Abstract: Recent years have witnessed rapid developments in the field of machine-translation, which has covered a wide range in research field and thus has been one of the researchers’ major concerns in terms of translation exactness and costs. This paper presents a Super-Function based model which is aimed at constructing a translation system through the combination of translation principles. According to this model, translation cost is expected to be reduced and the quality of the translation to be greatly improved. In the present research, sufficient Chinese-Japanese causative sentence patterns have been employed as a language-database for experiment, which proves the suggested model can effectively improve translation quality within the range under discussion. Some problems concerning translation output have proven to be reduced, among which are the unnaturalness, the lack of logic and the mixture of varied mistakes. Meanwhile some methodological problems related to the present research are also included in the discussion for further improvement.

Key-Words: machine translation, Super Function, Chinese-Japanese Causative mode, Natural language

1 Introduction
In the field of machine translation, the lack of logic and the mixture of varied mistakes are still found. It is, therefore, a very important to improve the accuracy of machine translation. Accordingly, in recent years, some improvements have been achieved concerning the correctness and the agreement with the target language, which can be found in Rule-Based Machine Translation (RBMT); Knowledge-Based Machine Translation (KBMT); Sentence-to-Sentence Machine Translation[1][2][3][4]; Sentence-Patten Machine Translation and Translation-Memory Machine Translation. However, the scope that these models have covered is quite limited.

In Example-Based Machine Translation [5], the application scope has been enlarged, but the correctness of the translation has yet to be further improved. In the 1990s, Statistics-Based Machine Translation [6] gained wide attention in the field of machine translation for its obvious improvement of translation quality. But still it needs further improvement concerning its correct and logic translation output. Other research in this field include the combination of Patterns, Template, Chunks and Statistics-Based methods [7][8], which have made some breakthroughs in the machine translation field. However, further improvements are still required for high-quality translation output.

All this indicates that the present challenge in machine translation field is still focused on translation quality. Therefore, how to make the
translation more accessible to the users on one hand and to improve translation quality at lower costs on the other hand has become one of the hot topics in the research field.

This paper suggests a new Super-Function (SF) which is based on Super-Function (SF) [9][10] and which is combined with translation principles. As a multi-lingual translation mode, SF is known for its lower costs, and is applicability to common users who do not have high demand on translation quality. But when combined with translation principles, SF can improve translation quality and is applicability to high-demand users.

In this paper, 5,767 Chinese-Japanese causative sentence patterns are employed as a language database in the experiment of our proposed translation mode, which has proved to effectively improve translation quality.

This paper will continue as follows, part two is a brief introduction of SF’s basic principles. Part three is a description of the characteristics and translation rules of causative sentences both in Chinese and Japanese. Part four introduces methods of combining SF with translation principles. The last part is the result of experiment and evaluation on it.

2 Super-Functions (SF)
2.1 SF Definition and Format

SF Definition
A Super-Function (SF) is a function that shows the correspondence between an original language sentence (word, phrase, sentence, paragraph, text) patterns and a target language sentence (word, phrase, sentence, paragraph, text) patterns.

A SF can be represented as formula (1) or formula (2) using a formal description [10]:

\[ \text{SF}_O(O \_ \text{STRING}, O \_ \text{VARiable}) \Rightarrow \text{SF}_T(T \_ \text{STRING}, T \_ \text{VARiable}) \] .... (1)

\[ f(X_1, X_2, \ldots, X_n) \] ................. (2)

Here, \( O \) means original language; \( T \) means target language. \( \text{STRING} \) means a natural language (original language or target language) character string; \( \text{VARiable} \) could be a word, a phrase, a sentence, or a paragraph. \( \text{VARiable} \) could also be a SF. \( X_i (i = 1, 2, \ldots, n) \) is a \( \text{VARiable} \), \( n \) means the number of variables in the SF \( f \). We show some SF as follows.

**SF Format**

We use the following notation when describing a super-function: variables are represented with \( X \) or \( Y \), strings are represented with \( S \) or \( R \). Lowercase \( o \) and \( t \) are used to represent Original language and Target language.

Additionally, we use subscript \( O \) and \( T \) in the variable and we use the string to represent Original language and Target language, the SF can be represented as formula (3):

\[ S_{o\omega} \prod X_{o\omega} S_{o\omega} = S_{t\eta} \prod X_{t\eta} S_{t\eta} \] ................. (3)

Here, \( S_{o\omega} \) and \( S_{t\eta} \) represent an original language string and a target language string, \( X_{o\omega} \) and \( X_{t\eta} \) represent the original language variable and target language variable, respectively.

2.2 SF Architecture

Two architectures could be considered representing the SF: a Directional Graph (DG) and a Transformation Table (TTB).

**Directional Graph**

Figure 1 shows a DG according with previous SF. Strings are represented by circle nodes; variables are represented by edges; the starting node (the first string of a SF) and the final node (the last string of a SF) are depicted with two concentric circle; the empty string is depicted with \( \phi \); NULL_EDGE indicates the variable
without any condition; NOUN_EDGE indicates the variable with noun-properties; VERB_EDGE indicates the variable with verb-properties. \(X_i\) is represented as EDGE\(i\) and \(S_i\) is represented as NODE\(i\) in DG.

Transformation Table

Another architecture of SF is the Transformation Table (TTB). TTB consists of an Node Table (NTB) and a Edge Table (ETB). The construction of NTB and ETB are described in Table 1 and Table 2. NTB is also called String Table (STB). ETB is called Variable Table (VTB) too.

Language \(i\) in NTB is a string of language \(i\); Kind in ETB indicates the kind of variable or condition. The location \(i\) in ETB indicates the location relationship between language \(i\) and language \(j\) that is base language.

At present, we use TTB to represent the SF. However, it is easy to transfer DG into TTB and transfer TTB into DG.

3 SF-based Chinese-Japanese Causative Sentence Translation

3.1 Forms of Chinese-Japanese Causative Sentences

In Japanese, a causative sentence is expressed as \(X\) GA \(Y\) NI \(V\) SASERU. And Causative sentences in Chinese are expressed as \(X\) JIAO \(Y\) \(V\), \(X\) RANG \(Y\) \(V\) or \(X\) SHI \(Y\) \(V\). Chinese Causatives JAIO RANG and SHI are used together with a verb to express SASERU in Japanese.

For example:

ChenJingLi JIAO Jianglin QU JiChang jie Ke ren.
(Manager Chen asks Jianglin to meet the guests at the airport.)

<table>
<thead>
<tr>
<th>ChenJingLi</th>
<th>JIAO</th>
<th>Jianglin</th>
<th>QU</th>
<th>JiChang</th>
<th>JIE</th>
<th>KeRen</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td>Predicate</td>
<td>Object/ Subject</td>
<td>predicate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commander</td>
<td>SASERU</td>
<td>performer</td>
<td>Action / Behavior</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Basic Usage of Japanese Causative Sentences

The basic usage of Japanese causative sentences can be seen as follows [11][12][13][16]:

1. No matter whether \(Y\) is \(V\) (i.e. no matter whether \(Y\) performs certain action), \(X\) forces \(Y\) to \(V\) (i.e. \(X\) forces \(Y\) to perform certain action)

Example: Fuqing JIAO wo qu mai dongxi.
(Father asked to buy things.)

2. \(Y\) \(V\) after \(X\) ’s permission (i.e. \(Y\) performs certain action after being permitted by \(Y\))

Example: Ni neng rang wo liu xue ma?
(Could you let me study abroad?)

3. \(X\) keeps silent as to \(Y\) ’s behavior

Example: Mama Faxian erzi zhunbei likai jia, ta meiyou wanliu, Rang erzi que le.
(Mother found son is going to leave home. She didn’t ask him to stay. She let him go.)

4. to express mildly (Please allow me to do…)
Example: Qing rang wo shuo liang ju, hao ma?
(please allow me to say a few words, ok?)

5. to blame others or ask others to be responsible for …
Example: Zhe dian nandao rang keren chi zheme nanchi de dongxi ma?
(This restaurant would let its customers have such terrible food?)

6. to be willing to hold responsibility for things because of one’s own fault
Example: Yinwei wo de bu zhuyi shi ta shoushang le.
(I made him suffer because of my carelessness.)

7. When \(Y\) is resulted for the absence of certain action by \(X\)
Example: Huazi zai zhangzheng zhong shiqu le 3ge erzi.
(Hua zi lost 3 sons in the war.)

8. When the subject is non-human/living entity
Example: Er nv men de dong shi rang lao ren men huan xin.
(Children’s thoughtfulness made the old people comforted.)

Y is part of X’s body, thus the change of Y affects X.
Example: Ta xin li tangte bu an de zou le jin lai.
(She came in with her heart full of uneasiness.)

(2) Basic Usage of Chinese Causative Sentence
In Chinese, the usage of RANG, JIAO, and SHI differ from one another. Following below is a summary of their respective usage.

Usage of JIAO
It is more colloquial than RANG; JIAO is used for making orders or to give command; Like RANG, after X gives command to Y, Y can either perform or not perform the action.
Example: Baba jiao wo qu mai dong xi, ke shi wo bu qu.
(Dad asked me to buy something, but I didn’t go.)

Usage of RANG
It is more polite than Jiao, and the tone for making orders or giving commands is milder than JIAO; Like JIAO, after X gives command to Y, Y can either perform or not perform the action; Emphasis is laid on people, stressing that someone has performed certain behavior or action; Unlike JIAO, it can be used in the first-person when “I” or “we” are agents; It can be used to express that someone wants to do something; It can be used when others want to fulfill a wish.
Example: Rang ta qu wai mian chuang chuang ba.
(Let him go outside for a venture.)

Usage of SHI
Unlike Jiao and RANG, Y is the effect caused by X’s command or the result of X’s action; It is used when the subject is a non-human/non-living entity, or used when certain result is caused by some reason.
Example: Baba de si shi ta hen shang xin.
(Father’s death made him suffer a lot.)
When X is a non-human/non-living entity whose action and behavior are irrelevant to its thought, Y is a living entity (man or animal); Emphasis is laid on things, as a certain result is caused by a certain thing.

Usage of Idiomatic Phrases:
In the process of causative sentence collection, it is found that Chinese causative verbs JIAO RANG and SHI correspond to SASERU in Japanese. But there are some Chinese idiomatic phrases that can correspond to SASERU in Japanese, with the absence of causative verbs in Chinese. The causative usage of Chinese idiomatic phrases is categorized in the following table 1.

<table>
<thead>
<tr>
<th>Types</th>
<th>Chinese</th>
<th>Japanese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proverbs</td>
<td>(1) Xuxin shi ren jinbu, jiaao shi ren luohou.</td>
<td>Kennkyo na kokoro ha hito wo shinpo sase, Goumann na kokoro ha hito wo tatiokuresaseru.</td>
</tr>
<tr>
<td></td>
<td>(2) You qian neng shi gui tuimo.</td>
<td>Jigoku no sata mo kaneshidai.</td>
</tr>
<tr>
<td>Tools operation</td>
<td>(3) Bi xia shi liushui.</td>
<td>Keimyou ni hude wo hashiraseru.</td>
</tr>
<tr>
<td></td>
<td>(4) Kaiche</td>
<td>Kuruma wo hashiraseru.</td>
</tr>
<tr>
<td>Special performance</td>
<td>(5) Kaihua</td>
<td>Hana wo sakaseru.</td>
</tr>
<tr>
<td></td>
<td>(6) Maoyan</td>
<td>Kemuri wo tanabikaseru.</td>
</tr>
<tr>
<td>Special human body</td>
<td>(7) Juezhezui</td>
<td>Kuti wo togaraseru.</td>
</tr>
<tr>
<td>performance</td>
<td>(8) Zhayanjing</td>
<td>Me wo patikurisaseru.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2 The General Translation Principles of Translating Chinese JIAO, RANG, SHI into Japanese

<table>
<thead>
<tr>
<th>Chinese Causative Verbs</th>
<th>Judging Criteria</th>
<th>Japanese Equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RANG</strong></td>
<td>X+RANG+Y+V, + transitional predicate clause</td>
<td>V saseru</td>
</tr>
<tr>
<td></td>
<td>X+RANG+Y+V; (jian yu ju: A clause used as two functions)</td>
<td>V youniiu</td>
</tr>
<tr>
<td></td>
<td>X+RANG+Y+GEI+X+V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X+RANG+Y+DAN/ZUO+V+Object</td>
<td>Y wo V nisuru</td>
</tr>
<tr>
<td></td>
<td>RANG+the first person +V</td>
<td>V sasetekudasai</td>
</tr>
<tr>
<td></td>
<td>RANG+the first person +V+BA</td>
<td>V saseteageru</td>
</tr>
<tr>
<td></td>
<td>RANG+the third person +V+BA</td>
<td>V saseteyaru</td>
</tr>
<tr>
<td></td>
<td>RANG+the third person +V+LE</td>
<td>V saseteokou</td>
</tr>
<tr>
<td></td>
<td>RANG+ the first person + preposition + V + V</td>
<td>V saseteshimatta</td>
</tr>
<tr>
<td><strong>JIAO</strong></td>
<td>X+JIAO+Y+V, + transitional predicate clause</td>
<td>V saseru</td>
</tr>
<tr>
<td></td>
<td>X+JIAO+Y+V; (jian yu ju: a clause used as two functions)</td>
<td>V youniiu</td>
</tr>
<tr>
<td></td>
<td>X+JIAO+Y+GEI+X+V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>X+JIAO+Y+BA+object + V</td>
<td></td>
</tr>
<tr>
<td><strong>SHI</strong></td>
<td>Predicate clause X+SHI+Y+V</td>
<td>surukotonlyotte + V saseru</td>
</tr>
<tr>
<td></td>
<td>X (subject clause as reason) + SHI + Y + V</td>
<td>~ node V saseta</td>
</tr>
<tr>
<td></td>
<td>Inanimate X+SHI+Y+V</td>
<td>V saseta</td>
</tr>
</tbody>
</table>

Notes: Translation of the Chinese proverbs in the table 1.
(1) Modesty can make people achieve progress; Pride can make people lag behind.
(2) Money can make ghost work.
(3) Words flow under nice pen. (A good writer can produce a masterpiece with his pen.)
(4) to drive a car
(5) to make flowers boom
(6) to give off smoke Special human body performance
(7) to protrude mouth
(8) to blink eyes

### 3.2 The Translation Principles of Chinese and Japanese Causative Verbs

The General translation principles of translating Chinese JIAO, RANG, SHI into Japanese (Table 2):

### 3.3 SF Construct based on Translation Principles

#### 3.3.1 Construct of Source Language Directional Tree

We demonstrate the construct based on the translation principle with concrete examples:

e.g 1:  Chen jin li JIAO Jianglin qu ji chang jie ke ren. (Manager Chen asks Jianglin to meet the guests at the airport.)

The extraction condition in Chinese causative sentences shown in table 3:

We perform morphological analysis with FreeICTCLAS[14] provided by the Chinese Science Institute and get the following result:
It is reliable to judge whether a sentence is causative sentence or not according to the extraction condition in Chinese causative sentences (V+N+V). If yes, it is easy to take out the causative key words: JIAO/v, JIANG/nr, LIN/nr, QU/v. Therefore, first we can fix the directional diagram of the causative key words, this is a simple sentence and it the stem of a tree. Then the diagram can be expanded by adding other parts of speech. The diagram with compound sentences looks like a tree with more branches. Figure 2 show the tree-forming procedure.

We use lines (branches) to stand for the constant in relevant location (n), circle for the variable (v), φ for blank, concentric circle for starting and ending points. From SF tree, we can see the abbreviated translation process and apparent translation result. Translation of nouns can be achieved directly by a bilingual dictionary; the blank between two nouns can be generally deleted, i.e. to get a compound word. The variable dots connect the translation to a complete target language.

Moreover, the translation tree of causative verbs develops from a stem into a tree with branches and leaves. We can make a causative translation model with SF to place most of the detailed grammatical and rhetoric translation on branches and leaves so as to reduce the translation work enormously.

### 3.3.2 The Matching of Target Language Directional

The process of translating into target language is the SF and target language matching process.

Through NTB and ETB, we can complete the SF matching from source language to target language. There are two steps to complete the matching. First, the matching of NTB and ETB, this step is simple and feasible. We set a judging point in the NTB to judge if there is any branch, this judging point can serve as an entrance to the NTB and ETB. Then, the matching of the NTB and ETB is done through matching the entrance and the end of the target language directional diagram.

Table 4 shows NTB and ETB, the top is stem NTB, ETB, the underside is branch NTB, ETB. iN is the entrance symbol of branches, which is the entrance to the branch NTB and ETB. The judgment and establishment of iN is based on the rule: the...
causative key words V+N+V followed by V, the V is a verb phrase or compound sentence.

Therefore, it is reversible from transformation table to directional graph. We can get e.g.1’s Japanese directional tree from NTB and ETB in Table 4, as shown in Fig 3.

To construct the causative SF database according to the translation principles from Chinese causative sentences to Japanese causative sentences has basically solved the problem of Chinese-Japanese translation accuracy and improved the accuracy of the translation of compound sentences to a large extent.

We deal with the irregular causative sentences with translation devices for usages, including some non-causative sentences, which are habitually translated into causative verbs.

3.3.3 Example of SF

The translation of causative sentences consists of A, B, C, D, we can apply Formula (4) to the translation of sentences constructed by A, B, C, D, which means the further abbreviation of the search and SF combination in translated text.

\[
\begin{align*}
SF_C(X_1, X_2, X_3) &= [X_1]\text{RANG}/\text{SHI}/\text{JIAO}(X_2)[V][X_3] \\
\Rightarrow SF_J(X_1, X_2, X_3) &= [X_1]\text{GA}[X_2][X_3]V \sim \text{SASERU} \\
\end{align*}
\]

A: Mama

Laoshi

Ta de hua

B: rang

jiao

shi

C: gege

xuesheng

D: jiaoxun didi.

dushu.

hen shiwang.

4 Experiments and Conclusion

To prove the accuracy and feasibility of the translation principles and algorithm, we construct an experimental system based on Chinese-Japanese causative sentences translation. The system collects and stores 5767 Chinese and Japanese causative sentences in its bilingual database. These bilingual materials are mainly from news and ordinary textbooks, 80% of them are compound sentences.

We manually tested and evaluated 200 sentences (140 compound sentences and 60 single sentences) according to the demand of specified limits and contrasted the manual and automatic modes. We analyze Chinese words with FreeICTCLAS and Japanese words with ChaSen[15]. The result of manual testing of translating target language for correctness and accuracy is shown in Table 5 as following:

<table>
<thead>
<tr>
<th>Table 5 Result of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Manual</strong></td>
</tr>
<tr>
<td>Single sentences (30)</td>
</tr>
<tr>
<td>Compound Sentences (40)</td>
</tr>
<tr>
<td><strong>Automatic</strong></td>
</tr>
<tr>
<td>Single (30)</td>
</tr>
<tr>
<td>Compound Sentences(100)</td>
</tr>
</tbody>
</table>

From the analysis of the result we can conclude that the system can basically deal with the translation correctly within the text discussion range. The main
element concerning accuracy is the accurate translation of words, which confronts us with plenty of hard tasks as to how to establish a complete and accurate SF knowledge bank, how to use it to analyze and recognize semantically and how to permeate into all aspects in Chinese and Japanese Mechanic translation. This is what we are striving for.

Reference: