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A REPORT ON THE TUTORIAL ON

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The Institute, a branch of the Fondazione dalle Molle, is carrying on research on artificial intelligence (AI); about ten scholars devote themselves to the study of communication between man and machine, under the direction of Manfred Wettler.

The tutorial was a week of lectures, seminars, and discussions conducted by the staff of the Institute, supplemented by evening discussions and presentations of their own results by participants. About 100 persons from Germany, Great Britain, Italy, Holland, Denmark, France, Belgium, Switzerland, Norway, Israel, Canada, and Japan attended. They were teachers, students, or researchers with various fields of interest and background: linguistics, psychology, philosophy, automatic translation, computer science, social sciences, engineering, etc. The courses offered embraced a wide range of topics related to semantics. Some of them were introductory courses, others were survey courses including the lecturers' own scientific results and discussions of these in relation to recent research. This variety of fields taught at different levels was well suited to the audience.

Below we will account for the lectures chronologically, describing at greater length those which were most relevant to us

PARSING ENGLISH - *Yorick Wilks*

A survey and comparison of some of the better known AI systems, this course began with certain fundamental concepts and general characteristics of relevance for all the systems in question. A principal issue is parsing. Wilks defined it as "procedural ascription of structures to sentences, where the structures are not syntactic at all, but semantic." Parsing may be done in two different ways: TOP-DOWN or BOTTOM-UP. Bottom up is the more straightforward way. The words of the sentence are listed and each word is replaced by its category Then pairs of category symbols (for instance Verb + NP) are rewritten by reversing the grammar's rewrite rules (Verb + NP --> VP) until the final sentence symbol S is reached. The lines of the derivation can then be considered as the parsing.

Top-down parsing is the reverse procedure starting with the generations and continuing from left to right until the last word is reached. Another important pair of technical terms is BREADTH-FIRST and DEPTH-FIRST. Breadth-first is the parallel treatment of all possible alternative structures at a given time, none of which is given precedence. In depth-first parses, the alternative structures are treated sequentially. So far the description may apply to any kind of parsing, but it was Wilks's aim to demonstrate parsing procedures where the structures are not syntactic but semantic. He described his own view of semantics as a version of the "meaning is procedures" attitude, i e. the procedures of its application give a parsed structure its significance.

After mentioning what he called the "problem of natural language", by which he meant the problem of systematic ambiguity, Wilks gave a brief historical sketch of the first approaches to machine translation, the failure of which he put down to the ambiguity problem.

Terry Winograd has proposed a distinction between "first" and "second" generation AI language systems. This distinction that seems now to be widely accepted also lies behind the survey below, where the systems of Winograd and Woods are considered first-generation and those of Simmons, Schank, Charniak, and Wilks belong to the second generation. Winograd's well-known dialogue system SHRDLU operates in a closed world of colored blocks and pyramids. The grammar of SHRDLU is not the conventional list of rules but small subprograms that actually represent procedures for imposing the desired grammatical structure. In terms of the notions set out earlier, Winograd's parsing is top-down and depth-first. After the syntactic parsing a number of "semantic specialists" attach semantic structures to specific syntactic structures. These semantic structures can then be used by the deductive component of the system. Woods's system, too, is considered first-generation, but both Woods and Winograd have argued that their systems are essentially equivalent, which is the reason why Wilks described only one of them in detail

What the second-generation systems have in common is the assumption that understanding systems must be able to manipulate very complex linguistic objects, or semantic structures, and that no simplistic approach to understanding language with computers will work. A common feature in connection with second-generation systems is what Minsky (1974) calls a FRAME. It is described as a data-structure representing a stereotyped situation and attempting to specify in advance what is going to be said, and how the world encountered is going to be structured.

Colby s system, too, is a dialogue system, by which an interview between a doctor and a paranoid patient called PARRY is carried out. The input text is segmented by a heuristic that breaks it at any occurrence of key words. Patterns are then matched with each word string segment. Stored in the same format as the patterns are rules expressing the consequences for the patient of detecting aggression and overfriendliness in the interviewer's questions and remarks. The matched patterns are then tied directly, or via these inference rules, to the response patterns which are generated. A very interesting aspect of the PARRY system is the fact that the answers of the system cannot be distinguished from those of a human patient This fact suggests that many people on many occasions seem to understand the information they receive in the same way that PARRY does.

Schank's is a rich system of semantic representation. It consists of the following three components:

1. an ANALYZER of English, due to Riesbeck
2. a SEMANTIC MEMORY component, due to Rieger
3. a GENERATOR OF ENGLISH, due to Goldman

The aim of Schank's system is to provide a representation of meaning in terms of which different kinds of analysis and machine translation can be carried out; a representation, moreover, that is independent of any particular language, and of syntax, and, indeed, of all traces of surface structure

After a detailed description of Schank's so-called CONCEPTUALIZATIONS, built up by conceptual categories, primitive acts, cases, etc., Wilks gave his own comments on Schank's system.

Like that of Schank, Wilks's system has a uniform representation, in the shape of structures and primitives, for the content of natural language. It is uniform in that the information that might conventionally be considered syntactic, semantic or factual is all represented within a single structure of complex entities (called FORMULAS and PARAPLATES), all of which are in turn constructed from 80 primitive semantic entities. The formulas are tree structures of semantic primitives, stored in the dictionary of the system. The main element in any formula is its "head", i.e. the fundamental category to which the formula belongs. Sentences and their parts are represented by the socalled TEMPLATE STRUCTURES, built up as networks of formulas. Templates always consist of an agent node, an action node, and an object node, and other nodes that may be governed by these. A formula for, say, the noun "drink" can be thought of as an entity at a template action node, selecting a liquid object, that is to say a formula with FLOW STUFF as its head, to be put at the object node of the template (sentence structure). This seeking is preferential in that formulas not satisfying a given requirement will be accepted, but only if nothing satsifying it can be found. The template ultimately established for a fragment of text is the one in which the most formulas have their preferences satisfied. This preference principle is of essential importance in connection with solving the many ambiguity problems in natural language texts. When the local inferences have been done that set up the agent-action-object templates for fragments of input text, the system attempts to tie these templates together so as to provide an overall initial structure for the input called a CASE TIE.

Case ties are made with the aid of another class of ordered structures called PARAPLATES, each of which is a string of functions that seek inside templates for information. The last step in the parsing is the inference procedure in which commonsense inference rules attempt by a simple strategy to construct the shortest possible chain of rule-linked template forms, on the principle of preference.

The other main section of this course was a comparison of the parsing systems described, including Charniak's system. This comparison was based on the following principal aspects:

LEVEL OF REPRESENTATION. At this point there are two opposite views: that language can be realized or represented at different levels depending on the subject matter, or that the appropriate level of computation for inferences about natural language has to be to some degree reduced. The different level attitude is supported mainly by Colby and Charniak, while Schank and Wilks hold that a certain primitivization is necessary

CENTRALITY OF INFORMATION. This aspect concerns the degree of specificity of the information required. Some systems, like Charniak's, are based on information highly specific to particular situations, while the sorts of information central to Schank's and Wilks's systems are of a much more general nature, consisting mainly of partial assertions about human wants, expectations, and so on. This problem of centrality is of great theoretical importance, which Wilks illustrated by an example: A person might know nothing of a particular type of situation, for instance a birthday party, but could not for this reason be accused of not understanding the language. Yet, if he did not have available some very general inference such as for instance people getting sleepy at night, then it is possible that his failure to understand quite simple sentences would cause observers to think that he did not know the language. Wilks went on:

> An interesting and difficult question that then arises is whether those who concentrate on central and less central areas of discourse could, in principle, weld their bodies of inference together in such a way as to create a wider system; whether, to put the matter another way, natural language is a whole that can be built up from parts.

PHENOMENOLOGICAL LEVEL. This is a question of degree of explicitness. Here Schank s system is distinctive. Wilks's opinion is that the amount of detailed inference that a system may perform must be limited not to go beyond 'common sense'. As an example he mentioned Schank's analysis of the action of eating (performed by moving the hands to the mouth) and described it as "going too far from the 'meaning' of eating, whatever that may be, towards generally true information about the act which, if always inferred about all acts of eating, will carry the system unmanageably far. ... There clearly is a danger of taking inferences to a phenomenological level beyond that of common sense," he concluded.

DECOUPLING. The issue is whether the actual parsing of text into an understanding system is essential. Charniak and Minsky believe that this initial parsing can be decoupled. In Wilks's opinion this is not so, because he believes semantic analysis to be fundamental and because many of the later inferences would actually have to be done already, in order to have achieved the initial parsing. Also the problem of systematic ambiguity may be met much more efficiently with a system that does not decouple the parsing from the inference procedure.

AVAILABILITY OF SURFACE STRUCTURE. In first and second generation systems it is generally accepted that word-sense is closely associated with the surface structure of the sentence, but Schank has made a point of the nonavailability of the surface structure, on the grounds that an ideal representation should be totally independent of the input surface structure and words. In connection with this claim of Schank's, Wilks pointed out two things: in many cases the order of the sentences in a text is part of its surface structure, and this information should be available in some way. The other point concerned the form of representation employed Wilks was not sure that a structure of primitives is sufficient for specifying and distinguishing word senses adequately without transferring information specifically associated with the input word.

APPLICATION. This concerned the way in which different systems display, in the structures they manipulate, the actual procedures of application of those structures to input text or dialogue Here the most distinctive system is that of Winograd where the procedural notation, by its nature, tends to make clear the way in which the structures are applied. In his view, as stated in some of his more recent writings, the control structure of an understanding program is itself of theoretical significance, for only with a control structure, he believes, can natural language programs of great size and complexity remain perspicuous.

FORWARD INFERENCE. Is it necessary to make massive forward inferences as one goes through a text, as Charniak and Schank do, or can one adopt some laziness hypothesis' about understanding and generate deeper inferences only when the system is unable to solve, say, a referential problem by more superficial methods? Charniak's argument is that, unless forward inferences are made during the analysis, the system will not in general be able to solve ambiguity or reference problems that arise later. Wilks had some theoretical difficulties in arguing against this view, and he admitted the difficulty of defining a degree of forward inference that aids the solution of later semantic problems without going into unnecessary depth

THE JUSTIFICATION OF SYSTEMS. Finally Wilks tried to contrast the different modes of justification implicitly appealed to in terms of the power of the inferential system employed, of the provision and formalization, of a system's actual performance, and of the linguistic or psychological plausibility of the proffered system of representation.

In his conclusion Wilks concentrated on those areas where the greatest problems within the field of AI are found. The following needs seem to be the most pressing ones the need for a good memory model (stressed by Schank), the need for an extended procedural theory of texts and for a more sophisticated theory of reasons, causes, and motives for use in a theory of understanding. Wilks ended his survey by stressing the fact that there is an AI paradigm of language understanding which embraces first and second generation approaches and goes back to a considerable amount of earlier work in computational linguistics

INFERENCE AND KNOWLEDGE - *Eugene Charniak*

Why do we make inferences? We do when we use language and when we decode the information conveyed by language, i.e. in the case of structural disambiguation as well as in word-sense disambiguation, reference determination, question answering, translation, summarizing, etc., everywhere a thing not stated explicitly has to be assumed. In so doing we are looking for a piece of information, for knowledge beyond the given text or situation Charniak poses five questions about how knowledge is used to make inferences:

1 *What concepts, and in what combinations, do we need to record our impressions of the world?* (semantic representation)

2. *Under what circumstances and why do we make inferences?* (inference triggering)

3. *How do we locate the needed information?* (organization)
4. *Once located, how do we know how to use the information?* (inference mechanism)
5. *What is the knowledge that we have of the world that enables us to understand language?* (content)

After this program had been put forth, Charniak presented two partial answers to the questions the first order predicate calculus (FOPC) and the programming language PLANNER.

FOPC consists of a language for expressing facts and rules for deriving new facts from old. The language consists of constants, variables, predicates, functions, logical connectives, and quantifiers. There are rules for inference. Charniak then outlined RESOLUTION THEOREM PROVING. It is a system for setting up proofs for deciding which rule of inference to use. Charniak proceeded to look at the five questions he had set forth and examined what answers FOPC provides to them. He concluded that FOPC is primarily a theory of inference mechanism, but that it says very little about semantic representation. As FOPC does not tell how one is to locate the facts which are to be used to prove the derived result, theoretically we come up against a huge amount of possibilities when we combine the number of possible clauses with the number of possible resolutions. This is called the "combinatorial explosion" and is a serious problem in most inference systems, not only for FOPC.

Charniak then examined the problem of when we make inferences. There are two obvious occasions when we may make one:

1. When a question is asked which requires an inference to be made (question time)

2. When the system has been given enough input information to make the inference (read time)

Although the inference making restricted to question time would seem to be more economical since inference is done only when we must, in order to answer the system user's question, there is some evidence that inference is done at reading time (e.g. psychological experiments on recall of texts). Furthermore, it is not possible to do word sense or structural disambiguation without making inferences. Wilks makes a distinction between "problem occasioned" and "nonproblem occasioned" inference. A typical example of the latter is given in "Janet shook her piggy-bank. There was no sound." We assume that there is nothing in the piggy-bank although the problem has not yet arisen in the story. Charniak believes that to do question answering on complex stories the system must perform nonproblem occasioned inference. He gives examples from children's stories where persons lie about things and where the system has to guess why the person is lying

An alternative to FOPC is to use the natural properties of some programming language to make inferences. Bertram Raphael (1968) did this in the system SIR when he used LISP to construct a data base. Another way is making the programming languages more suited to the needs of inference making. Such a system has been designed but not implemented: PLANNER

(Hewitt 1969) In this system we are able to pick up an assertion by knowing parts of it If no appropriate assertion can be made, we can try to have theorems (i.e. programs) investigated An antecedent theorem is one where we are given the antecedent and we assert the consequent, while with a consequent theorem we are asked to prove the consequent and we try to find the antecedent. PLANNER has the ability to choose which theorems to use on the basis of their patterns. This is called PATTERN DIRECTED INVOCATION. Furthermore, the system can back up to see if any earlier choices might be changed. This feature is somewhat controversial, since it might encourage the construction of programs which depend on blind search. PLANNER's advantage over FOPC is that it offers several built-in organizational features, the primary one being pattern directed invocation. A disadvantage about it as theory of knowledge and inference is that it is too vague Charniak (1972) illustrates the pros and cons of PLANNER using children's stories. Given a piece of simple narration, the system should be able to answer reasonable questions about it. Charniak stresses the need for looking ahead in the story to make inferences For this he uses an antecedent theorem or a "demon". The routines which are available to set up demons he calls BASE ROUTINES. In addition he makes use of BOOKKEEPING for updating the assertions and of consequent theorems called FACTFINDERS: the basic idea behind factfinders is that they are used to establish facts which are not too important so that we do not want to assert them and store them in the data base. The main advantage of this system is that it provides a good theory of organization. It states in particular that "given a particular assertion, the way we find those facts which we should use to make inferences from the assertion is to look in two places, first the base routine for assertions of that form, and second for any demons which happen to have been activated which are looking for assertions of that form". Charniak concluded his lectures by examining the recent works of three scholars:

1. McDermott's system TOPLE (1974) is mainly concerned with the problem of beliefs, describing a simple world consisting of a monkey and an experimenter in a single room. The program listens to a present-tense account of what is happening in the room; it tries to understand why things happen and what can be expected to happen as the story goes on. It tells us at the end of every sentence what new assertions it has assumed as a result of hearing. TOPLE's restrictions are the following: it does not answer questions, it does not handle actual natural language but rather a formal-looking input language. On the other hand, it tries to visualize concretely a situation. It is based on a "multiple world structure"

2. Rieger (1974) is the first to have attempted to use Schank's conceptual dependency theory within a theory of inference and knowledge. Rieger's program has as its main purpose to make reasonable inferences from the input it is given. The

input is expressed in a suitable formalism, i.e. conceptual dependency representation. It is also designed to understand stories, engage in dialogues, figure out references and word-sense ambiguity, answer questions about the way the world normally is

3. Minsky's (1974) frames are reinterpreted by Charniak as "a collection of questions to be asked about a hypothetical situation. Frames specify issues to be raised and methods to be used in dealing with them."

Charniak also gave a double lecture on SYNTAX IN LINGUISTICS. This was an introduction to generative grammar for those who had not had a formal course in linguistics.

MEMORY MODELS - *Greg W. Scragg*

After introducing SEMANTIC NETS, Scragg discussed their most important properties and compared several systems including some with partial semantic nets, some with partially quantified semantic nets, some with fully quantified semantic nets, and some with executable semantic nets.

He compared semantic net representations and predicate calculus representations.

Attempts to construct proofs in the predicate calculus will show the difficulty of selecting the relevant information for making a particular deduction from a specific fact. The techniques currently employed in theorem proving programs are even less efficient at selecting the most relevant material.

In comparison of predicate calculus and semantic nets, most problems center around the question of quantification. How does one quantify relations in a semantic net? Scragg mentions three different approaches.

1. There are six possible quantifications for a two-place predicate Pxy

$\forall x \forall y Pxy$, $\exists x \forall y Pxy$, $\exists y \forall x Pxy$, $\forall x \exists y Pxy$, $\forall y \exists x Pxy$, $\exists x \exists y Pxy$

In Scragg (1973) the claim is made that the first three forms are so rare in everyday (nonscientific) situations that they may be ignored. The remaining ones may be distinguished with a type-token flag.

2. Palme (1973) tries to represent quantification by introducing a third quantifier, ITS (meaning something like the possessive pronoun "its"). With three quantifiers, he now can define six separate relations for each previous relation: Quantifying with FOR-ALL or EXISTS on the left and FOR-ALL, EXISTS, or ITS on the right of the old relation. One disadvantage of this is that he potentially has six times as many relations to work with and has to keep track of the relationships between each of the six versions of the same relation.

3. Schubert (1975) treats quantifiers in a different way. He first puts the predicate calculus representation of the statement into SKOLEM FORM (a form which has no existential quantifiers and with all universal quantifiers outside of the body of the expression). Any node that is existentially

quantified but dependent on a universally quantified node is connected to that governing node. An event is asserted if and only if there is no arrow pointing to that node in the diagram. The semantic net structures here tend to become very complex.

It is not clear that any of the three approaches give really practical (or intuitively satisfying) results.

What we need at present is a theory of more complex actions. For example, how do we link the descriptions of the various substeps of the process of cake making into a single description of the overall action of making a cake?

There are those who claim that all knowledge is stored in the form of procedures and there are those who claim that it is stored as a collection of facts.

Scragg (1974; see also Norman 1973 and Norman et al 1975) takes an intermediate approach by making use of ambiguous (data or procedure) representations to store information about actions. The system knows how to simulate various human actions such as toasting bread, making spaghetti or cleaning up the kitchen. The information about how to perform these simulations is stored as procedures. However, these procedures can be used as data by other parts of the system to answer such questions as "How do you make a ham and cheese sandwich?", "How many utensils do you use if you make a mushroom omelette?" or "Why did Don use a knife?"

SEMANTICS IN LINGUISTICS

SEMANTIC MARKERS AND SELECTIONAL RESTRICTIONS. Phillip Hayes discussed in detail the influential paper by Katz and Fodor (1963). He concluded that their semantic theory is not quite adequate even for the purely linguistic system they try to outline. Nevertheless, it can be a useful component of an AI theory of natural language comprehension.

GENERATIVE SEMANTICS. Margaret King outlined the defining characteristics of this theory and then concentrated on its relationship with AI. As a conclusion, she stated that the definition of grammar logically should be extended to embrace not only wellformedness and semantic acceptability but also all possible aspects of the context of use of a sentence. This is contradictory to the traditional view of grammar understood as the sole means of determining which sentences are grammatical for the majority of speakers of the standard form of the language.

CASE GRAMMAR. Wolfgang Samlowski surveyed Fillmore's theory with special reference to its influence on American linguistic theories of semantics and on leading researchers within AI. The survey consisted of a presentation of case grammar, an examination of some explicit and implicit traces left in AI by the case grammar theory, and a demonstration of some of the complications that the acceptance of the case grammar theory by language-understanding researchers would cause

DIVERSE

PHILOSOPHY OF LANGUAGE. Yorick Wilks, in a double lecture, compared and contrasted modern philosophy with relation to linguistics, in particular systems of formal logic, represented by the works of Ludwig Wittgenstein and Richard Montague. The survey had special reference to the application of such systems of formal logic to the preparation of language understanding systems.

PSYCHOLOGY OF LANGUAGE AND MEMORY.: Walter Bischof gave a selective historical survey of the prevailing concepts in the field: association, organization of data, Gestalt, meaningfulness of data, temporal structure of memory, reaction-time paradigm to investigate semantic memory and the network models of representation as proposed by Collins and Quillian (1969) Recent work based on the same assumption has shown that the structure of semantic memory is not quite the logical, hierarchical and economical structure proposed by Collins and Quillian. Bischof gave a list of possible relationships between artificial intelligence and cognitive psychology and concluded that these two disciplines have little to say to each other because of their different aims and because the available experimental tools proposed by psychology are too poor.

LISP. Margaret King taught an "O-level" course and Philip Hayes a more advanced introductory course, to this programming language, which is being used widely by AI researchers, in its original form or in some of its extensions (CONNIVER, PLANNER).

TUTORIAL GROUPS. Work consisted of discussions between participants in smaller groups and one or two of the lecturers Some evening lectures were given by the participants. These included H. Harrell, R. Güntermann, and G. Zifonun, who presented ISLIB (Information System on a Linguistic Base), a system for answering questions to an input in restricted German, carried out at the Institut für deutsche Sprache at Mannheim. A. McKinnon of McGill University, Montreal. discussed his work on the Kierkegaard indices. Some lectures caused vivid discussion. For example that of V. V. Raskin, Hebrew University, Jerusalem, advocated corpus dependent semantic models and recommended his own "restricted sublanguages"

APPRECIATION

Altogether, the tutorial in Lugano was very inspiring and profitable for the participants. It was well organized and gave good opportunity for discussions. The teachers in the tutorial being familiar with each other's work succeeded in giving a comprehensive view on the topic of computational semantics. Some of us, however, felt a need for more precise definitions of standard notions. this being a very acute problem in view of the heterogeneity of the participants' backgrounds. We are, however, aware that this is an inherent and recurring problem at such gatherings, where people with different qualifications meet to discuss common problems We would like to express the wish that the Fondazione dalle Molle will be able to arrange more tutorials of a similar kind in the future.

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