

**ACTIVE SCHEMATA
AND THEIR ROLE
IN SEMANTIC PARSING**

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Abstract

In the past years we have been applying semantic ATN-grammars - as introduced by Brown & Burton (1974) - to natural language question-answering tasks (e.g. a LISP-Tutor [Barth, 1977], a question-answering system about the micro-world of soccer [Rathke & Sonntag, 1979]). We found that semantic grammars execute efficiently, but become large very quickly even with moderate domains of discourse. We therefore looked for ways to support parsing by domain-dependent knowledge represented in an inheritance network [Laubsch, 1979]. In this paper we first briefly describe our representation language ObjTalk, and then illustrate how it is used for building an understanding system for processing German newspaper texts about the jobmarket situation.

keywords: newspaper processing, ATN, frames semantic grammar, object-oriented programming, ObjTalk

Concepts as active schemata

We have developed an object-oriented representation language - called ObjTalk - in which objects are frame-like data structures which have behavioral traits and communicate through message passing. The objects (classes and instances) are organized into a (multiple) inheritance hierarchy. ObjTalk is an extension to Lisp and was inspired by SMALLTALK [Goldberg&Kay, 1976], FRL [Roberts&Goldstein, 1977], and KLONE [Brachman, 1978].

An inheritance net of objects (with the root class **Object**) is constructed by sending the message NEW: to the class CLASS, i.e. a concept definition in ObjTalk has the form:

```
(ASK CLASS NEW: <concept-name>
  SUPERC (<concept-name!>...)
  GENERIC-PROPERTIES
    <slot-name>: <filler-description>
  ...
  METHODS
    <method-name>: [<filter> => <body>]
  ...
  TRIGGER-ATN
    <Trigger-keys> ; attached ATN
    [<subATN-node> <production>]
  ...)
```

The effect of sending NEW: to CLASS is to define a class with the given <concept-name> as a subclass of the named **superclass(es)**. Instances are made by sending the concept a message that causes to fill its slots with fillers which satisfy the filler description. If an object receives a message, this will be matched against the method-filters. In case of success the corresponding method's body will be evaluated. Concepts inherit methods and generic properties from their superclass(es) recursively upto the root node **Object** (which implements the system-defined messages). Objects may be further specified dynamically by adding slots or methods, or filling slots.

For schema-driven parsing, a semantic subATN should be activated whenever a particular **word** is found, or **concept** is expected. The basic mechanism is to attach **trigger-keys** to a schema that state which words

The knowledge-base

which words or concepts make a schema active. Once active it puts the named subATN-nodes in a preferred **activatable** state. The ATN-machine has been extended to prefer PUSH arcs from non-deterministic states if they are **activatable**. This is implemented by primitives for activating a subATN, deactivating an active one, and a test for activation.

The subATNs of the trigger-atn form (or those ones in filler descriptions) are made activatable if

- (1) a concept has been **partially** instantiated (an instance of this concept or one lower in the hierarchy was made, but not all obligatory roles are filled), or
- (2) one of the **concepts** mentioned in trigger-keys has been instantiated, or
- (3) one of the **words** mentioned in trigger keys was found by the scanner.

Arc actions of the ATN may send messages to concepts, and thus (partially) instantiate a concept.

Application to newspaper understanding

We are currently applying ObjTalk to understanding newspaper reports about the jobmarket situation. Reports of this kind are **highly stereotypical**: They describe the present jobmarket situation in terms of a few attributes and their respective changes. These indicators are interpreted and discussed within the framework of a simple model of jobmarket fluctuations by officials of the issuing organization. Sometimes the data are also commented upon by political speakers of different views.

Jobmarket reports are prototypical for related **"official statistical reports"** (e.g. developments of population, crime, stockmarket etc.). These articles are differing in structure and contents (data, values, changes, explanantions, interpretations) from the more "event"-oriented newspaper-texts of DeJongs FRUMP [1979] and Cullingfords SAM [1978].

We have built a knowledge-base of (ObjTalk-) concepts in order to process news articles of this type. The design was guided by the principle of providing an active schema for everything that would be considered a "thema" in the reports.

The most global frame is the one for **"job-market-situation"** (jms). It combines in its roles all what would "normally" be reported in our texts and should therefore be expected by the system: time, region, relevant aspects or indicators - i.e. jobless-rate, open-jobs, new employments ... - , explanations for the general situation, general predictions. (Think of a jms-frame as a "snapshot" of the jobmarket-developments; Schankian people may think of it as analogous to a script).

The **relevant aspects** are in a sense constituting the jms, technically spoken: are in a part-of relation to the jms-frame. Their frames themselves are combined from frames for the static and the dynamic part of the jobmarket-factor, i.e. an index- and an index-change-frame. Each concept for an individual jobmarket-aspect also involves encoded knowledge for a (specific) evaluation, explanation and prediction.

The common traits of the individual jm-indices are organized in the **jm-index-frame**, which itself inherits knowledge (slots,...) from a more general index-frame that combines the shared traits of all such indices (cf. above). This organization should later allow easy extension of the system.

Examples

Parsing the sentence

"DIE ZAHL DER ARBEITSLOSEN IN ENGLAND IST IM MAI UM 14000 AUF 1,509 MILLIONEN ZURUECKGEGANGEN"

("THE NUMBER OF UNEMPLOYED PERSONS IN ENGLAND HAS DECREASED IN MAY BY 14000 TO 1,509 MILLION") would cause the following instances to be created and included into the static and dynamic roles of the resp. jm-aspect:

```

jobless-index-1 = ( a jobless-index with
  region: (England)
  value: (1.509 million)
  time: (DATE 31 5 80)
  sex: (AND MALE FEMALE)
  jobtypes: (ALL JOBTYPES)
  changes: change-jobless-index-1
  ... )

```

```

change-jobless-index-1 = ( a change-of-index
  with
  ref.-index: jobless-index-1
  time-new: (DATE 31 5 80)
  time-old: (DATE 30 4 80)
  time-interval: (DATE-INT 5 80)
  value-new: (1.509 million)
  value-old: (1.523 million)
  change-abs: (-14000)
  change-qual: (DECREASE)
  evaluation: (POSITIVE)
  ... )

```

(The last inference is done by a method of class jobless-index which says that for this index DECREASE is evaluated positively; this rule does of course not hold for e.g. the open-jobs-index).

Schemata for argumentations

Statements about facts are often followed by explanations given by an official person. Such statements are recognized and dealt with by a schema called **"interpretation"** which is activatable e.g. by verbs like the German "erklaeren" ("declare").

```

The interpretation schema has as roles:
  fact: (OR (CLASS jm-indicator)
           (CLASS jm-situation))
  speaker: (CLASS official/person)
  object: (CLASS explanatory/statement)

```

The object of an interpretation is an explanatory statement, which has roles for a manifest fact and supporting reasons. The system has an elementary knowledge about (jm-specific) economic dependencies (e.g. decrease in the jobless rate in the time interval from March to May may be due to seasonal effects), and uses this to identify resp. utterances as reasons in an explanatory statement.

Guiding ATN control through schemata

The kernel of our grammar consists of **semantic ATNs** particular to role fillers of (ObjTalk-) concepts. In general, the parser tries to use the most specific subATN possible, and only falls back onto a syntactic subnet if no expectations are active.

The semantic subATNs may be rather idiosyncratic (like the one for NP/jobmarket/official/person to handle phrases like "DER PRAESIDENT DER BUNDESANSTALT FUER ARBEIT IN NUERNBERG, JOSEF STINGL ...") and are organized hierarchically. They may be used by diverse concepts with similar slots. The value returned via the POP arc of a subnet may be used directly as filler for the triggering slot. A more general interface between the ATN results and the slots of a schema is provided by the productions in the trigger-atn form. The production filters out those parts of an ATN result that fit as role-fillers of the concept.

Writing semantic ATNs is simplified by the chance to specify only one generic PUSH arc (e.g. NP) that processes a class, instead of the possibly large set of more specific PUSHes (e.g. NP/PERSON, NP/OFFICIAL/PERSON, NP/JOBMARKET/OFFICIAL/PERSON, ...).

If the parser is in the starting state of such a generic PUSH and a schema is active whose roles are to be filled by semantic subATNs, then those standing in subclass relation to the generic PUSH are preferred. E.g., if an unfilled slot expects a NP/OFFICIAL/PERSON, and the parser expects a NP, then, since NP/OFFICIAL/PERSON is a specialisation of NP, it is activated and - in case of success - the result is used to fill that slot.

In general, several schemata can be active at a time, in the sense that some of their slots are unfilled. (In other words: There may be several "thematic expectations" looking for further information in the article). Then all of the attached subATNs are activatable. It is possible that an expected subATN succeeds but the result fails to meet a filler-restriction (or even does not match the production). This is treated like a failure of the subATN itself.

An informal parse

The following example - slightly shortened from a real news note - is intended to give a flavor of how knowledge base and parser processes cooperate in analysing a jobmarket report:

>>DIE ZAHL DER ARBEITSLOSEN ..

(The number of unemployed ..)

This triggers the concept for a jobless-index and, since there is no one active yet, instantiates a jobmarket-situation as context for further processing. Within it, the jobless-index becomes the static part of the resp. jms-aspect-frame.

>> .. VERRINGERTE SICH .. (.. decreased ..)

An instance of change-of-index for jobless-index is created (because verbs like "decrease" are attached to index-changes) and identified as the expected dynamic part of the still active jms-aspect.

>> .. IM MAI UM 58000 AUF 766000.

(.. in may by 58000 to 766000.)

Various unfilled slots in the active jobless-index and change-of-index schemas are filled by successfully processed particular PP-nets attached to those slots (e.g. PP/TIME-INT for time-interval), some slots get their default values, which reflect newspaper conventions of "what is known without having been said" (e.g. the region slot gets "western germany").

>>DER PRAESIDENT DER BUNDESANSTALT FUER ARBEIT, JOSEPH STINGL, ERKLAERTE ...

(The president of the federal employment office, J.S., declared ...)

This leads to the instantiation of an interpretation frame (which itself will fill the explanation slot of the jms-aspect) with the named official filling the speaker slot, and makes thus a schema for an explanatory statement active. Slots to be filled here are a manifestation and reasons.

>> .. DIE ENTWICKLUNG AM ARBEITSMARKT ..

(.. the development on the jobmarket ..)

This refers to the previously built change of jobless-index (as - by default - central aspect of jms-developments and - in this context - only "development" talked about so far). It becomes filler for the manifestation slot.

>> .. LASSE KEINE KONJUNKTURELLEN AUFTRIEBS-
KRAEFTE MEHR ERKENNEN, ..

(.. does not show any signs of economic recovery, ..)

Since the manifest fact may be explained by economic recovery or other reasons, the intent of this statement is to exclude the former explanation. The exclusion of a reason activates a more general argumentation schema which now demands that a positive explanation must follow (at least in well written texts).

>> .. DER RUECKGANG DER ARBEITSLOSIGKEIT SEI NUR
AUF SAISONALE EINFLUESSE ZURUECKZUFUEHREN.

(.. the decrease in jobless rate is only caused by seasonal influences.)

The first part repeats the manifestation (and is optional), and the second part claims seasonal effects as reason for it. This explanation is confirmed by one of our inference rules (time-interval is May) about the relations between season and changes in jobmarket-indices. This finally allows to fill the reason slot of the explanatory statement.

REFERENCES

Barth, K. "Zur Implementierung eines Lehrsystems fuer LISP." Diplomarb. 62, IPI-UNI Stuttgart, 1977.

Brachman, R.J. "A Structural Paradigm for Representing Knowledge." BBN Rep. No. 3605, Cambridge, 1978.

Brown, J.S., Burton, R.R. & Bell, A.G. "SOPHIE - a Sophisticated Instructional Environment for teaching electronic trouble-shooting." BBN Rep. 2790, Cambridge, 1974.

Cullingford, R.E. "Script Application: Computer Understanding of Newspaper Stories" Res.Report #116, Yale, 1978.

DeJong, F.D. "Skimming Stories in Real Time: An Experiment in Integrated Understanding" Res.Report #158, Yale, 1979.

Goldberg, A. & Kay, A. (Eds.) "SMALLTALK-72 Instructional Manual." XEROX PARC, Palo Alto, 1976.

Laubsch, J.H. "Interfacing a semantic net with an augmented transition network." Proc. 6th Intern. Joint Conf. on Artificial Intelligence, Tokyo, 1979.

Rathke, Ch. & Sonntag, B. "Einsatz semantischer Grammatiken in Frage/Antwort-Systemen, Teil I +II." Diplomarb. 230 & 231, IPI-UNI Stuttgart, 1979.

Roberts, R.B. & Goldstein, I.P. "The FRL Manual." MIT-AI Memo 409, Cambridge, 1977.

Rosenberg, St.T. "Frame-based Text Processing" MIT-AI Memo 431, Cambridge, 1977.