The Chinese Aspect Generation Based on Aspect Selection Functions

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Abstract

This paper describes our system for generating Chinese aspect expressions. In the system, the semantics of different aspects is characterized by specific temporal and conceptual features. The semantic applicability conditions of each individual aspect are theoretically represented by an aspect selection function (ASF). The generation is realized by evaluating implemented inquiries which formally define the ASFs, traversing the grammatical network, and making aspect selections.

1 Introduction

Aspect is one of the most controversial topics among linguists and philosophers. Unlike the function of tense, which relates the time of situation to a deictic center, aspects are different ways of viewing the states of a situation with respect to the situation's internal temporal constituency (Yang, 2007). This paper describes our system for generating Chinese aspect expressions. The aspect forms covered in the present research were derived from a corpus analysis. The main task of the aspect research from a computational perspective is to implement computationally both the semantic interpretations and the grammatical realizations of aspects as formulated in theoretical work. The theoretical principle of this is, to a large extent, based on Montague's intensional logic (Montague, 1970; Dowty, 1979; Bestougeff and Ligozat, 1992, Portner and Partee, 2002). It is held that the goal of semantics is to present the truth conditions for each well formed sentence.

In previous studies there are some fruitful experiments on computationally processing temporal information in Chinese, e.g. Lee and Hsu's Chinese to English machine translation system (1990), Li, Wong, and Yuan's temporal information-extraction system (2001), Xue's machine learning system (2008), and Xue, Zhong & Chen's tense annotation system (2008). However, a systematic investigation, including the implementation of the semantics of aspects, has rarely been carried out before and is one of the main contributions of the present research.

Aspects are determined by both situation types, which build specific situation structures, and particular viewpoints that construct specific temporal relations between the *viewing points* and the internal temporal constituencies of situations. These two kinds of factors, which influence aspect selections, can be characterized by aspectual features. This makes it possible for us to use a function which takes relevant time points and concepts as its parameters and "calculates" the truth value of the semantic applicability conditions of a specific aspect in order to make a corresponding aspect selection in language generation. We term this function the Aspect Selection Function (ASF). The ASFs are used for the theoretical descriptions of the aspects and, at the same time, they are the basis for our computational implementation of the semantics of the aspects.

Our system has been implemented as a grammar for the KPML multilingual generator (Bateman, 1997a, 1997b) which is equipped with a large systemic grammar and all the technical components required in generation, including an input component, a traversal component, a realization component, and so on. This brings direct benefits for us in both theoretical and implementational respects since we could then focus on the linguistic treatment of the Chinese aspects.

The paper is organized into five sections. In the next three sections the semantic features of the aspects, the aspect selection functions, and the detailed description of the generation of the

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aspects will be given. Finally in Section 5, we make a brief conclusion.

2 The semantic features of the aspects

One of the methods adopted in aspect studies is to use semantic features to characterize different situations (cf. Comrie, 1976; Smith, 1991, 1997; Olsen, 1997; and Dai, 1997). This is also taken as the basic principle in the present research. For the purpose of characterizing the semantics of an aspect, the features needed are not only those reflecting the properties of situation types, but also those reflecting the temporal relations between the viewing points and the internal temporal constituencies of the situations. When we establish a system of aspects, we say that the features used are necessary and sufficient if different aspects included can be distinguished from each other by means of these features. Consequently, the more aspect expressions are involved, the more aspectual features are needed.

Two kinds of aspectual features are proposed in the present research. One kind of aspectual feature can be directly represented in terms of relations holding over time points. These are termed features of temporal relations (FTR). For example, the feature *durative*, which is used for situations extended in time, can be represented with the temporal relation $t_1<t_2$ where t_1 and t_2 denote two time points bounding the situation. Similarly, the feature *punctual* (*momentary*), which is used for situations theoretically taking a moment, can be formally represented by the temporal relation $t_1=t_2$.

There is then a further kind of aspectual feature which cannot be directly represented by temporal relations, although they may also concern temporal properties of situations. This kind of feature can only be represented by parameters which serve to provide a conceptual classification of the situations involved; therefore, they are termed features of conceptual type (FCP), such as *dynamic* and *repeatable*.

In addition, there is a special kind of aspectual feature which reflects qualitative properties of temporal relations: *far-precede* and *shortly-precede*. These two features indicate qualitative distances between time points; the former means that one time point is linearly much before another time point on the time axis; the latter means that one time point is only a little before another time point. In specific context, these kinds of qualitative properties are reflected relatively in comparative or inclusive relations between temporal and spatial scopes of situations.

Aspectual features are the basic elements to be used for aspect descriptions. The range of aspectual features is not held to be cross-linguistically valid. In the present research, the following aspectual features are used to describe Chinese aspects. The states of relational type formed by the verbs like 是 (shì, be), 有(yǒu, have), 等于(děngyú, equal) etc. are associated with relational processes (Halliday, 1985) and therefore not included in the features listed. In the following feature definitions, t_i refers to the initial time of a situation, t_t the terminating time of a situation, and t_r the reference time of an aspect. In the present research, we define the reference time as the time from which the state of a situation with respect to the situation's internal temporal constituency is contextually examined.

(1) durative (FTR): describes situations which take time. It is represented by the temporal relation $t_i<t_t$.
(2) punctual (FTR): describes situations which theoretically take only a moment of time. It is formally represented by the temporal relation $t_i=t_t$.
(3) realized (FTR): describes situations which have occurred, have existed, or have shown the property of reality by some specific time. It is represented by the temporal relation $t_t \leq t_r$.
(4) dynamic-state (FCP): describes a durative changing situation.
(5) stative-state (FCP): describes a durative unchanging situation associated with the activity meaning of an activity verb.
(6) change-of-state (FCP): indicates either the inception or termination of a situation.
(7) event (FCP): describes a dynamic situation viewed as a complete whole (Comrie, 1976, p.13) and is aspectually associated with the occurrence, taking place, or completion of the situation.
(8) repeatable (FCP): describes situations which can occur repeatedly.
(9) specific (FCP): when a time point is specific, it has a particular position on the time axis which can be determined from context.
(10) unspecific (FCP): when a time point is unspecific, its position on the time axis is unknown.

(11) far-precede (FCP): indicates a qualitative distance, one end point of which is linearly much before another end point.
(12) shortly-precede (FCP): indicates a qualitative distance, one end point of which is linearly a little before another end point.
(13) excluded (FCP): when one of the end points of a time interval has the feature *excluded*, the time interval is *open* at that point.
(14) included (FCP): when one of the end points of a time interval has the feature *included*, the time interval is *closed* at that point.

Concerning the opening and closure of a time interval at its end points, two principles are proposed by the present research. The opening and closure of a time interval at its end points can be determined according to the following principles, which we term exclusiveness principles (ELPs):

> ELP (1) For the initial time t_i: when the initial time t_i of the situation is specific, then the time interval at the initial time t_i is considered closed; when the initial time t_i of the situation is unspecific, then the time interval at the initial time t_i is considered open.
> ELP (2) For the terminating time t_t: when the situation does not hold at the terminating time t_t, the time interval is considered closed at the terminating time; when the situation still holds at the terminating time t_t, the time interval is considered open at the terminating time. As far as the temporal structures of aspects are concerned, there is an extreme case: when the terminating time t_t precedes the reference time t_r, in which case the time period of the situation is definitely closed at the terminating time t_t.

The semantic feature *telicity* indicating that the situation referred to has an internal end point (cf. Vendler, 1967; Comrie, 1976) is not used in the present research for the Chinese aspect descriptions. The feature *telicity* is not an effective feature for characterizing Chinese aspects from a language generation point of view because there is no single aspect of the present aspect system that absolutely requires that the situations expressed be *telic* or *atelic*.

3 The aspect selection functions

Specific features of temporal relations and the conceptual features together build semantic applicability conditions for each individual aspect. The semantic applicability conditions are represented by the aspect selection function (ASF) of the aspect. The ASF of a specific aspect assumed by the present research is, therefore, principally composed of two sets of predicates: one set of predicates for testing temporal relations (Allen, 1984; Yang & Bateman, 2002), another for testing the values, i.e. conceptual features, of parameters associated with the aspect. All the predicates are connected with conjunctions at the top level. At the lower levels, the logical relations among the predicates can be a conjunction *and*, a disjunction *or* and a negation *not*. To evaluate the truth condition of the ASF for a specific aspect, the values of all relevant temporal relations and parameters are evaluated. When all the predicates are true, i.e., all of the required conditions are met, the value of the ASF is true; otherwise, the value of the ASF is false.

In the predicates of the ASFs, there are two kinds of parameters: temporal parameters associated with the time points involved in the temporal structures of the aspects and conceptual parameters associated with the specific conceptual features of the aspects. The conceptual features will be taken as values of the corresponding parameters and represented by EQUAL(p, c), in which 'p' refers to a parameter and 'c' refers to the conceptual feature associated with that parameter. Some of the parameters are given as follows:

(1) STATE-ACTION-PROPERTY$_p$ (SAP$_p$): this parameter indicates whether the property of the situation is *dynamic-state*, *stative-state*, *state*, or *event*. The subscript *p* denotes Process.
(2) CHANGEABILITY$_p$ (CB$_p$): this parameter indicates whether the situation has the feature *change-of-state*.
(3) REPEATABILITY$_p$: this parameter indicates whether the situation is *repeatable*.
(4) RETRIEVAL$_t$ (RT$_t$): this parameter indicates whether the time point *t* is *specific* or *unspecific*.

(5) $POSITION_{t1\text{-}t2}$: this parameter indicates whether the time point t_1, which precedes another time point t_2, is much before (*far-precede*) or a little before (*shortly-precede*) time point t_2.
(6) $EXCLUSIVENESS_t$ (EXLt): this parameter indicates whether the time point *t*, which is one of the end points of a time interval, has the feature *excluded* or *included*.

We now take the unmarked-realized (URE) aspect V+了 (V+le) as an example to illustrate the structure of the ASF. The URE aspect V+了 (V+le) is one of the perfective aspects, serving to indicate that the occurrence, development, or change of the situation is realized (not necessarily complete) by some specific time. The temporal structure of the aspect is shown in Figure 1.

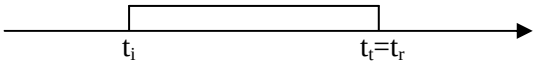

Figure 1 The temporal structure of the URE aspect V+了(V+le):
{t_i, t_t}, (t_i<t_t or t_i=t_t), t_t=t_r, RT_{tr}=specific

The temporal structure in Figure 1 is explained as follows: The situations expressed in the URE aspect can be either punctual, i.e. t_i=t_t, or durative, i.e. t_i<t_t. The time interval of the situation defined by "{t_i, t_t}" is either closed or open at its ends. The feature *realized* is represented by specifying that the terminating time equals the reference time, i.e. t_t=t_r, rather than that the terminating time either equals or precedes the reference time, i.e. $t_t \leq t_r$ — the latter is the general condition for all perfective aspects. In Figure 1, the case of a punctual situation, i.e. t_i=t_t, is theoretically taken as a very short time period and not explicitly represented. RT_{tr} indicates that the reference time t_r is a *specific* time point.

In addition to the temporal relations explained above, the URE aspect V+了 (V+le) has prominently three characteristics associated with the situation properties. When the URE aspect V+了(V+le) expresses a durative situation, the situation can be either a state or an event. When the process is of relational type, a change of state should be emphasized. When a change of state is involved in the situation, the URE aspect V+了 (V+le) focuses on the realization of the event, rather than the resultative state, unless current relevance is indicated in context. These three characteristics can be respectively represented by corresponding conceptual features associated with the parameters SAP_p, CB_p, and PROCESS involved in the predicates of the ASF of the URE aspect as shown in Figure 2. The ASFs are used for the purpose of theoretical descriptions, but also, as we shall see in the next section, give the basis for the implementation of the semantics of the aspects.

$F_{ure}(t_i, t_t, t_r, RT_{tr}, CB_p, SAP_p, PROCESS, EXL_{ti}, EXL_{tt}) \rightarrow$
(AND(OR(SAME(t_i, t_t))
(PRECEDE(t_i, t_t)))
(SAME(t_t, t_r))
(EQUAL(RT_{tr}, specific))
(OR(EQUAL(EXL_{ti}, included))
(EQUAL(EXL_{ti}, excluded)))
(OR(EQUAL(EXL_{tt}, included))
(EQUAL(EXL_{tt}, excluded)))
(AND(PRECEDE(t_i, t_t))
(OR(EQUAL(SAP_p, state))
(EQUAL(SAP_p, event))))
(OR(NOT(EQUAL(PROCESS, relational-process)))
(AND(EQUAL(PROCESS, relational-process))
(EQUAL(CB_p, change-of-state))))
(OR(EQUAL(CB_p, not-change-of-state))
(AND(EQUAL(CB_p, change-of-state))
(EQUAL(SAP_p, event)))))

Figure 2 The ASF of the URE aspect V+了(V+le)

4 The generation of the aspect expressions

4.1 Inquiries, choosers, and the input specifications

The present research uses the multilingual generator KPML as its implementation platform and takes Systemic Functional Grammar (SFG) as its theoretical basis. Fourteen primary simple aspects, and twenty-six complex aspects are organized into a hierarchical system network. In a system network, grammatical units are constructed by corresponding traversals of that network. Each path through the network from the root to an end node corresponds to a specific language expression. If we need to produce a specific expression, semantically appropriate choices need to be made so as to follow a path

leading to the creation of that expression. The system is guided by the joint actions of the inquiries and choosers of the system (Fawcett, 1987; Matthiessen and Bateman, 1991; Bateman, 2000; Yang & Bateman, 2002). "A chooser is straightforwardly represented as a 'decision tree' with a particular kind of inquiry, called a *branching inquiry*, forming the decision points" (Bateman 1997c, p.20). Inquiries are responsible for finding the answers required by choosers by accessing semantic information represented in input specifications, written in the form of the Sentence Plan Language (SPL) (Kasper, 1989; Bateman, 1997a), and in the knowledge base of the system.

The semantics of an aspect associated with a sentence to be generated is represented in the input specification. The time points involved in the temporal structure of the aspect to be generated, i.e. the initial time, the terminating time, and the reference time(s), are presented with specific time values in the input specification. The speaking time has a default value corresponding to the present moment. All the parameters characterizing the conceptual features of the aspect to be generated are also included in the input specification.

The implemented inquiries, written in LISP, play a crucial role in the generation of the aspect expressions. The implemented inquiries associated with different types of aspects formally define the semantic applicability conditions represented by the ASFs of the aspects. Each implemented inquiry has a set of parameters with specific values to represent temporal relations and conceptual features of a specific aspect. The inquiry is composed of a set of predicates which will have the value T when the conditions defined are satisfied. The truth condition of an inquiry will be met only when all the predicates involved have the value T. Hence, evaluating an implemented inquiry refers to the process of testing the truth conditions of all the predicates involved in the inquiry according to the semantic information represented in the corresponding input specification.

In the implemented inquiries, two basic predicates PRECEDE(t_1, t_2) and SAME(t_1, t_2) are used to test temporal relations involved in the semantic applicability conditions of different aspects. In the generation, the parameters t_1 and t_2, are replaced with the values of the initial time t_i, the terminating time t_t, or the reference time t_r, which are given in the input specifications. Logically, given a specific context, the precedence of two points can be determined in terms of concepts PAST, PRESENT, and FUTURE with reference to a relative deictic center. To evaluate the precedence between two time points, nine different time values are defined on the time axis as shown in Figure 3. In Figure 3, the values *at-past-present*, *at-present*, and *at-future-present* correspond to three time points. The other six values correspond to specific intervals on the time axis. The time points within each interval are given a specific time value, as shown below, where "-∞" stands for the infinite past, and "+∞" stands for the infinite future:

(-∞, at-present) = at-past;
(at-present, +∞) = at-future;
(-∞, at-past-present) = at-past-past;
(at-past-present, at-present) = at-past-future;
(at-present, at-future-present) = at-future-past;
(at-future-present, +∞) = at-future-future.

The nine qualitative time values defined above build a calculating system for time comparison in the present research. To generate a specific aspect, i.e., from semantics to the surface expression of the aspect, what we need to do is to distribute each time point involved in the temporal structure of the aspect with one of the qualitative time values and to establish appropriate temporal relations between them as to be illustrated in the next section.

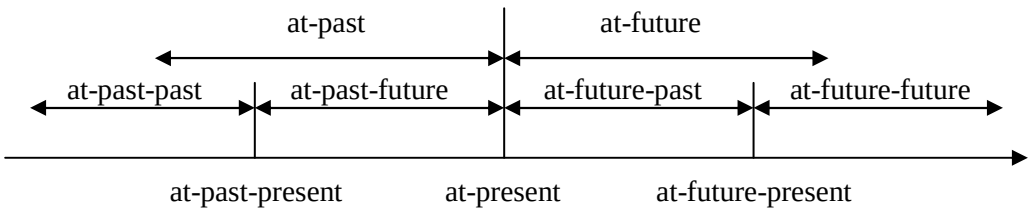

Figure 3 Nine qualitative values of time on the time axis

4.2 An example of generating the aspect expressions

In this section we illustrate the generation process with an example. We focus on the generation of the aspect expressions and ignore the generation process for the other sentence constituents. Because of the limitation of input associated with relevant files in the implementation, we use numbers 1, 2, 3, and 4 to refer to the four tones of Chinese characters in all the realization statements. For instance, *wang1*, *wang2*, *wang3*, and *wang4* refer to *wāng*, *wáng*, *wǎng*, and *wàng* respectively. The neutral tone is not marked by numbers.

In the present case, the semantics represented in the input specification is set for the situation that "zhe4 sou1 chuan2 jin1tian1 zhuang1yun4 le yi1 liang4 you3 gu4zhang4 de ka3che1" (The ship loaded an inoperative truck today). The situation happened at a specific time *today* (jin1tian1) and was finished before the speaking time, i.e., the present moment. The situation refers to an event rather than a state. The process of loading the truck took a period of time; and the realization of the situation is focused. Our aim now is to generate an appropriate aspect expression for this particular loading situation by applying the semantic information represented in the input specification.

The aspect-related semantic information in the input specification is as follows. Because the situation was finished before the present moment, we can consider that both the initial time t_i and the terminating time t_t precede the present moment. Because the situation took a period of time, the initial time t_i is regarded as preceding the terminating time t_t. Because the realization of the situation is focused, the reference time t_r is considered as being located at the terminating time. Representing these temporal relations with our qualitative time values illustrated in Figure 3, we have the following: SPEAKINGTIME has the value *at-present* which is a default value. REFERENCETIME has the value *at-past-future* and is a specific time point. INITIALTIME, with respect to other relevant times, has the value *at-past-past*, indicating the occurrence time of the situation. The value of TERMINATINGTIME equals that of REFERENCETIME, i.e. *at-past-future*. This means that the state of the situation indicated by the aspect to be generated is viewed from the terminating time. Theoretically, the reference time of an aspect, i.e., the viewing point of the aspect, establishes specific temporal relations with the internal temporal constituency of the situation reflecting what the speaker focuses on when s/he views the state of a situation. In our present case, the reference time is placed at the terminating time of the situation, indicating that the speaker's focus is on the termination or completion of the situation. If REFERENCE-TIME has other values, e.g., *at-present*, which is after the terminating time, it indicates that the focus of the speaker is on either the recent past or experiential meaning of the situation, rather than on the termination or completion of the situation. Correspondingly, they show temporal structures of different aspects.

In the input specification, several parameters are also used to represent the conceptual features of the aspect. The conceptual features and the corresponding parameters define the space of possible aspect-related semantic variation: this shows precisely which facets of aspectual semantics are grammaticised in the language; the particular grammatical consequences are then distributed over the grammatical choice points defined in the grammatical component. When using this for generation, any given situation to be expressed must be 're-conceptualized' in terms of parameters provided. This should be done by the user interested in investigating the grammatical realizations of distinct temporal relations. The parameter CHANGEABLITY has the value *change-of-state*, indicating the completion of the situation. The value of the parameter STATE-ACTION-PROPERTY is *event*, indicating that the situation is not of type state and can be viewed as a whole. Both the parameter EXCLUSIVENESS-TI and the parameter EXCLUSIVENESS-TT have the value *included*, indicating that the time interval over which the situation holds is closed at its two end points. This means that the situation occurred at some specific time and finished. The parameter REPEATABILITY has the value *irrelevant*, indicating not being related to any particular conceptual feature.

Referring to the semantics above, we follow the system traversal to generate an aspect expression by evaluating the relevant inquiries. The traversal starts from the system of WITH-ASPECT-MARKER-TYPE and needs to make a choice among its three options: *imperfective*, *perfective*, and *imminent*. Corresponding to the definition of aspect in the present research, perfective, imperfective, and imminent aspects are interpreted in the following ways: perfective

is the way of viewing the states of a situation with respect to its internal temporal constituency from outside the situation structure: the viewing point of the aspect is after or equal to the terminating time, i.e., $t_t \leq t_r$; imperfective is the way of viewing the states of a situation with respect to its internal temporal constituency inside the situation structure: the viewing point of the aspect ranges from the initial time, including the initial time, to the terminating time of the situation, i.e., $t_i \leq t_r < t_t$; imminent is the way of viewing the occurrence of a situation from outside the situation structure and with the viewing point shortly before the initial time of the situation, i.e., $t_r < t_i$ and $P_{tr\text{-}ti}$=shortly-precede. The temporal relations of the perfective, imperfective, and imminent aspects are captured by specifying appropriate values for the inquiries named perfective-q-code, imperfective-q-code, and imminent-q-code respectively. When operating within the context of a full generation system, these values would generally be provided via the results of text planning in the usual manner.

The with-aspect-marker-type chooser, which takes the form of a decision tree as described in section 4.1, is in charge of making the selection by asking relevant inquiries to see what type of aspect has the semantic applicability conditions which match the semantic inputs represented in the input specification. The fine classification and distinct semantic descriptions of different aspects are sufficient to constrain choice regardless of their particular order of application. Therefore, alternative implementations of the choosers, such as specifications of feature vectors, could be envisioned. Possible consequences of such changes for the other components of the generation architecture would then need to be considered, however. Because in the present case both the terminating time t_t and the reference time t_r have the value *at-past-future* that meets the temporal condition required by the perfective aspects, the option *perfective* is chosen and the system of PERFECTIVE-PRIMARY-TYPE is entered.

After entering the system of PERFECTIVE-PRIMARY-TYPE, a selection among three options *recent-past* (the REP aspect V+(NP)+lai2zhe), *experiential* (the unmarked-experiential aspect V+guo and the marked-experiential aspect ceng2jing1+V+(guo)), and *realized* (the URE aspect V+le and the perfect aspect yi3jing+V+(le)) has to be made. The perfective-primary-type chooser is responsible for making this choice. Accordingly, the chooser firstly evaluates the inquiries named recent-past-q-code and experiential-q-code respectively. The recent-past (REP) aspect V+(NP)+lai2zhe serves to indicate that a durative situation existed not long ago. The semantic applicability conditions represented by the ASF of the REP aspect V+(NP)+lai2zhe include the following: the situation expressed by the aspect shows the feature *durative* which can be represented in the temporal relation $t_i < t_t$; the terminating time of the situation precedes the reference time, i.e., $t_t < t_r$; and the reference time t_r is a specific time point. A further condition required is represented by the parameter $P_{tt\text{-}tr}$ with the value *shortly-precede*, indicating the qualitative distance from t_t to t_r. The parameter EXL has the value *excluded* and *included* for the initial time t_i and the terminating time t_t respectively.

After evaluating the inquiry of recent-past-q-code, the perfective-primary-type chooser gives a negative result, indicating that the semantics presented by the input specification does not match the semantic applicability conditions of the REP aspect. One obvious mismatch is reflected in the temporal relation between the terminating time t_t and the reference time t_r. The condition given by the input specification is $t_t = t_r$, while the condition required by the REP aspect is $t_t < t_r$.

After failing to select the REP aspect, the perfective-primary-type chooser continues to evaluate the inquiry associated with the experiential aspects. The experiential aspects include the unmarked-experiential (UEX) aspect V+guo and the marked-experiential (MEX) aspect ceng2jing1+V+(guo). Although the two experiential aspects have some differences in usage (cf. Yang, 2007), they have the same aspectual function to indicate that a situation existed at least once in the past and was over, not having current relevance. The semantic applicability conditions shared by the two experiential aspects are: the terminating time t_t precedes the reference time t_r; the situation referred to has the feature repeatable; the parameter EXL_{ti} has the value either *excluded* or *included*; the parameter EXL_{tt} has the value *included*.

Similarly to the failure of selecting the REP aspect elaborated above, the evaluation of the

inquiry of experiential-q-code will also fail because the semantic applicability conditions of the experiential aspects do not meet the semantic information shown in the input specification. Except for the mismatch of the temporal relations, the conceptual feature *repeatable* required by the experiential aspects is also absent in the input specification.

When both the REP aspect and the experiential aspects have been excluded, the perfective-primary-type chooser selects aspects of realized type, and then the traversal enters the system of REALIZED-TYE, then a further selection between the URE aspect V+le and the PEF aspect yi3jing+V+(le) has to be made. The realized-type chooser is responsible for making this selection. To make the selection, the realized-type chooser firstly evaluates the inquiry unmarked-realized-q-code to check whether the semantic applicability conditions of the URE aspect V+le can be met. The inquiry unmarked-realized-q-code is defined according to the ASF of the URE aspect as shown in Figure 2. The realized-type chooser evaluates the inquiry unmarked-realized-q-code by comparing the input semantics with the semantic applicability conditions of the URE aspect. The evaluation of the unmarked-realized inquiry succeeds because all the predicates of the unmarked-realized-q-code give the value T (Due to the space limit, we will not describe the whole process of evaluation in detail here). Hence, according to the algorithm of the realized-type chooser, the URE aspect V+le should be chosen and the perfect-q-code does not need to be evaluated. The generated sentence, marked up to show its constituency, is then as follows:

((zhe4/这)(sou1/艘)(chuan2/船)) ((jin1tian1/今天))
this CL ship today
(zhuang1yun4/装运) (le/了) ((yi1/一) (liang4/辆)
load URE one CL
((you3 gu4zhang4/有故障)(de/的))
have problem of
(ka3che1/卡车.))
truck
(The ship loaded an inoperative truck today.)

5 Conclusion

With the method elaborated above, a test-bed of forty aspect expressions of the Chinese aspect system has been correctly generated in the forms of both Chinese phonetic alphabet and characters. In the present research the application of the ASFs provides a formal way to represent semantic applicability conditions of the aspects; the grammatical network built on the basis of systemic functional grammar systematically organizes and distinguishes semantic functions of different aspects. The computational implementation verifies both grammatical organization and semantic descriptions of the Chinese aspects. The complete system files and the sentences generated are available on the website: "`http://www.fb10.uni-bremen.de/anglistik/langpro/kpml/genbank/chinese.htm`".

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