reverse this trend!

ISSUE: Performance related learning is a factor in language learning, and a precursor to other aspects of language learning. But what role does it have and how can performance related developments in specialized domains incorporate into HALs.

ISSUE: Organization and consolidation have not been problems in some toy systems or specifically applied adaptive contexts. But in general, learning to associate similar things, classify and consolidate, can create problems in relation to memory. Programmers don't like to throw anything away. (It can involve implementational difficulties anyway.) People don't remember everything(?). And they certainly don't remember everything with the same ease or for the same time. Clutter can be a problem. The frame problem is really a special manifestation of this.

METRICS
1: Who provides the examples? (Teacher)
2: Who corrects the examples? (Critic)
3: Who evaluates the grammar? (Cheat)
4: How is meaning represented externally? (Examples)
5: How is meaning represented internally? (Knowledge)
6: What is the function of the system? (Interaction)
7: What aspects of grammar are learnt? (Phoneme to Book)
8: What aspects of semantics are learnt? (Noun to Article)
9: What aspects of ontology are learnt? (Robot or Database)

These are the metrics I have used in relation to the systems below. A comprehensive tabulation on the basis of such a list of metrics does not yet exist - I could fill it in off the top of my head, but a more considered analysis would actually be in order. One day, ...

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8. SUBMISSIONS

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