# ON THE SYSTEM OF CONCEPTS RELATIONS AND OUTLINE OF THE NATURAL LANGUAGE SYSTEM

Sho Yoshida
Department of Computer Science
Kyushu Institute of Technology
Tobata 804 JAPAN

## Abstract

Systems that simulates thinking processes of a man through natural language are called natural language systems. We present here outline of a natural language system in connection with the system of concepts relations which plays important role in our system. The system of concepts relations is a set of words or short sentences connected through various basic view-points- Semantic analyses procedure using the system of concepts relations is shown by an example. We regard desire as basic cause of thinking in our system. Outline of the relation between desire system and thinking processes using natural language as a base Is given in later chapters.

## Structure of the Natural Language System

Natural language systems are the systems that simulate thinking processes of man ( processes that perceive of our world ) by describing them through natural language. We are living with thinking or behaving all the time. We behave as a result of thinking and think as a result of behavior. What determines a man's thinking and behavior is the existence of desires. So to speak, desires are the basic cause of all behavior of man.

Thinking and behavior are means of satisfying desires, have no meanings to be satisfied, and therefore what binds the relation between thinking and behavior internally are desires, and in order to satisfy the desires thinking is necessary as the means for realizing them. Our life is satisfaction or processes of satisfying of various desires each of us have in our mind, and as the means for satisfying these desires we inquire of thinking under the restrictions of environment.

## Natural Language System

The natural language system is consisted of "world ( outside world )" given in natural language and "thinking system". The natural language system simulates thinking processes on the things about out6ide world using natural language as a part of raetij language ( in other words, using natral language as a part of means for describing thinking processes ). The input to the system are given in natural language sentences ( given from outside world or generated internally from the thinking system ) and then the system thinks about these sentences, and outputs results in natral language sentences. In short, "outside world" is a set of input sentences.

## Structure of the Thinking system

Figure 1 shows structure of the thinking system. Input sentences ( from outside world ) are infered ( generate new sentences ), judged ( give modalities such as * true','false','doubtful', etc. ) while making syntactic, semantic and pragmatic analyses. In order to do such inferrence and judgement about input sentences, it is necessary to consult environment concerning input sentences simultaneously from outside world. Environment including experiences from the pa6t to the present are also needed in the system, and these are stored in the system as "knowledge about the world". In Figure 1, "knowledge about language" gives relation between language and its meanings, "desire system" starts thinking and controls the overall system.

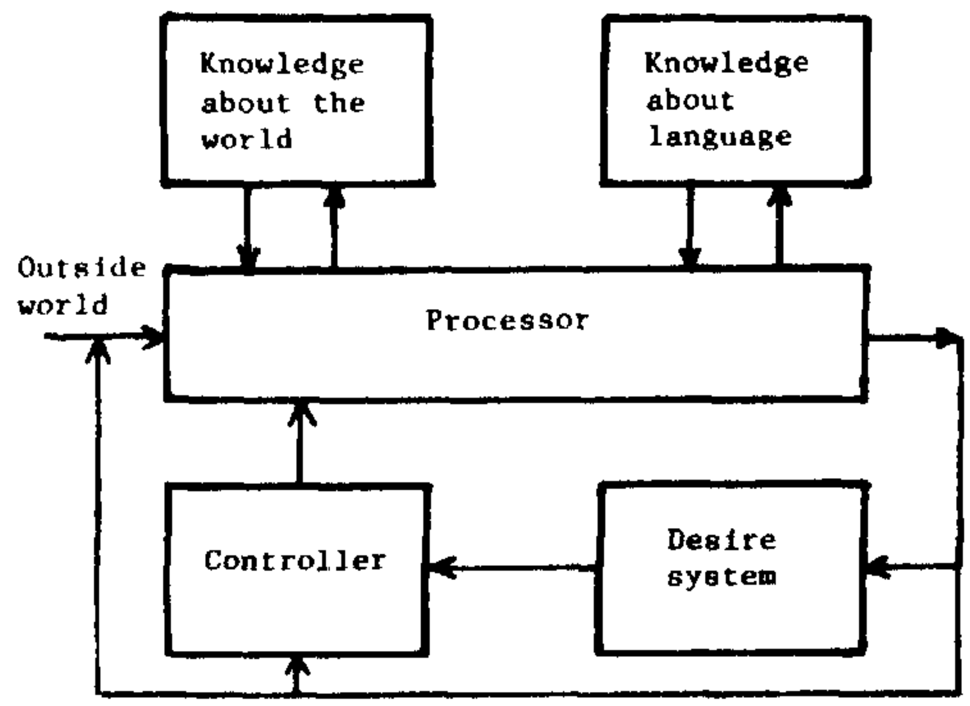



**Figure 1. Structure of the thinking system**

## Behavior of the Thinking System

The thinking system in Figure 1 behaves as follows.

A) Analyze input sentences and give which are the intervals among words, which word consist "bunsetsu" ( the smallest element that can be a sentence, which is consisted by an independent word and annex words ), what are the dependency relations among bunsetsu's in the input sentences.

These stages of analyses and the following stages of B,C,D are not independent to each other, therefore the system is only able to get possible analyses of sentences by following grammatical rules including tendencies ( or statistical rules) in this stage of analyses.

B) After guessing structures of input sentences, the system generates a set of normal form sentences which the system can process more easily than original sentences by simplifying, formalizing *and unit*orraalizing the *sentences* on/in which the system can handle. In short, a normal form sentence consists of a formal expression ( sentences ) which expresses predicate and case relations between the predicate and theob'-ects that original sentence intended to express, and of the formal expression of the annex words and their meanings which intended to express modalities of the predicate. We also use normal form sentences for describing the system ( to describe "environment", "knowledge about language" etc. ).

These two stages of A and B may be called input sentence recognizing stages.

C) After generating normal form sentences ( in correct, after assuming ), the system will proceed to semantic analyses of them by getting meanings of them through certain view-points. In this stage of analyses the system needs "system of concepts relations" in the "knowledge about language" and "view-point selection signals" from the controller.

D) Next ( in parallel with above analyses ), the system analyzes normal form sentences pragmaticaly ( analyzes relation between desires and normal form sentences ). In this stage of analyses ( thinking ) relatione to desires, to environment with normal form sentences are watched and normal form sentences which express "what want to do" are generated and stacked, and control the direction of thinking. We will discuss C and D in the following chapters.

<u>System of Concepts Relations</u>

The system of concepts relations gives information between language and their semantics, and constitutes a part of "knowledge about language" in the thinking system. If we try to describe meanings of a word by using words belonging to the same language, it becomes necessary that the system of words and their meanings express mutual relations among words. Though relations between words and their concepts do not make a one to one relation in the strict sence, it can roughly be said that a certain concept is denoted by a word or a short phrases.

<u>Abstract Words</u>

Abstract words are classified roughly as Figure 2. Abstract words are described in the system of concepts relations from the following standpoints.

1) Rough classification of abstract words through the view-point of 'kind' (or upper and lower relation ).

2) In what relation with other 'things' or 'events' do they defined? In other words, what kind of sentences containing these abstrct words are hold.

**Example 1.** Abstract word 'subject' is classified as 'the words explaining events'. If thing or event (N) is the subject of P then the sentence 'N is the subject of P' hold. Where 'P' denotes any predicate having subject case (almost all predicates have subject case). We express this as follows.

Subject → [Explanation] → $(\forall P)P(\_(s)P)$
⇄ [Cause & effect] ⇄ $(\forall P)P(N(s))$

**Example 2.** Abstract word 'thought' is classified as ' the words explaining mental behavior of human being'. It is explained as the concept that holds following sentences.

Thought → [Explanation] → $(\exists N)(Think(man_{(s)}, N_{(o)})$ ⇄ [Cause & effect] ⇄
← $Know(man_{(s)}, N_{(o)})$ {mode of 'Know'=[desire]}
→ $Know(man_{(s)}, N_{(o)})$

<u>Words that Express Modality</u>

Adjectives and adverbs are classified as Figure 3 which is a tree structure. Each word belonging to this class expresses modality of things and events. When we give the mode to a given thing or event, suitable word (mode) belonging to the considering classification item is chosen from this classification tree. Figure 4 is an exsample of modalities of 'pencil'.

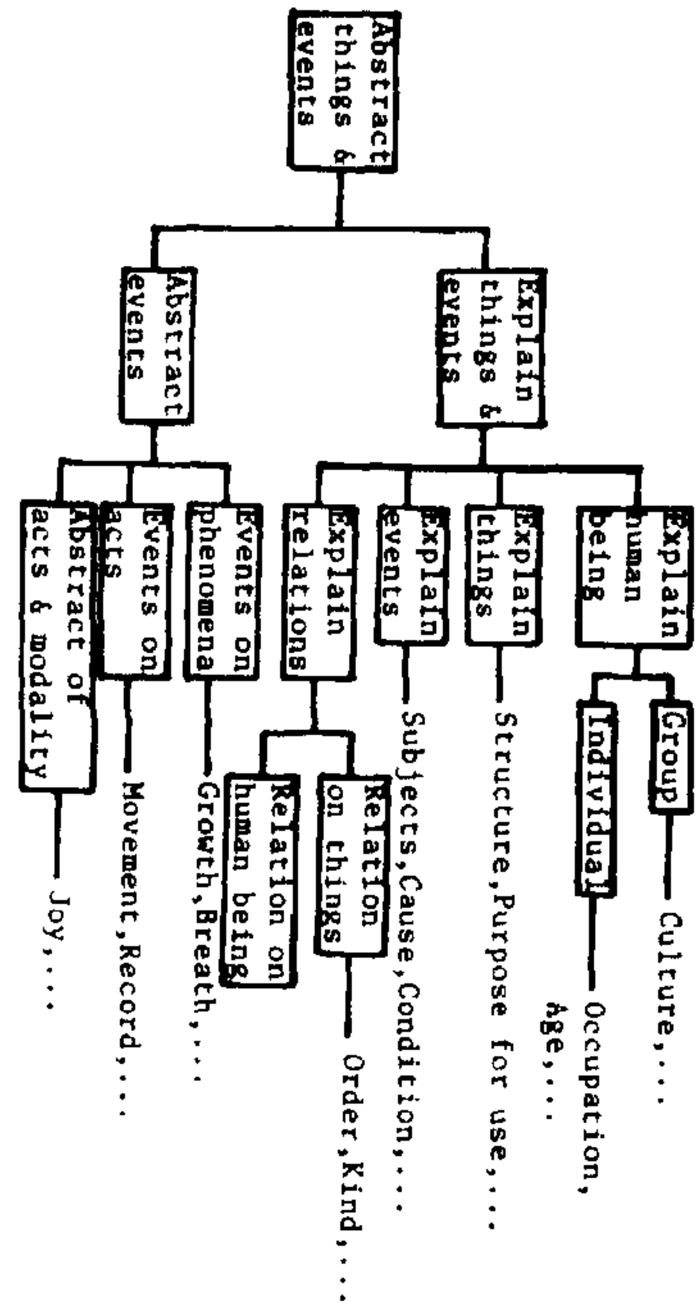



Figure 2 Classification of Abstract Words

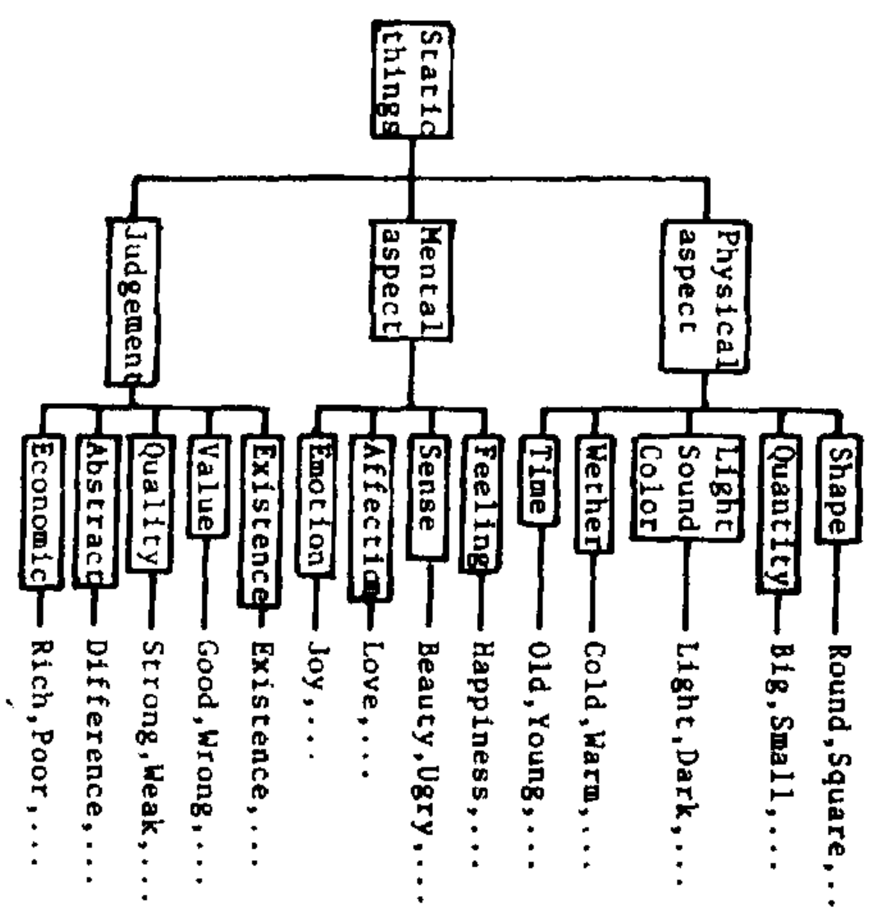



Figure 3 Classification of Words which Express Modality

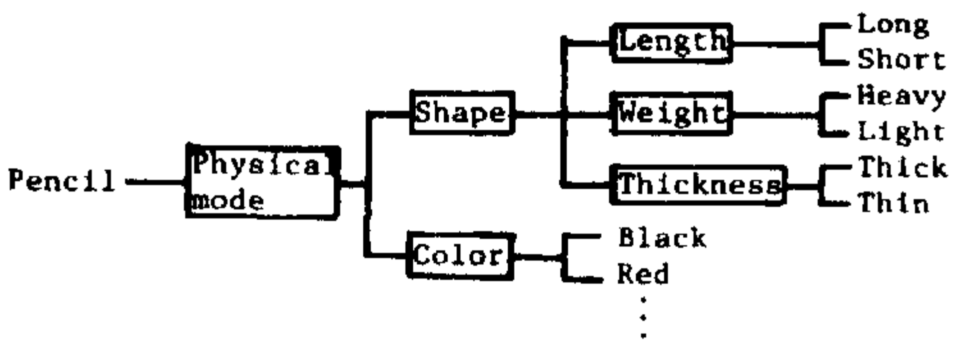



Figure 4 A part of Modalities of 'Pencil'

**Verbs**

Verbs are described from the following standpoints.

1) In what case relation with other concepts does the verb defined?

For example, a verb 'Eat' is defined by the case relation, indicated in parenthesis, with other objects indicated by < >, like

Eat: <man or animal>$_{\text{(subject of eat)}}$, <objects that can be object to eat>$_{\text{(object of eat)}}$, <time>$_{\text{(when to eat)}}$, <place>$_{\text{(where to eat)}}$, <way>$_{\text{(how to eat)}}$

We call this as 'basic expression of semantics' (BES). It becomes important problem what classification level concepts should be used as things and objects in the BES. (See classification of concrete nouns) All verbs have case relations with time and place. Therefore, they may be omitted except when they are necessary for the verbs. Therefore, we have to obtain necessary cases for each verb, and have to given them the class of things and objects.

2) By what cause and effect relation does the verb relates to other verb ?

Eat(man$_{(s)}$,concrete object$_{(o)}$) $\rightarrow$ Deminish(concrete object$_{(s)}$)

Hungry(man$_{(s)}$) $\rightarrow$ Eat(man$_{(s)}$,concrete object$_{(o)}$) [mode of 'Eat'=[desire]]

are cause and effect relations.

Cause and effect relations are expressed like '$P_1 \rightarrow$ cause-effect $\rightarrow P_2$', and indicates the relation that if objects denoted by $P_1$ holds then the objects denoted by $P_2$ may hold. This relation is divided into sub-relations such as 'before and after relation','cause and effect relation in the narrower sense','means or way','logical condition' 'synonymous relation',etc. There may be direct cause and effect relations and indirect cause and effect relations in each case.

Example:

Drink(man$_{(s)}$,liquor$_{(o)}$) $\rightarrow$ Intoxicate(man$_{(s)}$) ......indirect

Drink(man$_{(s)}$,liquor$_{(o)}$) $\rightarrow$ Decrease(liquor$_{(s)}$) ......direct

3) Descriptive description(definition) of a verb.

An example of descriptive description is as follows.

Eat(man$_{(s)}$,object$_{(o)}$)=(Put(man$_{(s)}$,object$_{(o)}$, mouth$_{(into)}$) $\rightarrow$ Chew(man$_{(s)}$,object$_{(o)}$)* $\rightarrow$ $\rightarrow$ Swallow(man$_{(s)}$,object$_{(o)}$))*

where '*' indicates repetition. Note that all sentences appearing in this description can be found in the chain of cause and effect relations, but this description is needed in order to give description of eating behavior directly.

**Concrete nouns**

Concrete nouns are classified from the following standpointg.

1) Classification in order to give basic words.

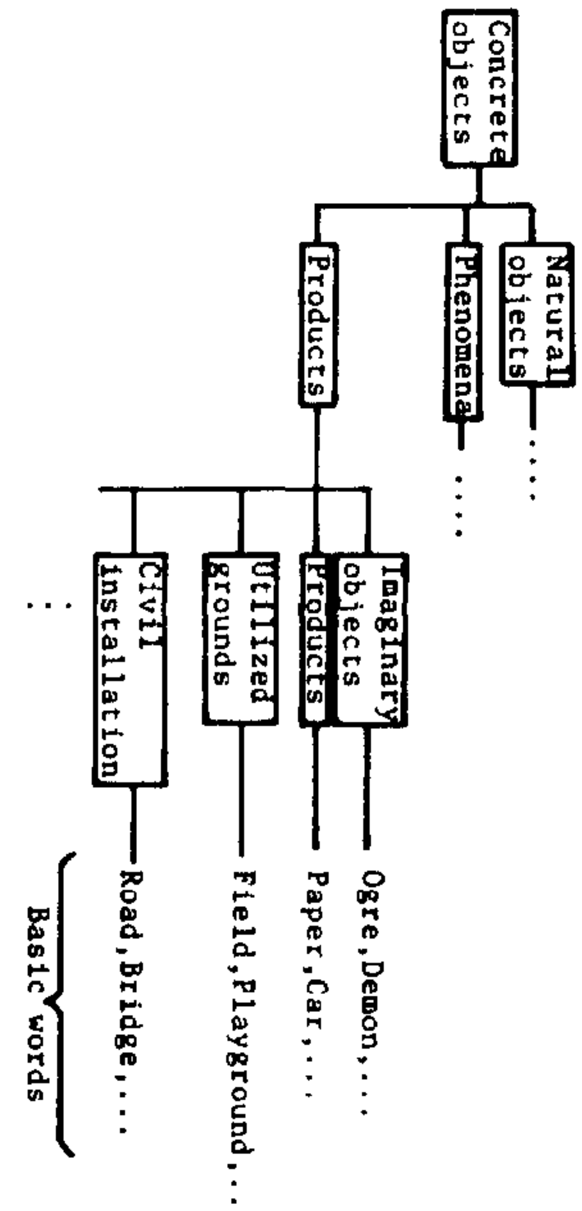



Figure 5 A Part of Classification of Concrete Objects and Basic Words

Basic words are those which are too vague If they are classified more roughly and are too fine that almost every word becomes compound word ( like list-watch, color-pencil,...) if they are clssified more finer. Basic words are words used in ordinary sentences. For example, a sentence ' Animal bought product.' is too vague to know what kind of animals, what kind of products the animal bought. Instead, 'I bought television.' is a sentence which can be used as an ordinary sentence, though it does not say what kind of 1 or what kind of television.

2) Begining from basic words, obtain their kinds defined by basic view-points. At the same time we give words relating to basic words through basic view-points. See Figure5.

Here the problems are: 'Are there basic view-points?' If there are view-points, how can we fined them out? Chose a basic word W from a dictionary and select words intuitively which are related to W. Then try to find out through what view-points are they related to W. For example, let W='paper'. Then chose words related to W 'manuscript paper','pulp','write','wrap' , ....

Between 'paper' and 'manuscript paper' we can find the view-point "purpose for use". Namely, 'manuscript paper' is a kind of 'paper' seeing through the view-point "purpose for use".

After extracting the view-point "purpose for use" we judge it whether it is acceptable as a basic view-point or not by examining it as follows.

Choose any word W'(#W) and related words, then examine whether the view-point "purpose for use" is applicable between W' and related words. Repeating this process several tiroes choosing different W's, we know that the view-point "purpose use" can be a basic view-point. We can obtain basic view-points for "concrete objects" by this way.

## System of Concepts Relations and Semantic Analysis

### Substitution Rules for 'Kinds'

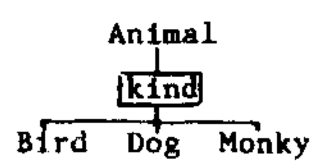
When the system makes inferrence using the system of concepts relations, the system must know how to refer to it. In the system of concepts relations, concepts are related through basic view-points, therefore, the system must know how to make use of them when making inferrence. For example, when UP Infer

**Animal is living → Dog is living**

**we use following inferrence rule.**

$$\forall(x)(A(x) \rightarrow Live(x))$$

$$\frac{A(a)}{Live(a)}$$




**Where A(y) means 'y is a kind of A' (A=Animal)**

**To the basic view-point "kind", we usually make this form of inferrence.**

**Here the problem is:**

**Is the inferrence rule necessary for each view-point?**

**Let us discuss this problem in the following.**

### Elements Necessary for Inferrence

**Drop($I_{(s)}$,$cup_{(o)}$)[mode of 'Drop'=[perfect]] ....... BES in normal form**

**From this sentence, we will infer 'Cup is broken' (Break($cup_{(s)}$)[mode of 'Break'=[intransitive]'be...en']), and examine the process of the inferrence.**

**A) Get the BES with respect to the verb 'Drop'.**

**1) Drop:$W_{1a1(s)}W_{2a2(o)}W_{3a3(d)}W_{4a4(ar)}$ ........ BES of the 1st kind**

**d=departure point, ar=arrival point**

**2) Drop:Concrete $object_{(o)}$ ....... BES of the 2nd kind**

**3) Drop:Concrete $object_{(o)}$,Abstract $object_{(m)}$ ....... BES of the 2nd kind**

**m=means**

**1) or 2) is applicable BES to 'Drop($I_{(s)}$, $cup_{(o)}$)'. For this is obtained from the following relation 'kind'(or 'upper and lower' relation) between concepts.**

**I ∈ man ∈ animal ∈ concrete objects**

**cup ∈ table ware ∈ products ∈ concrete objects**

**Drop($I_{(s)}$,$cup_{(o)}$) → Drop($man_{(s)}$,$cup_{(o)}$) → Drop($man_{(s)}$,concrete $objects_{(o)}$)**

**B) Next we will analyze the process of 'Drop($man_{(s)}$,$cup_{(o)}$) → Break($cup_{(s)}$)'.**

**1) Drop($cup_{(o)}$) → Break($cup_{(s)}$)**

**2) Drop(table $ware_{(o)}$) → Break(table $ware_{(s)}$)**

**3) Drop($china_{(o)}$) → Break($china_{(s)}$)**

**4) Drop(concrete $object_{(o)}$) → Break(concrete $object_{(s)}$)**

**Among cause and effect relations (with respect** to the verb 'Drop' ) from 1) to A), it is no problem if there exist, for each word, cause and effect relation like 'cup' as 1). Though we can not expect the existence of these, they may exist in the system of concepts relations as empirical (experienced) facts. It is expected that there exist cause and effect relation 2) in the system of concepts relations.

Cause and effect relations 3) and 4) are probably in the system of concepts relations (especially 4)).

**Let the cause and effect relation 3)**

**Drop($china_{(o)}$) → Break($china_{(s)}$)**

**be found in the system of concepts relations. In this case, if it is inferred that 'cup' is a kind of 'china', we can infer**

**Drop($cup_{(o)}$) ... Break($cup_{(s)}$)**

**from the following inferrence rule.**

$$\frac{P_1(A) \rightarrow P_2(A) \qquad a \in A}{P_1(a) \rightarrow P_2(a)}$$

**where $P_1(x)$:Drop($x_{(o)}$)**

**$P_2(x)$:Break($x_{(s)}$)**

**A:china**

**a:cup**

**a ∈ A means 'a is a kind of A'.**

We cannot expect that cup is directly related in the system of concepts relations as a kind of 'china'. Then how can we infer that 'cup' is a kind of 'china'? Let us consider a part of the system of concepts relations of Figure 6.

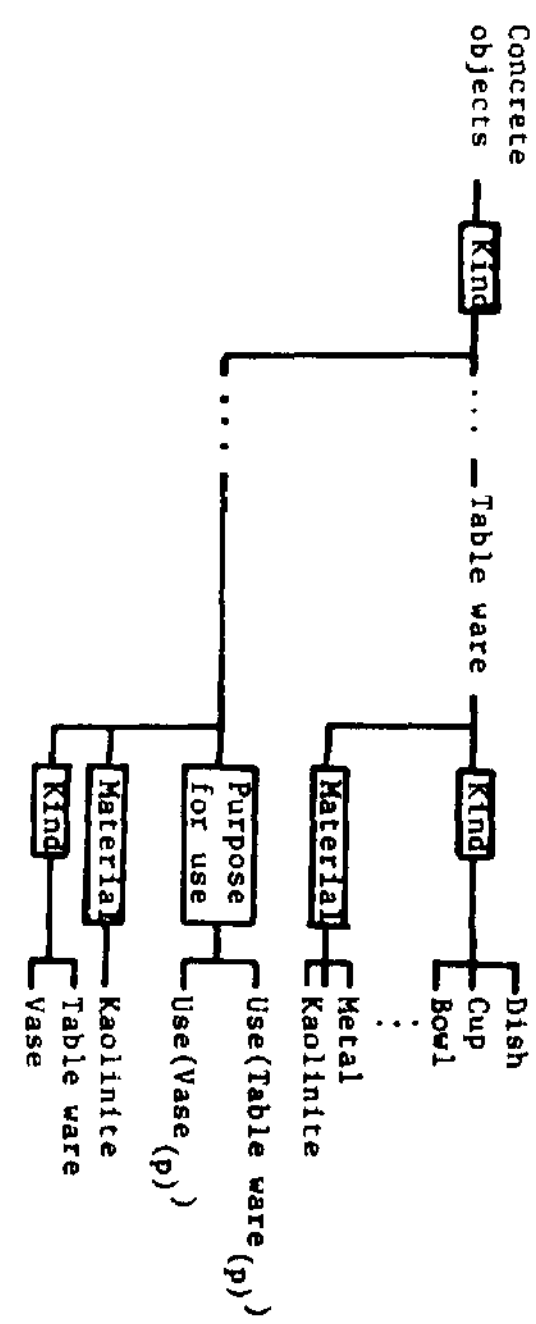



Figure 6 A Part of Concepts Relations Related to 'Cup'

From Figure 6, we obtain the following.

Concrete objects → [[kind](table ware)∘kind] → cup / dish / bowl
↳ [kind](china)∘kind] → table ware ⋮

Therefore, following relation holds.
Concrete objects →
[kind](table ware)∘[[kind](china)]∘[kind]
→ bowl / cup / dish

Hence there is 'china' as a kind of 'concrete objects', and there is 'table ware' in it, and there is 'cup' in it as a kind.

In case of 4), we will begin from following inferrence.

Drop(concrete object $_{(o)}$) → Break(concrete object $_{(\beta)}$)
↳ Condition — Physical property — Break[mode of 'Break' =[easily]] / Brittle
— Shape — Thickness — thin

From this cause and effect relation and its conditions (to hold), it can be known that in order to break a concrete object it is necessary that it has physical property 'Breakable', or its thickness is 'thin'. Therefore, the system has to find out that 'cup' is a kind of concrete object and it has physical property 'Breakable*.

From above considerations, we know that the inferrence processes use following information.

1) We use 'kind','material','purpose for use', 'physical property'.... as basic view-points, but basic view-points are used in order to make composition of (generate) 'detailed kinds'.

2) Cause and effect relations among verbs are used.

3) BES with respect to verbs are used.

A) From the conditions described with the cause and effect relations and BES with respect to verbs are hold,basic view-points are chosen to make inferrence.

5) Substitution with respect to the concepts related through the basic view-point 'kind' is used.

6) Functions that generates (fined out) concepts related to a given concepts through compositioned (generated) view-points are required.

Here those factors which plays important role in making inferrence as desires are neglected.

## Control of View-points in the System of Concepts

### Relations

As mentioned above, the system is able to get meanings of concepts (in other words, relation to other concepts with the concept) by following the concepts related through certain view-points in the system of concepts relations. In this case the system has to select view-points in succession.

We call the system which generates these view-point selection signal as 'view-point controller'. The structure of view-point controller is not clear and we expect to psychological,engineering investigations about the structure of view-point controller. Primary factors which select view-points, namely, primary factors which controls the view-point controller are as follows.

A) Personal or general tendencies (acquired tendencies).

B) Prijnary tendencies (like instincts).

C) Restrictions of environment (including experiences) .

Of these factors, restrictions of environment are given first from the 'environment' in the thinking system, and then view-points selection will be made following the factors of A and B.

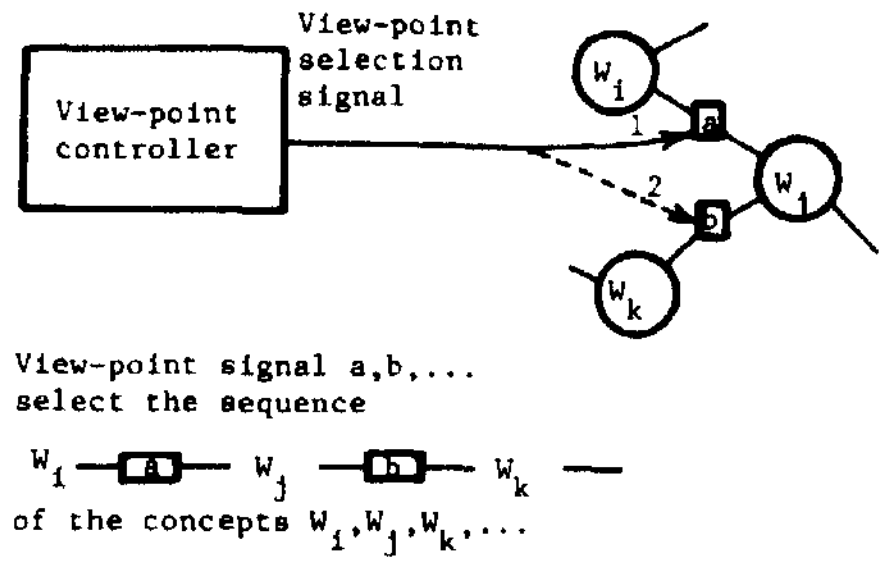



Figure 7 Selection of view-points

## Desire System as a Basic Cause of Thinking

### Relation between Desires and Language

Desires give to the system basic cause of thinking 'what to think about', and the system behaves to realize the desire under restrictions of environment. We call this process thinking.

Desire realizing processes (thinking processes) for a given desire are as follows:

A) Select verbs directly related to each desire.

B) Get the BES with respect to the verb. There may be several BES for each verb.

C) Generate normal form sentences for each BES.

D) Store the normal form BES generated for each desire to the storage which has suitable storing structures.

There may be many kind of models for storing structures. Pushdown stacking can be one of the models. Conditions to erase the stored contents should be given to the system. For example, normal form sentences generated in relation to the desire 'appetite* may be erased after the desire is satisfied.

### Desire System and Stimulation

AS mentioned above, each desire is watching input sentences from its own stand-point of whether the input normal form sentences can be stimulative to the desire system . If it is judged that the input normal form sentence can give stimuli to the desire system , then the system sends out a signal to the stimulator. When the stimulator receives the signal, it produces output (stimulation) having certain strength and it will change states of the desire system. Strength of the stimuli is determined by the states of the desire system.

Relation between Desires and Semantic, Pragmatic Processing

The procedures of semantic and pragmatic analysis of input sentences (given in natural language) given to the thinking system are as follows:

A) Generates normal form sentences from input sentences.

B) Watching generated normal form sentences from the standpoint of each desire, the desire system determines whether they should produce stimulating signal to the desire system or not.

B1l) Analyze the normal form sentences from the standpoint of each desire.

Example:

Watch the input sentence 'run' from the standpoint of 'desire for evasion'- Get the following chain from the system of concepts relations.

run —> move —> tired . .. evasion

B-2) Such chains are stored in the system for each verb. Therefore, the system is able to know for each desire, whether the given verb satisfies the given desire or not, and hence the system is able to know whether the given verb should produce stimulating signal or not. In this example,'run' produces stimulating signal to the desire for evasion.

**C) Send out stimulating signals. Signals $s_1, s_2, \ldots, s_n$ in Figure 9.**

D) Then the stimulator works according to the input signals $s_1, s_2 \ldots, s$ and the states of structured set of desires may change to new states.

E) Thus the states of desires are determined. With this states and normal form sentences generated from input sentences, the thinking system generates normal form sentences expressing 'what to do (about what does the BYstem want to think)'.

**Example:**

**run ⟶ tired ... evasion**

**:**

**$S_1$: run[mode of 'run'=[want][mode of 'want'= [negation]]]**

Therfore the system generates normal form sentence $S_1$ , and stores it in the structured storage.

Thinking Processes

Thinking processes are the processes that starting from the given initial states of the desire system, try to realize (in this realization process semantic analyses mentioned before are needed, though we do not go into details of this process in this paper) the stated contents of the normal form sentences (indicating 'what to do') in the store getting information from the system of concepts relations, under the restrictions of environment. While thinking, new normal form sentences may be generated and stored in the system and at the same time some of the stored information may be erased according to the change of states of the desire system. In these thinking processes, generated information such as input normal form sentences (for each desire), sentences expressing environment etc. should be stored in the system and the relation to each stored normal form sentence (relation graph) have to be generated.

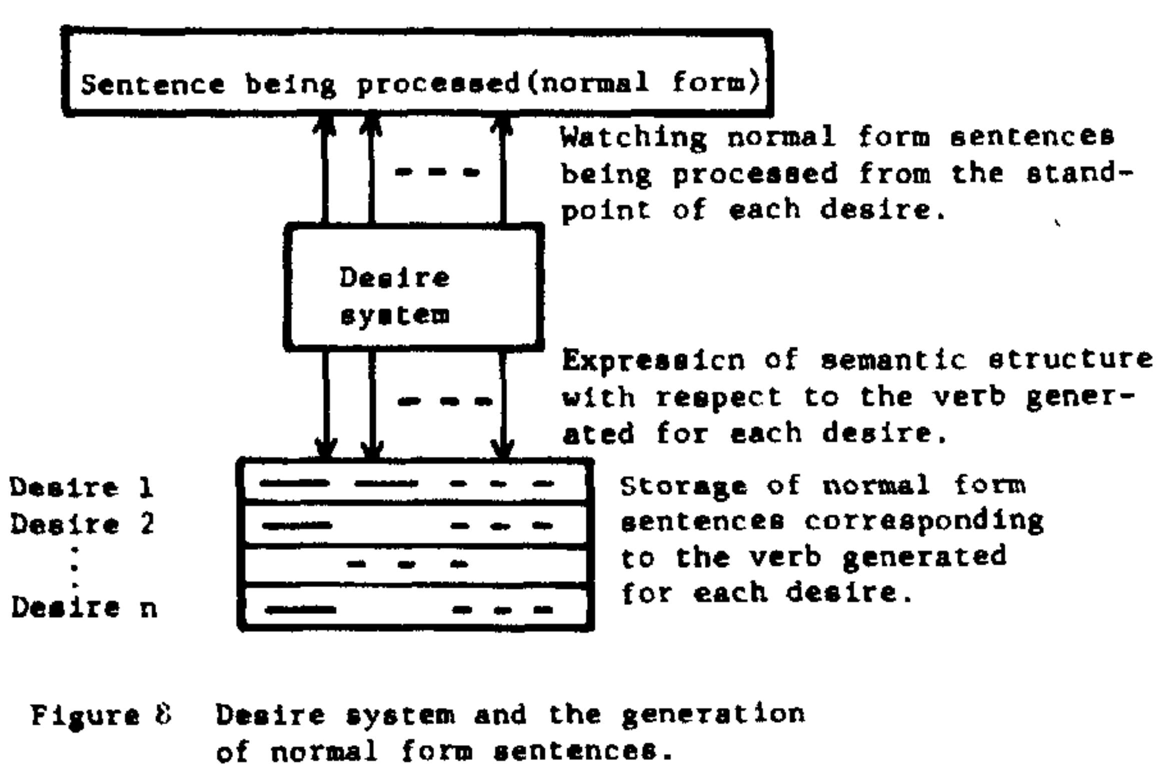



**Figure 8 Desire system and the generation of normal form sentences.**

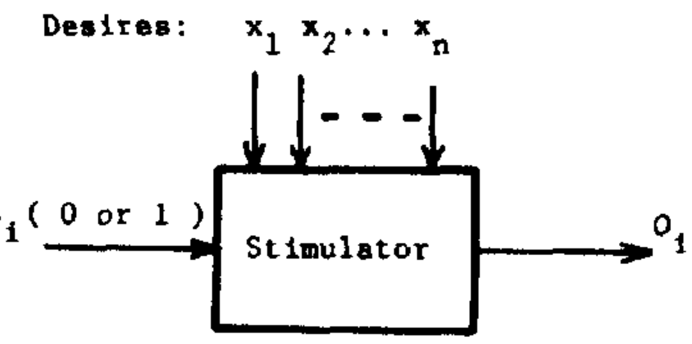



**Figure 9 The stimulator generates its output $O_i$ according to the input $S_i$ and states of desires $(x_1, x_2, \ldots, x_n)$**

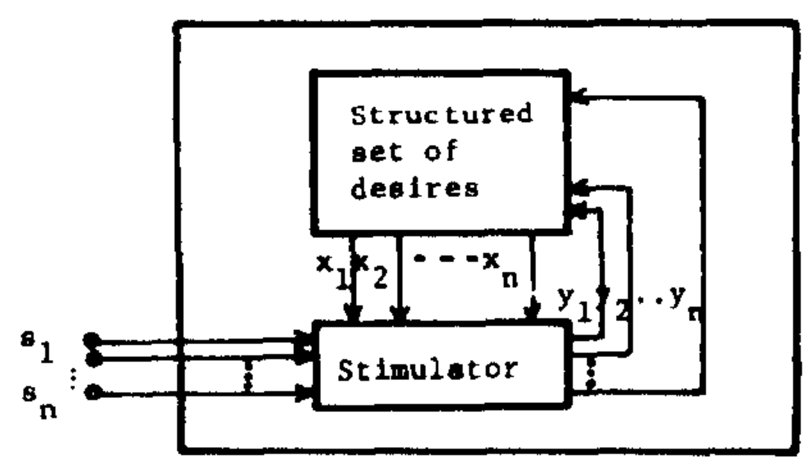



**Figure 10 Structure of the desire system**

**References**


**T.Fujita,H.Tsurumaru,S.Yoshida: "Machine Processing of Japanese- Decomposition of Japanese Sentences into Their Normal Forms", The J. of the Inst. of Electronics and Communication Engineers of Japan, July,1975. (in Japanese)**


**Acknowledgement**


**This research has been sponsored by the Japanese Ministry of Education Science Foundation "Advanced Information Processing of Large Scale Data over a Broad Area", group C-5 "Application of Language Structure Theory to Scientific Information Processing".**