Verb forms and concordance in English to Swahili machine translation[1]

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Abstract

The translation of English verb forms to Swahili is exceptionally problematic for several reasons. While English verb has only five possible forms, Swahili verb has theoretically millions of valid forms. Not all of them can be found in practice for each verb lemma. However, it is not difficult to find over two thousand forms for a single verb. The complexity derives from the noun class system and from the fact that Swahili encodes morphological and also syntactic features as part of the verb. Most of these features are prefixes, but also verb derivation by means of suffixes is common. In this report we investigate various phases in the process of constructing valid translation of verbs from English to Swahili.

Key Words: *verb inflection, machine translation*

1 Introduction

Swahili has several prefix slots for verbs, and each slot may be filled with the appropriate prefix. Each slot has up to 15 alternative prefix forms. The verb is also productive in that it normally allows several derived forms with specific meaning. Also, part of verb inflection is marked by suffixes or by alteration of the final vowel.

Because English as source language has none of these features, direct mapping is not possible. Translation requires a complex sequence of precisely designed operations. Below I will demonstrate by examples how such translation process can be constructed. Because the construction of verb forms may require information elsewhere in the sentence or in the paragraph, the examples below are sometimes longer than a sentence.

Although English does not have noun classes, information on noun classes is available, when the English nouns are given their Swahili glosses. The information available in these glosses can then be used for deriving the correct form for the verb morphemes.

2 Main phases in translation

Let us look at a simple analyzed and disambiguated sentence in (1).

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```
(1)
"<This>"
      "this" %SUBJ CAPINIT PRON DEM SG
"<was>"
      "be" %+FMAINV V PAST
"<a>"
      "a" %DN> DET SG
"<teacher>"
      "teacher" %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
```

The demonstrative pronoun *this* is in singular. However, it cannot be directly translated, because in Swahili we must also know the noun class of its referent. The referent is *teacher* and it is in singular. The verb *was* is in past tense.

We add swahili glosses to the reading and disambiguate the reading semantically (2).

```
(2)
"<This>"
      "this" { h } %SUBJ CAPINIT PRON DEM SG
"<was>"
      "be" { INFMARK+wA } MONOSLB %+FMAINV V PAST
"<a>"
      "a" %DN> DET SG
"<teacher>"
      "teacher" { 1SG 2PL alimu } HUM %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
```

The demonstrative pronoun is a single consonant *h*. The verb is *wA* and by default it has the infinitive marker, because it is a monosyllabic verb. The referent of the pronoun is *alimu*, and it has a prefix for singular and plural. In this phase the linguistic information is presented by means of linguistic tags.

The demonstrative pronoun is the subject, and the subject prefix of the verb should be in concordance with the subject. However, in this case the subject is a pronoun, and the only thing that we know from source language is that it is in singular. So we cannot directly define the subject prefix of the verb. We must first specify the noun class of the pronoun, as in (3).

```
(3)
"<This>"
      "this" { h } %SUBJ CAPINIT PRON DEM SG DEM-1
"<was>"
      "be" { INFMARK+wA } MONOSLB %+FMAINV V PAST
"<a>"
      "a" %DN> DET SG
"<teacher>"
      "teacher" { 1SG alimu } HUM %PCOMPL-S N SG NOM INDEF
"<.>"
```

```
        "."
```

Now the pronoun has the tag DEM-1, and on the basis of it we can add the subject prefix tag SP-1 and the past tense tag TAM-li to the verb. Also, the noun will have only the singular tag (4). The determiner is removed as redundant.

```
(4)
"<This>"
      "this" { h } %SUBJ CAPINIT PRON DEM SG DEM-1
"<was>"
      "be" { INFMARK+wA } MONOSLB %+FMAINV V PAST TAM-li SP-1
"<teacher>"
      "teacher" { 1SG alimu } HUM %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
```

The tags will be moved to the position, where they should be in final translation (5).

```
(5)
"<This>"
      "this" { h+DEM-1 } %SUBJ CAPINIT PRON DEM SG
"<was>"
      "be" { SP-1+TAM-li+INFMARK+wA } MONOSLB %+FMAINV V PAST
"<teacher>"
      "teacher" { 1SG alimu } HUM %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
```

The inflection tags will be converted into surface form (6).

```
(6)
"<This>"
      "this" { h+uyu } %SUBJ CAPINIT PRON DEM SG
"<was>"
      "be" { a+li+ku+wa } MONOSLB %+FMAINV V PAST
"<teacher>"
      "teacher" { mw+alimu } HUM %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
```

Translation is in (7).

```
(7)
```
Huyu alikuwa mwalimu.

3 Monosyllabic verbs

The production of correct forms in monosyllabic verbs is problematic, because some finite forms take the infinitive prefix. The rule is that if the stress would fall on the prefix, which cannot take the stress, the infinitive marker is added to take the stress. In polysyllabic verbs the infinitive marker is only in infinitive forms.

The problem can be solved in two ways. In one method, the Swahili gloss of the verb is the bare stem, without infinitive marker. Then we construct a rule system, which adds the infinitive marker in monosyllabic verbs when needed. In another method, we add the infinitive marker to the lexicon by default. The infinitive marker would appear in all verb forms, and it is then later removed, if the structure requires it. In this report we have used the latter method. The method is demonstrated below (8).

(8)
```
a.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<ate>"
      "eat" { INFMARK+lA } HUM-V MONOSLB SVO %+FMAINV V PAST TAM-
li SP-1
"<food>"
      "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
      "."
b.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
      "may" { SUBJN } %+FAUXV ACR V AUXMOD PRES TAM-na SP-1
"<eat>"
      "eat" { INFMARK+lA } HUM-V MONOSLB SVO %-FMAINV V INF TAM-
SBJN SP-1
"<food>"
      "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
      "."
c.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
      "may" { SUBJN } %+FAUXV ACR V AUXMOD PRES TAM-na SP-1
"<eat>"
      "eat" { INFMARK+lA } HUM-V MONOSLB SVO %-FMAINV V INF TAM-
SBJN SP-1 OP-9
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
d.
"<Lion>"
      "lion" { 9SG simba } AN %SUBJ N SG NOM DEF
"<may>"
```

```
        "may" { SUBJN } %+FAUXV ACR V AUXMOD PRES TAM-na SP-1
"<eat>"
        "eat" { INFMARK+lA } HUM-V MONOSLB SVO %-FMAINV V INF TAM-
SBJN SP-1 OP-2
"<people>"
        "people" { 2PL tu } %OBJ N INDEF
"<.>"
        "."
```

In ech sentence above is the verb *lA* (eat) as main verb. It is a monosyllabic transitive verb and represents the behaviour of all monosyllabic verbs. We see that in all sentences the tag INFMARK is added to the gloss by default. We move the tags to their locations in the verb (9).

```
(9)
a.
"<Man>"
        "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<ate>"
        "eat" { SP-1+TAM-li+INFMARK+lA } HUM-V MONOSLB SVO %+FMAINV
V PAST
"<food>"
        "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
        "."
b.
"<Man>"
        "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { SP-1+TAM-na+SUBJN } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { SP-1+TAM-SBJN+INFMARK+lA } HUM-V MONOSLB SVO
%-FMAINV V INF
"<food>"
        "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
        "."
c.
"<Man>"
        "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { SP-1+TAM-na+SUBJN } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { SP-1+TAM-SBJN+OP-9+INFMARK+lA } HUM-V MONOSLB SVO
%-FMAINV V INF
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
        "."
d.
```

```
"<Lion>"
      "lion" { 9SG simba } AN %SUBJ N SG NOM DEF
"<may>"
      "may" { SP-1+TAM-na+SUBJN } %+FAUXV ACR V AUXMOD PRES
"<eat>"
      "eat" { SP-1+TAM-SBJN+OP-2+INFMARK+lA } HUM-V MONOSLB SVO
%-FMAINV V INF
"<people>"
      "people" { 2PL tu } %OBJ N INDEF
"<.>"
      "."
```

Now all the morphological tags that influence the appearance if the infinitive marker are as part of a single string. Here it is possible to delete the infinitive marker where needed. Also, the tag TAM-SBJN realises as zero in its position, but moves the verb final A to e. After these modifications, the sentences are as in (9).

(9)
```
a.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<ate>"
      "eat" { SP-1+TAM-li+INFMARK+lA } HUM-V MONOSLB SVO %+FMAINV
V PAST
"<food>"
      "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
      "."
b.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
      "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
      "eat" { SP-1+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<food>"
      "food" { 7SG akula } %OBJ N SG INDEF
"<.>"
      "."
c.
"<Man>"
      "man" { 1SG anadamu } AN %SUBJ N SG NOM DEF
"<may>"
      "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
      "eat" { SP-1+OP-9+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

```
d.
"<Lion>"
        "lion" { 9SG simba } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { SP-1+OP-2+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<people>"
        "people" { 2PL tu } %OBJ N INDEF
"<.>"
        "."
```

We see that in (a), the infinitive marker is present, but in the other examples it is absent, The object marker can bear stress, as can also the subject prefix. Therefore, there is no need to retain the infinitive marker. It is tempting to think that TAM cannot bear stress. In many cases this is true, but not in all cases. The conditional -*ki*- and narrative -*ka*- do bear stress.

The tags are converted to surface form in (10).

```
(10)
a.
"<Man>"
        "man" { mw+anadamu } AN %SUBJ N SG NOM DEF
"<ate>"
        "eat" { a+li+ku+la } HUM-V MONOSLB SVO %+FMAINV V PAST
"<food>"
        "food" { ch+akula } %OBJ N SG INDEF
"<.>"
        "."
b.
"<Man>"
        "man" { mw+anadamu } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { a+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<food>"
        "food" { ch+akula } %OBJ N SG INDEF
"<.>"
        "."
c.
"<Man>"
        "man" { mw+anadamu } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { a+i+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
```

```
                "."
d.
"<Lion>"
        "lion" {  simba } AN %SUBJ N SG NOM DEF
"<may>"
        "may" { NOGLOSS } %+FAUXV ACR V AUXMOD PRES
"<eat>"
        "eat" { a+wa+le } HUM-V MONOSLB SVO %-FMAINV V INF
"<people>"
        "people" { wa+tu } %OBJ N INDEF
"<.>"
                "."
```

We also see that if the object is an inanimate noun, the object is not marked in verb (a, b). If the object is an animate noun, it is usually marked also in verb (d). If the object is a pronoun, it is only marked in verb (c).

Finally, the translation of the sentences is in (11).

(11)
a. Mwanadamu alikula chakula.
b. Mwanadamu ale chakula.
c. Mwanadamu aile.
d. Simba awale watu.

4 Translating relative constructions

Swahili has three ways of expressing relative relations. The stem *amba* can be used for that purpose, whereby the class identification is added as a suffix. Relative relation can also be expressed by adding the prefix to the verb. The third method is to add the relative marker as a suffix to the verb. The first two methods are rather productive and can be used alternatively in most constructions. The third one is so called general relative, and it can be used when the verb does not express time, and the referent of the relative marker is often a pronoun.

   Below we shall see how relative construction can be produced in each of the three ways (12).

(12)
a. He who reads it.
b. They who read it.

The text is analyzed and inflection tags are added (13).

(13)
```
a.
"<He>"
        "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
```

```
        "who" { amba } %SUBJ <Rel> PRON WH NOM REL-1
"<reads>"
        "read" { somA } HUM-V SVO %+FMAINV V PRES SG3 TAM-na SP-1
OP-9
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
        "."
b.
"<They>"
        "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
        "who" { amba } %SUBJ <Rel> PRON WH NOM REL-2
"<read>"
        "read" { somA } HUM-V SVO %+FMAINV V PAST TAM-li SP-2 OP-9
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
        "."
```

The tags are attached to lemmas (14).

```
(14)
a.
"<He>"
        "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
        "who" { amba+REL-1 } %SUBJ <Rel> PRON WH NOM
"<reads>"
        "read" { SP-1+TAM-na+OP-9+somA } HUM-V SVO %+FMAINV V PRES
SG3
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
        "."
b.
"<They>"
        "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
        "who" { amba+REL-2 } %SUBJ <Rel> PRON WH NOM
"<read>"
        "read" { SP-2+TAM-li+OP-9+somA } HUM-V SVO %+FMAINV V PAST
"<it>"
        "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
        "."
```

The referent pronoun of the relative pronoun is translated with a suffix in the relative pronoun *amba*. So the referent needs no gloss. The subject prefix of the verb is defined by the relative pronoun, which is the subject. The noun class of the object is not known. We

only know that it is non-human. In cases such as this the default is that if it is singular, the class is 9, and if it is plural, the class is 10.
We get the translation as in (15).

(15)
a. Ambaye anaisoma.
b. Ambao waliisoma.

The second way to express the relative structure is to mark it as the verb prefix (16).

```
(16)
a.
"<He>"
      "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM REL-1
"<reads>"
      "read" { somA } HUM-V SVO %+FMAINV V PRES SG3 TAM-na SP-1
OP-9 REL-1
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
b.
"<They>"
      "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM REL-2
"<read>"
      "read" { somA } HUM-V SVO %+FMAINV V PAST TAM-li SP-2 OP-9
REL-2
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

We see that the relative pronoun *who* has no gloss. The relative prefix tag has been added to the verb. The sequence of the prefixes is displayed in (17).

```
(17)
a.
"<He>"
      "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM
"<reads>"
      "read" { SP-1+TAM-na+REL-9+OP-9+somA } HUM-V SVO %+FMAINV V
PRES SG3
```

```
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
b.
"<They>"
      "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM
"<read>"
      "read" { SP-2+TAM-li+REL-2+OP-9+somA } HUM-V SVO %+FMAINV V
PAST
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

We note that although the added tags were in arbitrary order, they were moved to the verb stem in strict order. This can be done by ordering the move rules as a strict sequence, so that first is moved the object prefix, then the relative prefix, then the TAM prefix, and finally the subject prefix. If a particular prefix type is not in the structure, the next prefix type in order is moved next. By moving individual tags at a time instead of tag clusters, the rule system becomes clear and easy to maintain.

As a result, only the verb is translated and the information contained in other English words is included into the verb prefixes (18).

(18)
a. A+na+ye+i+soma.
b. Wa+li+o+i+soma.

In the third method of expressing relative structure, the relative marker is moved as a suffix. This is general relative and no TAM marker is allowed. The process is demonstrated below (19).

(19)
```
a.
"<He>"
      "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM REL-1
"<reads>"
      "read" { somA } HUM-V SVO %+FMAINV V PRES SG3 TAM-0 SP-1
OP-9 REL-SUF-1
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

```
b.
"<They>"
      "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM REL-2
"<read>"
      "read" { somA } HUM-V SVO %+FMAINV V PAST TAM-0 SP-2 OP-9
REL-SUF-2
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

The verb prefixes are collected as normal, but the relative marker is attached after the verb stem (20).

(20)
```
a.
"<He>"
      "he" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM SG3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM
"<reads>"
      "read" { SP-1+TAM-0+OP-9+somA+REL-SUF-1 } HUM-V SVO %+FMAINV
V PRES SG3
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
b.
"<They>"
      "they" { NOGLOSS } %SUBJ ACR CAPINIT PRON PERS NOM PL3
"<who>"
      "who" { NOGLOSS } %SUBJ <Rel> PRON WH NOM
"<read>"
      "read" { SP-2+TAM-0+OP-9+somA+REL-SUF-2 } HUM-V SVO %+FMAINV
V PAST
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

The translation is in (21).

(21)
a. *A+i+soma+ye.*
b. *Wa+i+soma+o.*

5 Determining the noun class of relative and object markers

In Swahili, relative markers and object markers must have the appropriate noun class concordance. This can be problematic, if the referent is a pronoun, or if the referent is beyond the sentence boundary. If the referent is human, the problem can often, but not always, be solved, because those belong to class 1 (singular) and class 2 (plural). English makes a difference between human and non-human singular (he, she, it), but not in plural (they). On the other hand, English does not make a difference between singular and plural in relative pronouns (which, that, who), but it differentiates humans (who) and non-humans (which, that). All this lack of systemacy in English causes a lot of problems in translation.

In (22) is an example, where the object is a pronoun, and it should be translated with the object prefix of the verb.

```
(22)
"<This>"
      "this" { h } %SUBJ CAPINIT PRON DEM SG DEM-5
"<is>"
      "be" { ni } MONOSLB %+FMAINV V PRES SG3
"<axe>"
      "axe" { 5SG shoka } %PCOMPL-S N SG NOM DEF
"<which>"
      "which" { amba } %SUBJ <Rel> PRON WH NOM REL-5
"<cuts>"
      "cut" { katA } HUM-V %+FMAINV V PRES SG3 TAM-na SP-1 SP-5
OP-9
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

The verb has received an object tag of the class 9. But it is not known on the basis of this sentence what the referent is. Therefore, it receives the default class 9. The translation is in (23).

(23)
H+ili ni shoka amba+lo li+na+i+kata.

Now we add a sentence before the example sentence to show what the actual referent of the object pronoun is (24). Note that determiners are removed as redundant.

```
(24)
"<That>"
      "that" { le } %SUBJ CAPINIT PRON DEM SG DEM-3
"<is>"
      "be" { ni } MONOSLB %+FMAINV V PRES SG3
"<big>"
      "big" { -kubwa } A-INFL %A> A ABS INDEF A-3
```

```
"<tree>"
      "tree" { 3SG ti } %PCOMPL-S N SG NOM INDEF
"<.>"
      "."
"<This>"
      "this" { h } %SUBJ CAPINIT PRON DEM SG DEM-5
"<is>"
      "be" { ni } MONOSLB %+FMAINV V PRES SG3 OP-3
"<axe>"
      "axe" { 5SG shoka } %PCOMPL-S N SG NOM DEF
"<which>"
      "which" { amba } %SUBJ <Rel> PRON WH NOM REL-5
"<cuts>"
      "cut" { katA } HUM-V %+FMAINV V PRES SG3 TAM-na SP-5 OP-3
"<it>"
      "it" { NOGLOSS } %OBJ ACR PRON SG3
"<.>"
      "."
```

The verb *cut* has now the tag OP-3. The rule gets information on it from the prevuous sentence. The rule is in (25).

(25)
```
ADD (OP-3) TARGET V (*1 ("it") + OBJ BARRIER CLB) (*-1 SNTB
BARRIER SNTB LINK *-1 (3SG) BARRIER N);
```

The rule reads: Add the tag OP-3 to the verb, if somewhere to the right is the pronoun it, which is in object position. Do not scan beyond clause boundary. Somewhere on the left should be sentence boundary, and before that somewhere on the left the tag 3SG. From the sentence boundary to the left, stop scanning on the first noun.

The translation now is as in (26).

(26)
U+le ni m+ti m+kubwa.
H+ili ni shoka amba+lo li+na+u+kata.

The relative prefix of the verb usually refers to the subject of the clause. It can also refer to the object. Consider the example in (27).

(27)
```
"<The>"
      "the" %DN> CAPINIT DET
"<tree>"
      "tree" { 3SG ti } %SUBJ N SG NOM DEF
"<which>"
      "which" { amba } %OBJ <Rel> PRON WH REL-3
"<I>"
      "i" { NOGLOSS } %SUBJ ACR PRON PERS NOM SG1
"<cut>"
```

```
        "cut" { katA } HUM-V %+FMAINV V PAST TAM-li SP-SG1
"<has>"
        "have" { AUX } %+FAUXV ACR V PRES SG3
"<fallen>"
        "fall" { angukA } %-FMAINV V EN TAM-me SP-3
"<.>"
        "."
```

The translation is implemented using the *amba* structure (28).

(28)
M+ti amba+o ni+li+kata u+me+anguka.

The sentence can also be translated using the prefix structure (29).

(29)
```
"<The>"
        "the" %DN> CAPINIT DET
"<tree>"
        "tree" { 3SG ti } %SUBJ N SG NOM DEF
"<which>"
        "which" { NOGLOSS } %OBJ <Rel> PRON WH
"<I>"
        "i" { NOGLOSS } %SUBJ ACR PRON PERS NOM SG1
"<cut>"
        "cut" { katA } HUM-V %+FMAINV V PAST TAM-li SP-SG1 OP-3
REL-3
"<has>"
        "have" { AUX } %+FAUXV ACR V PRES SG3
"<fallen>"
        "fall" { angukA } %-FMAINV V EN TAM-me SP-3
"<.>"
        "."
```

Note that the verb has taken the relative prefix and object prefix indirectly from the relative pronoun, which refers to tree. The rules for doing these two operations are in (30).

(30)
```
ADD (REL-3) TARGET V (-1 SUBJ) (*-1 OBJ + REL BARRIER CLB LINK -1
(3SG));
ADD (OP-3) TARGET V (-1 SUBJ) (*-1 OBJ + REL BARRIER CLB LINK -1
(3SG));
```

The translation is in (31).

(31)
M+ti ni+li+o+u+kata u+me+anguka.

6 Conclusion

The translation of verb structures from English to Swahili faces several problems because of very different ways of expressing linguistic features. The noun class system of Swahili makes the translation even more difficult. The report shows that it is possible to produce even the most complex forms using a carefully phased translation process. The remaining major challenges include how to formulate the rule system so that correct forms will be produced in all contexts.