The importance of temporal aspects and their extraction from a natural language text are discussed in this chapter.

6.1 SOURCES OF TEMPORAL INFORMATION

There are many sources by which temporal information is conveyed in a natural language text. The simplest way in which temporal progression is conveyed is the chronological ordering of events expressed using the same tense. This temporal progression may be interrupted by either a shift in the tense, (from simple past to past perfect) and by temporal connectives or time adverbials. Semantic categories of 'state', 'process' and converse relation also convey certain temporal information. These aspects can be obtained by analyzing the sentence (Figure 6.1).

6.2 TENSE, ASPECT AND REPRESENTATION

The tense and aspect are marked by the verb sequence. Individual verbs include modals such as will, can, could which have only one form and ordinary verbs which have five basic forms: infinitive (go, be, write), present (goes, is, writes), past (went, was, work), present participle (going, being, writing) and past
FIGURE 6.1 FLOWCHART FOR ANALYSIS OF TEMPORAL ASPECTS
participle *(gone, been, written). Certain verbs have the same form for both past and present participles. Some basic rules indicate the order in which verbs and auxiliaries can occur in the verb sequence. The pattern is of the form,

(Modal) (Have) (Be1) (Be2) Main verb

where parentheses indicate optional elements (Figure 6.2). Each element in the pattern determines the form of the one following it.

<table>
<thead>
<tr>
<th>Word in the sequence</th>
<th>Form of the element to follow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal</td>
<td>Infinitive</td>
</tr>
<tr>
<td>Have</td>
<td>Past participle</td>
</tr>
<tr>
<td>Be1</td>
<td>Present participle</td>
</tr>
<tr>
<td>Be2</td>
<td>Past participle</td>
</tr>
</tbody>
</table>

The first element indicates the tense or is of the modal form. The presence of the second type of BE element indicates that the sentence is passive. This is the heuristic that has been used to determine passive form by looking ahead for this form of verb sequence. These rules have been incorporated into the parser to check for the validity of the verb sequence.

The tense system in addition to indicating the time of the event described, may also indicate the time the utterance is spoken, and the reference time. Some sequences like be-going-to, can be treated as a single
FIGURE 6.2 STRUCTURE OF THE VERB SEQUENCE
entity indicating future tense. Modals indicate future tense if the word is will or shall. 'Have' indicates past tense and BE1 the present. Thus a single verb sequence may contain more than one aspect of tense.

Example, Was going to (Past future)

-> was(past) of form be-going-to(future).

might have to fix
modal modal

This type of tense information is represented by using '0' to indicate present 'm' to indicate modal '+ ' to indicate future and '-' to indicate past.

Thus the verb sequence

was going to have eaten
past future past

may be represented by the tense sequence '- + -'.

The length of the verb sequence is first determined and if the length is one, the tense is directly the tense of the verb which can be only a simple past or present. If the length of the verb sequence is two the initial word can only be modal indicating either a future tense or a modal or it can be a verb of type 'have' or 'be'. If it is of type 'have' then the tense is past, if it is of type 'be' then tense is present. Thus in this way the length of the verb sequence can be used to diverge into the different modules used to build a tense sequence (Figure 6.3).
FIGURE 6.3 FLOWCHART FOR OBTAINING TENSE AND ASPECT STRUCTURE
FIGURE 6.3 CONTINUED
6.3 TIME ADVERBIALS AND THEIR REPRESENTATION

In the earlier section a representation that represents the tense sequence of a single sentence has been discussed. The representation of the temporal relations of the events is now to be considered. Some of the desirable characteristics such a representation should have are:

* The representation should allow for a certain amount of imprecision. This is because much of the temporal knowledge is not absolute but relative.

* The representation should allow for uncertainty of information, while allowing certain constraints on how the different events are temporally related (Allen 1983).

There are many approaches to construct temporal representations. Formal models in artificial intelligence include the situation calculus model (McDermott 1982). Temporal information can also be represented using before/after chains and interval-based temporal logic with reasoning accomplished by algorithms (Allen 1984).

An action inherent in an event can take place at a particular time point or over a period of time. Those events that take place at a particular point of time are referred to as simple events while those events that take place over a period of time are referred to as spatial events. For example 'He was appointed on 1st May 1991' is a simple event and 'The party went on from 6'o clock in the evening to 3'o clock in the morning' is a spatial event. Both the examples indicate specific time aspects. Two or more events may be related by time adverbial. Adverbial expressions of time give the time of
an event in relation to a temporal reference point, which may be implicit (Sager 1987).

As every event has a certain time point or time interval associated with it, a careful tackling of the dates and the time adverbials, which form these time points and time intervals are required.

The basic way in which a natural language relates the states, processes, occurrences, actions etc., is by describing their relation to one another in time. Exceptions are sentences about abstract objects and generic sentences. Natural language divides time into two parts, past and future and the point of division i.e., the origin of the time dimension being the moment of utterance of the sentence. The past is represented to the left of the origin and the future to the right. The time scale is shown in Figure 6.4.

The tense sequence representation discussed in the previous section will designate the relative positions along this dimension. When two or more events are involved their temporal relation is expressed using time adverbials such as 'before', 'after', 'while', etc.. Given below is an example of a temporally related sentence.

I ate the cake before the man arrived. (1)

In sentence (1) 'my eating the cake' and 'the man's arrival' are both located to the left of the utterance point, but the former is located at a point some distance farther from the utterance point than the location of the latter.
FIGURE 6.4 TIME REPRESENTATION

FIGURE 6.5 PARSE TREE INDICATING THE EXPRESSION OF TIME ADVERBIALS AND THE CORRESPONDING LIST STRUCTURE
Considering another example,

I will eat the cake after you come (2)

In sentence (2) both events occur to the right of the utterance point but 'my eating the cake' may occur at a latter time than 'your arrival.'

The syntactic structure underlying the expression of temporal relation is a tightly knit one. Thus there is one grammatical relation for the verb sequence in the main verb phrase and another for the time adverbial and associated subordinate verb phrase. The syntactic parse tree and the corresponding list structure of the sentence are shown in Figure 6.5.

I ate the mango before the man arrived.

The system searches the sentence for time-adverbials and then extracts the individual events from the sentence. These events have the tense sequence attached to them and are then connected temporally depending on the semantic nature of the time adverbial. Thus E1 after E2 is represented as E1 > E2. The handling of spatial time adverbials like 'during' is slightly different in the sense that the time of occurrence of one event lies within the time interval indicating the time of the second event. Semantic properties and relations as described in chapter 5 can also be applied to these temporal representations to make semantic predictions.

Examples.
A semantically anomalous example,

I will eat the cake after the man arrived
indicates a semantically anomalous sentence since two events can be connected by time adverbial only if they are on the same side of the utterance point.

A semantically contradictory sentence is:

He worked for an hour during the last minute.

where the contradiction is due to the contradiction in the semantics of the words possessing temporal characteristics.

6.4 SEMANTIC NATURE OF TEMPORALLY INFLUENTIAL VERBS

The meaning of certain categories of verbs express temporal aspects. Some of such major semantic categories of verbs are 'state' and 'process'. Converse relations also exhibit temporal characteristics. State can be described as a condition of some entity at a given time or during a given time interval. Examples are sleep, live, suffer, etc. Process can be described as a change or transition from one state to another over a given time interval. Examples are grow, dry etc. One way of representing these concepts are by using simple semantic markers (state) and (process). However in order to bring out the temporal features of these concepts and to display the interrelations between them it is necessary to replace the above mentioned semantic markers by some structure built out of more primitive semantic markers structured in such a way as to indicate the concept underlying them. Given that the concept of state is that of the condition of something at a given time or during a given time interval the semantic marker 'state' can be represented as shown in Figure 6.6. The
(condition), ( ), ..., ( ) are semantic markers describing a condition. This part of the lexical reading would represent what is that about this particular state that differentiates it from other states. X1 and X2 are categorized variables where X1 is the description or reading of the entity where state is being described and X2 will be one of the readings indicating the temporal aspect.

The concept of process is used to describe a transition from one state to another through time. Thus the process of 'recovery' may be transition from state of 'sickness' to that of 'health'. The process semantic marker can be defined in terms of two state semantic markers as in Figure 6.7. The process should have an initial and a terminal state and may sometimes also have intermediate states. The states of a process can be said to occur in sequence.

Converse relations are expressed between semantically similar concepts which differ only by their temporal considerations.

Consider the examples

Ram bought the box from Sita for ten rupees (2)

Sita sold the box to Ram for ten rupees (3)

Both the above sentences should have the same derived meaning after application of projection rules. This aspect can be brought out only if we consider the converse relationship between 'buy' and 'sell'. Functional connections such as [np,s] here known as 'subject of' are used to exhibit both temporal and inflexional relations.
FIGURE 6.6 SEMANTIC MARKER FOR THE CONCEPT 'STATE'

FIGURE 6.7 SEMANTIC MARKER FOR THE CONCEPT 'PROCESS'

FIGURE 6.8 REPRESENTATION SHOWING TEMPORAL ASPECTS
The lexical reading of sell is

\(((\text{condition}) \ (\text{possesses} \ Y \ \text{of} \ X \ \text{at} \ T_i)\)

\(((\text{condition}) \ (\text{possesses} \ Y \ \text{of} \ Z \ \text{at} \ T_j)\))\text{and}

\(((\text{condition}) \ (\text{possesses} \ W \ \text{of} \ Z \ \text{at} \ T_i)\)

\(((\text{condition}) \ (\text{possesses} \ W \ \text{of} \ X \ \text{at} \ T_j))\).

Here considering sentence (3) Y stands for 'the box' X for 'Sita', Z for 'Ram' and W for 'ten rupees' as in Figure 6.8. Similarly lexical reading is used to describe 'buy' except that the place of X and Z are interchanged (Geetha 1988c).

The general concept of transfer of possession can be expressed by modifying the lexical reading described above. Transfer of possession has been dealt using a separate primitive act PTRANS in conceptual dependency (Schank 1980) and language generation (Jacobs 1987).

6.5 DIFFICULTIES IN TEMPORAL ASPECTS PROCESSING

One major problem is with defining relative relations between points of time and time intervals. Thus 'During the night it rained' does not mean that at every point of time in the night it rained. Another problem is to decide on the time scale the temporal events should be related. Thus in describing a major medical operation minute may be considered a suitable time unit but while talking about productions of a company, day may be a suitable time unit. Thus although it is possible to gather information about an overall relation between events, the handling of specific points and unit of time to be chosen is influenced by domain specific information (Moore 1981).
6.6 TEMPORAL ASPECTS AND DISCOURSE ANALYSIS

Tense is an important linguistic device used to convey knowledge about time. In the case of story understanding the tense system provides information as to where connections are to be checked – before, after or near the new point. The connection underlying the use of tense differ according to the type of situation. In narrative modes of simple stories the simple past tense is used and the chronological ordering of events is the same as the sequence in which the events occurred. In a conversation the simple past may not indicate temporal ordering at all but may simply refer to past events.

Another important information conveyed by tense is the fact that a shift in tense could indicate a reference to another event and then the text may refer back to the originally described event or may continue to describe the new event.

Thus, tense and temporal information are important agents used to convey information about actions being described either in a narrative or in a discourse setup.

Temporal information processing is relevant in the case of any narrative in domains like legal or medical where the sequence of events determines the final outcome of the analysis of a problem or case.