

Intelligent Computer-Assisted Language Learning: Implementation to Swahili

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Abstract

The paper presents an Intelligent Computer-Assisted Language Learning (ICALL) system, which is based on a language analysis component. In constructing interactive learning modules, use is made of the detailed analysis results, expressed as linguistic tags, lexical forms of the words, and as glosses in English. The system is tailored for practising difficult-to-learn concordance patterns and word order in Swahili language.

Key Words: *e-learning, ICALL, CALL, Finite State Methods, disambiguation, interactive learning*

1 Introduction

The rapid development of information technology opens up new possibilities in language learning (Jager et al. 1998). The Web offers many kinds of computer-assisted language learning (CALL) tools (Kazi 2004; Galloway and Peterson-Bidoshi 2008; Cushion 2005; Heller 2005; Brandl 2002). While the capabilities of computers and mobile devices are approaching each other, the mobile technology is becoming an important environment for language learning (Chinnery 2006; Stockwell 2007: 366, 378).

The applications for learning vocabulary have been available already for several years (Segler et al. 2002; Le Loup and Ponterio 2005; Christensen et al. 2007; Zapata and Sagarra 2007; Lee 2008), as well as systems for learning collocations (Nesselhaut and Tschichold 2002) and concordances (Gabel 2001).

Also more intelligent language learning systems have been integrated into the learning system, hence the extended name Intelligent Computer-Assisted Language Learning (ICALL). There is a lot of discussion on such applications (Nerbonne 2003; Tokuda 2002; Shaalan 2005; Schulze and Penner 2008; Gamper and Knapp 2002; Moghrabi 1998). Various approaches for including 'intelligence' into the learning systems have been proposed, such as intertating Constraint Grammar and CALL (Bick 2004, 2005), a 'context sensitive' parser (Chen et al. 2002), and Intelligent Language Tutoring Systems (Toole and Heift 2002). The Visual Interactive Syntax Learning (VISL) program applies a language parser into pedagogical use (Vinther, 2004). The phrase structure rules have also been used in learning applications (Mehreen 2002; Kazi 2002).

The availability of various language analysis tools raises also the question of re-usability of resources. Wood (2008) suggests the General Architecture for Text

Engineering (GATE) as a standard, and Armitage and Bowerman (2002) emphasize the reusability, maintainability and extensibility issues in designing e-learning systems.

Also audio exercises (Cushion 2005; Cushion 2006: 204-205) and multi-media exercises (Chinnery 2006; Mallon 2006; Godwin-Jones 2007; Lee 2008) are necessary in learning living languages.

While increasingly sophisticated technical solutions have been introduced into the learning systems, also learning theories continue to be a subject of discussion (Warschauer 1996; Rüschoff and Ritter 2001; Cushion 2006; Colpaert 2006; Heilman and Eskenazi 2007; Rosell-Aguilar 2007; Farmer and Gruba 2006). Without a proper pedagogical approach, a system does not function, whatever the level of sophistication is.

This paper adds to the current discussion on ICALL by describing an e-learning approach for training difficult-to-learn language structures. The approach makes use of language analysis. It was implemented on training Swahili structures. However, the approach is language-independent, and it is considered useful particularly in learning complex concordance structures of languages with noun classes. The current system was implemented using the Xerox FST package (Beesley and Karttunen 2003).

2 Concordance patterns of Swahili

Computational analysis tools of language make it possible to develop language learning systems that give the learner a freedom to use any vocabulary in training difficult-to-learn structures of the language. Despite this freedom, the system can be made to give the learner adequate feedback and instructions on how to proceed in the learning process.

Below is a description of a language learning system, where the learner can train morphological structures and word order in Swahili, a Bantu language with noun classes and a complex agreement system. Words dependent on the noun must be in agreement with the head noun.

In the discussion below, I use the terms 'noun group' and 'noun class'.

By 'noun group' I mean the group of nouns that take the prefix in singular and plural according to the same classes. For example, all nouns that take the singular prefix according to the noun class 1, and the plural prefix according to the noun class 2, constitute a noun group, which I mark with a numerical pair 1/2. An example of a noun belonging to this noun group is *mtu* (pl. *watu*, 'human being'), which has the singular prefix *m-* (class 1) and the plural prefix *wa-* (class 2). Therefore, the noun group, to which this noun belongs, is marked as 1/2. There are, of course, also nouns that have only one class affiliation, singular or plural. These nouns are marked accordingly. An example of a noun with singular only is *uhuru* (class 11, 'freedom'), and a noun with plural only is *maji* (class 6, 'water').

The term 'noun class' refers to the unique inflection pattern, which the constituents dependent on the noun must follow. Although the markers of each class are not identical in all constituents, the class affiliation is, except for a few animates, which we will discuss below.

Therefore, in the following examples, the noun has a tag that shows its singular and plural class affiliation. All other constituents of the phrase have only one class tag, expressed by a number.

A simple example of concordance is in (1).

- (1)
ki-ti ch-angu ki-zuri ki-le ki-me- vunjika
7/8-SG-chair 7-my 7-good 7-that 7-Past-get_broken
that my good chair is broken

Here the marker of class 7 is systematically *ki-*, except for the vowel-initial *-angu*, where it is affricated as *ch-*. The morphophonological changes taking place in front of the vowel can be predicted, and they can be learned quite easily.

More difficult are the cases, where the marker is not the same in all constituents, or where the marker is missing altogether in one or more constituents. Examples are in (2 and 3).

- (2)
saa y-angu n-zuri i-le i-me- potea
9/10-SG-watch 9-my 9-good 9-that 9-Past-get_lost
that my good watch has got lost

The noun *saa* that belongs to noun group 9/10 has a zero prefix. The possessive pronoun *-angu* has the prefix *i-*, which, when followed by the vowel-initial stem, becomes *y-*. The adjective *-zuri*, which starts with a voiced consonant, gets the prefix *n-*. The demonstrative pronoun *-le* gets the prefix *-i*. And the subject prefix, when followed by a consonant, is *i-*. Although all constituents agree in class 9, the surface form of the class marker varies.

- (3)
saa z-angu n-zuri zi-le zi-mepotea
9/10-PL-watch 10-my 10-good 10-that 10-get_lost
those my good watches have got lost

In (3), all constituents inflect according to class 10. In nouns, the class marker is the same in singular and plural, in this case a zero prefix. Also the modifying adjective has the same marker in singular and plural; in this case it is *n-*. The possessive pronoun *-angu* and the demonstrative pronoun *-le*, as well as the subject prefix of the verb, are different than in singular.

Many adjectives and numerals of Arabic origin do not take a noun class marker at all (4).

- (4)
vi-ti vy-angu imara vi-le sita vi-me- uz- wa
7/8-PL-chair 8-my 8-strong 8-those 8-six 8-Past-sell-Pass
those my six strong chairs have been sold

Particularly difficult to learn are such structures, where two different principles for assigning the noun class are in conflict. Such situations occur when the noun is an animate and semantically it should inflect according to the noun group 1/2 (class 1 in singular and class 2 in plural), but in regard to its form it should belong to another noun

group. Let us look first at a regular case (5). All units inflect according to class 1, although the prefix forms vary, depending on the prefix set they belong to.

(5)
m-toto w-angu m-zuri yu-le a-na- soma
1/2-SG-child 1-my 1-good 1-that 1-Pres-read
that my good child reads

There are cases, where also the noun class may be different on various constituents. To avoid conflicting concordances, some scholars classify animate nouns that are without class prefix into noun group 1a/2a, which is then a subclass of noun group 1/2. In this group, there are nouns including humans and animals. However, this does not solve the problem in cases 6 and 7, because the possessive pronoun inflects according to classes 9 and 10. Therefore, I classify these animate nouns into noun group 9/10, whereby in (6) the class affiliation is 9+9+1+1+1, and in (7) 10+10+2+2+2.

(6)
dada y-angu m-zuri yu-le a-na- soma
9/10-SG-sister 9-my 1-good 1-that 1-Pres-read
that my good sister reads

(7)
dada z-angu wa-zuri wa-le wa-na- soma
9/10-PL-sister 10-my 2-good 2-that 2-Pres-read
those my good sisters read

Another set of animates, all of them humans, have the prefix *ma-* in plural, but no prefix in singular (8 and 9). I have classified them as noun group 9/6 because of their formal properties. However, all dependent constituents, even the possessive pronoun, inflect according to classes 1 and 2. The class affiliation in (8) is 9+1+1+1+1, and in (9) 6+2+2+2+2.

(8)
bwana w-angu m-zuri yu-le a-na- soma
9/6-SG-master 1-my 1-good 1-that 1-Pres-read
that my good master reads

(9)
ma-bwana w-angu wa-zuri wa-le wa-na- soma
9/6-PL-master 2-my 2-good 2-that 2-Pres-read
those my good masters read

Other types of problematic cases are in examples (10-13), where the noun is animate, human or animal, and belongs to noun group 7/8. In these, all depending constituents inflect according to classes 1 and 2. The class affiliation in (10) and (12) is 7+1+1+1+1, and in (11) and (13) 8+2+2+2+2.

(10)
ki-boko w-angu m-zuri yu-le a-na- ogelea
7/8-SG-hippo 1-my 1-good 1-that 1-Pres-swim
that my good hippo swims

(11)
vi-boko w-angu wa-zuri wa-le wa-na- ogelea
7/8-PL-hippo 2-my 2-good 2-those 2-Pres-swim
those my good hippos swim

(12)
ki-ziwi w-angu m-zuri yu-le a-na- ona
7/8-SG-mute 1-my 1-good 1-that 1-Pres-see
that my good mute sees

(13)
vi-ziwi w-angu wa-zuri wa-le wa-na- ona
7/8-PL-mute 2-my 2-good 2-those 2-Pres-see
those my good mutes see

The above examples show that basically the noun class concordance in Swahili is systematic, so that each of the constituents depending on the noun has the noun class marker of the governing noun. Yet several such cases also occur, where the class affiliation of more than one class is present. All this complicates the system, because also the exceptional cases have to be correctly handled.

It can be seen in the above examples that when there is the class affiliation overtly declared, it is possible to write rules for identifying correct sequences of words. Ultimately, it is the noun class affiliation that is decisive in judging whether the string is correct or not, and not the surface form of the word.

3 The Approach

The central idea in devising the language learning system was that it should be flexible, allowing for maximal freedom for the learner to train with words on his/her own choosing. At the same time it should be accurate, so that it detects any type of error, whether in concordance, word order, word combination, or a typing error. Each type of error should be detected and information given to the learner according to the type of error.

In order to achieve this, the following requirements should be met:

- (a) Each word-form gets grammatical interpretation. This means that words need to be analyzed first.
- (b) Although most morphological analyzers work on the principle that each input line contains only one word or multi-word unit, the learning system must allow for several words on the same line. To achieve this, the morphological analyzer must be constructed to allow the combination of words.
- (c) The system must allow all kinds of word combinations, also wrong ones, so that the word-level analysis will be computed for all kinds of word sequences.

- (d) Only wrong word-forms, but not wrong word sequences, are allowed to be left without analysis.
- (e) After analysis, there will be two kinds of output strings: those that were analyzed and those that were not.
- (f) The system must identify various types of mistakes that the learner makes, such as the wrong word order and wrong concordance.
- (g) It also has to tell in which words the mistakes are, and what types of mistakes they are.
- (h) The system must allow for full self-learning, where the learner decides which words and which structures to use in training.
- (i) The system must also allow for guided training, where the system instructs step by step what to do next, while at the same time controlling whether there are mistakes. And if mistakes occur, they are reported accordingly.

In implementing the system sketched above, we encounter problems that have to be accounted for. Below I sketch out some of them and also show how to solve them.

4 Allowing sequences of words

Morphological parsers normally operate on the word level, handling each individual word separately. In the language learning system discussed here, we have to allow the concatenation of words, whereby the whole sequence of input words will be analyzed as one string. An example of a sub-lexicon that allows the concatenation of words is in (14). The notation of the Xerox FST package is used in the example.

```
(14)
Lexicon NounStem
tu N;

Lexicon N
# ;
% +POSS:% PronPoss;
% +ADJ:% Adjectives;
% +DEM:% PronDem;
% +NUM:% Num;
% +V:% Verbs;
```

The sub-lexicon with the name NounStem (14) allows the noun 'tu' to be terminated (the first entry '#' in Lexicon N). The other entries show the names of the sub-lexicons, where string recognition can continue. Note that the system expects that there is precisely one empty space between the input words.¹

¹The percent sign '%' in front of the space indicates that the 'character' that follows is a literal space, that is, the space between words. One must be careful in writing the lexicon. After the percent sign '%', there must be at least TWO empty spaces, one for the literal empty space, and another for separating the lexical part and the continuation class from each other.

5 Ambiguity

The word-forms in language tend to be ambiguous, that is, a word-form may have more than one interpretation. It is well known that the more comprehensive the analysis system is, the more ambiguity it also contains. In a language learning system, ambiguity should be avoided. The system should give only correct judgements. Ambiguity on word level is exemplified in (15).²

(15)
umeanguka +V+1-SG2-SP+PERF-ME{fall_down}anguka
umeanguka +V+3-SG-SP+PERF-ME{fall_down}anguka
umeanguka +V+11-SG-SP+PERF-ME{fall_down}anguka

When we combine more than one word into the string, the ambiguity of the first word is multiplied by the ambiguity of the second word, etc. Ultimately we find strings that have more than one thousand interpretations, if concordance rules are excluded. An example of how the number of words increases ambiguity is in (16).

(16)
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+3-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+3-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+3-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+11-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+11-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +DEM+11-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +DEM+3-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +DEM+3-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +DEM+3-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka

²In this notation, all grammatical and lexical information on a word is written as a single string without spaces. Each grammatical tag is written in capital and is preceded by the plus sign '+'. English glosses are surrounded by curly brackets '{' and '}'. The stem of the word is in the end of the string. However, demonstrative pronouns are produced in full because the formation of the stem in some of them is non-concatenative.

mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu
+DEM+11-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu
+DEM+11-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+2-PL{my}angu
+DEM+11-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +DEM+3-
SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +DEM+3-
SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +DEM+3-
SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+DEM+11-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+DEM+11-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+DEM+11-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+3-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+3-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+3-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+11-SG{that}ule +V+1-SG2-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+11-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka
mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+11-SG{my}angu
+DEM+11-SG{that}ule +V+11-SG-SP+PERF-ME{fall_down}anguka

It is clear that resolving ambiguity is a key issue in constructing the kind of language learning system we discuss here. Rule-based disambiguation systems are constructed so that ambiguity of a word is resolved using contextual information as criteria for writing rule constraints. Such disambiguation systems could probably be used also for the current purpose, although they work best with full-text analysis. Structures to be trained with this program are important sections of sentences, and most of ambiguity could be resolved using general disambiguation rules.

It is possible, however, to write also specific disambiguation rules for this particular purpose. The current language learning system was implemented using regular expressions in writing disambiguation rules. Through these rules, all such strings were disallowed that do not satisfy concordance rules. In this way, only one string became selected as the correct one, and the other ones were discarded. When applying the disambiguation rules, the correct reading is selected, and the ambiguous string in (16) becomes non-ambiguous as in (17).

(17)

mti wangu ule umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +DEM+3-SG{that}ule +V+3-SG-SP+PERF-ME{fall_down}anguka

One could perhaps be satisfied, if the system tells whether the string is correct, or whether the word order is wrong, or whether one or more of the words is incorrectly written. But it is possible to do much more. For example, if we construct the system so that any sequence of words in a noun phrase is accepted, provided that it fulfils the concordance rules, we get a temporarily accepted string. But with additional rules we can check whether there are mistakes in word order. And if there is a mistake, we can give the learner precise feedback on it.

6 Resolving ambiguity

The approach in disambiguation is that all readings of each word in the string are allowed, and the string that is correct, that is, follows concordance rules, is marked as correct (= OK). In (18), there is a string with two constituents.

(18)

mti mzuri +N+3/4-SG{tree}mti +ADJ+1-SG{good}zuri
 mti mzuri +N+3/4-SG{tree}mti +ADJ+3-SG{good}zuri **OK2**
 mti mzuri +N+3/4-SG{tree}mti +ADJ+11-SG{good}zuri

When the possessive pronoun (19) is added, there will be more ambiguity, but the correct reading can be marked.

(19)

mti wangu mzuri +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri
OK3
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+3-SG{good}zuri
 mti wangu mzuri +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+11-SG{good}zuri

Again, adding the demonstrative pronoun increases ambiguity (20).

(20)

mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu
 mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu
 mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu

mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+3-SG{this}huu **OK4**
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+11-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+3-SG{this}huu
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+11-
SG{good}zuri +DEM+11-SG{this}huu

When a numeral is added, the ambiguity increases further (21).

(21)

mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-
SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja

mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+1-SG{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja

mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+2-PL{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+11-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja **OK5**
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+11-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri +DEM+3-SG{this}huu +NUM+11-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+1-SG{one}moja
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+11-SG{my}angu +ADJ+1-SG{good}zuri +DEM+11-SG{this}huu +NUM+3-SG{one}moja

mti wangu mzuri huu mmoja umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja +V+3-SG-
SP+PERF-ME{fall_down}anguka **OK6**
mti wangu mzuri huu mmoja umeanguka +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja +V+11-SG-
SP+PERF-ME{fall_down}anguka
...

7 Selecting the correct reading

As can be seen in the examples (18-22), each correct reading is marked with a tag OK[1-6] (the number indicates how many constituents the string has). In the next phase, the lines with this tag will be selected, as in (23-27).

(23)
mti mzuri +N+3/4-SG{tree}mti +ADJ+3-SG{good}zuri **OK2**

(24)
mti wangu mzuri +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-
SG{good}zuri **OK3**

(25)
mti wangu mzuri huu +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-
SG{good}zuri +DEM+3-SG{this}huu **OK4**

(26)
mti wangu mzuri huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-SG{one}moja **OK5**

(27)
mti wangu mzuri huu mmoja umeanguka +N+3/4-SG{tree}mti +POSS+3-
SG{my}angu +ADJ+3-SG{good}zuri +DEM+3-SG{this}huu +NUM+3-
SG{one}moja +V+3-SG-SP+PERF-ME{fall_down}anguka **OK6**

8 Constructing interactive learning dialogues

The interpretations produced by the linguistic analyzer³ constitute the basis for constructing the interactive learning system. Using pattern matching techniques and loops with appropriate output for each loop, it is possible to construct many kinds of learning modules.

Because the output contains the original string, the stem of each word, the gloss in English, and grammatical tags for each word, it is possible to construct the patterns using

³ It is not appropriate to talk about a morphological analyzer here, because the system does more than morphological analysis. It controls also the correct word order, as well as the concordance between various constituents.

various degrees of specificity. One can use the word-specific features as well as grammatical categories in defining patterns.

8.1 Controlling word order

The word order in Swahili is quite strict. The general rule in noun phrases is: Noun+Poss+Adj+Dem+Num. An exception is the demonstrative pronoun, which can also appear before the noun: Dem+Noun+Poss+Adj+Num. In the learning system, both constructions are allowed. Below are some examples on how the violations of word order rules are reported to the learner.

For example, the occurrence of a possessive pronoun before a noun is not allowed. This can be done at least in two ways. The first method is to construct the lexicon so that from the sub-lexicon of possessive pronouns the access to the sub-lexicons of nouns is blocked. Using this method, only yes/no answers can be given, as exemplified in (28).

(28)
\$ wangu mtoto

wangu mtoto +?

In the second method, access from the possessive pronoun to a noun is allowed in the lexicon, as in (29). The construction is not correct, but because here the analysis of the whole string is given, a loop can be written to point out where the mistake is. The pattern for issuing the warning should be formulated so that +POSS precedes +N. If this is true, then a warning is given as in (29).

(29)
\$ wangu mtoto

Please check word order! Possessive pronoun can't be before a noun.
wangu mtoto +POSS+1-SG{my}angu +N+1/2-SG{child}mtoto

Also any other wrong word order can be handled using the same method (30).

(30)
\$ mzuri mtoto

Please check word order! Adjective can't be before a noun.
mzuri mtoto +ADJ+1-SG{good}zuri +N+1/2-SG{child}mtoto

A similar check can be done also in longer strings (31 and 32).

(31)
\$ wangu mtoto mzuri

Please check word order! Possessive pronoun can't be before a noun!
wangu mtoto mzuri +POSS+1-SG{my}angu +N+1/2-SG{child}mtoto +ADJ+1-SG{good}zuri

(32)
\$ mtoto wangu mzuri mmoja huyu

Please check word order! Numeral can't be before a demonstrative pronoun!

mtoto wangu mzuri mmoja huyu +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu
+ADJ+1-SG{good}zuri +NUM+1-SG{one}moja +DEM+1-SG{this}huyu

8.2 Reporting in free learning environment

The system is constructed so that the learner is not restricted in regard to vocabulary in practising constructions. This means that any nouns, possessive pronouns, adjectives, demonstrative pronouns and verbs can be used in training. It is also possible to use any of the millions of verb structures. The unlimited use of numbers is perhaps not necessary in training, but if needed, also this can be implemented.

The learner using the free learning alternative can get four types of responses.

First, if there is an error in typing any of the words in the string, an error message is given by the analysis system, and no analysis is given. Currently the system does not specify what the error is, and it would not be easy to implement such a system, because learners can type all kinds of errors. Therefore, if an error is typed, it is interpreted just as an error in typing, and an error message is given as in (33).

(33)
\$ wtoto zangu

Please check that spelling is correct!

wtoto zangu +?

Second, if the spelling is correct but the concordance is wrong, the following response is given.

(34)
\$ watoto zangu

Please check the concordance!

watoto zangu +N+1/2-PL{child}mtoto +POSS+10-PL{my}angu

Third, an error message is given, if the word order is not correct. Although this problem was discussed above, an example is give also here for the sake of completeness (35).

(35)
\$ mzuri mtoto

Please check word order! Adjective can't be before a noun.

mzuri mtoto +ADJ+1-SG{good}zuri +N+1/2-SG{child}mtoto

Fourth, if the string is correct, a message of correctness is given. Also various additional messages can be given. Examples are in (36-39).

(36)
\$ mtoto anasoma

Quite simple. Try something more difficult!

mtoto anasoma +N+1/2-SG{child}mtoto +V+1-SG3-SP+PR-NA{read}soma

(37)
\$ kitabu changu kizuri

This is a bit more demanding. It is correct!

kitabu changu kizuri +N+7/8-SG{book}kitabu +POSS+7-SG{my}angu +ADJ+7-SG{good}zuri

(38)
\$ uhuru wetu mzuri unatufaa

It becomes better! Correct!

uhuru wetu mzuri unatufaa +N+11-SG{freedom}uhuru +POSS+11-SG{our}etu
+ADJ+11-SG{good}zuri +V+11-SG-SP+PR-NA+2-PL-OBJ{suit}faa

(39)
\$ mtoto wangu mzuri huyu mmoja anasoma

OK. This is a full sentence with a long noun phrase.

mtoto wangu mzuri huyu mmoja anasoma +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+1-SG{this}huyu +NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA{read}soma

9 Guided learning tours

Learning a language is a complicated process, and many kinds of training options should be offered. Especially on the elementary level, the learner needs detailed guidance. Guided learning tours are important for ensuring that all sections of the subject will be studied. The present system described below tempts (or forces) the learner to do everything faithfully, because there is no possibility to skip any section or to look for the correct answer⁴.

Below is a demonstration of how such a guided learning tour functions. Initially, the learner types the word 'mtoto' and follows further instructions in the output. This is a sort of grand tour, where the learner is guided through the concordance patterns of all noun classes. This is perhaps suitable for an advanced learner, who already masters regular concordances, but has difficulties with exceptional cases. Because of space limitations, only the first part of the tour is presented here (40).

(40)

⁴ Of course, correct answers to the exercises can be made available, but preferably not directly accessible, so that the learner does not too easily fall into temptation to look at it.

\$ mtoto

OK. Combine this noun with adjective 'zuri'!

mtoto +N+1/2-SG{child}mtoto

\$ mtoto mzuri

OK. Add to this string a possessive pronoun 'angu'!

mtoto mzuri +N+1/2-SG{child}mtoto +ADJ+1-SG{good}zuri

\$ wangu mtoto mzuri

Please check word order! Possessive pronoun can't be before a noun!

wangu mtoto mzuri +POSS+1-SG{my}angu +N+1/2-SG{child}mtoto +ADJ+1-SG{good}zuri

\$ mtoto wangu mzuri

OK. Add to this string a numeral!

mtoto wangu mzuri +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri

\$ mtoto wangu mzuri mmoja

OK. Add to this string a demonstrative pronoun!

mtoto wangu mzuri mmoja +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +NUM+1-SG{one}moja

\$ mtoto wangu mzuri mmoja huyu

Please check word order! Numeral can't be before a demonstrative pronoun!

mtoto wangu mzuri mmoja huyu +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +NUM+1-SG{one}moja +DEM+1-SG{this}huyu

\$ mtoto wangu mzuri huyu mmoja

OK. Add to this string the verb 'soma'!

mtoto wangu mzuri huyu mmoja +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+1-SG{this}huyu +NUM+1-SG{one}moja

\$ mtoto wangu mzuri huyu mmoja anasoma

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'watoto'!

mtoto wangu mzuri huyu mmoja anasoma +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+1-SG{this}huyu +NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA{read}soma

\$ mtoto wangu mzuri huyu mmoja anayesoma

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'watoto'!

mtoto wangu mzuri huyu mmoja anayesoma +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+1-SG{this}huyu +NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA+1-SG-REL{read}soma

\$ mtoto wangu mzuri huyu mmoja anayekisoma

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'watoto'!

mtoto wangu mzuri huyu mmoja anayekisoma +N+1/2-SG{child}mtoto +POSS+1-SG{my}angu +ADJ+1-SG{good}zuri +DEM+1-SG{this}huyu +NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA+1-SG-REL+7-SG-OBJ{read}soma

\$ watoto

OK. Combine this noun with adjective 'zuri'!

watoto +N+1/2-PL{child}mtoto

\$ watoto wazuri

OK. Add to this string a possessive pronoun 'angu'!

watoto wazuri +N+1/2-PL{child}mtoto +ADJ+2-PL{good}zuri

\$ watoto wangu wazuri

OK. Add to this string a numeral!

watoto wangu wazuri +N+1/2-PL{child}mtoto +POSS+2-PL{my}angu +ADJ+2-PL{good}zuri

\$ watoto wangu wazuri watatu

OK. Add to this string a demonstrative pronoun!

watoto wangu wazuri watatu +N+1/2-PL{child}mtoto +POSS+2-PL{my}angu +ADJ+2-PL{good}zuri +NUM+2-PL{three}tatu

\$ watoto wangu wazuri hawa watatu

OK. Add to this string the verb 'soma'!

watoto wangu wazuri hawa watatu +N+1/2-PL{child}mtoto +POSS+2-PL{my}angu +ADJ+2-PL{good}zuri +DEM+2-PL{these}hawa +NUM+2-PL{three}tatu

\$ watoto wangu wazuri hawa watatu wanasoma

OK. Now exercise structures with other noun classes. Type 'mti'!

watoto wangu wazuri hawa watatu wanasoma +N+1/2-PL{child}mtoto +POSS+2-PL{my}angu +ADJ+2-PL{good}zuri +DEM+2-PL{these}hawa +NUM+2-PL{three}tatu +V+2-PL3-SP+PR-NA{read}soma

\$ mti

OK. Combine this noun with adjective 'kubwa'!

mti +N+3/4-SG{tree}mti

\$ mti mkubwa

OK. Add to this string a possessive pronoun 'angu'!

mti mkubwa +N+3/4-SG{tree}mti +ADJ+3-SG{big}kubwa

\$ mti wangu mkubwa

OK. Add to this string a numeral!

mti wangu mkubwa +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{big}kubwa

\$ mti wangu mkubwa mmoja

OK. Add to this string a demonstrative pronoun!

mti wangu mkubwa mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+ADJ+3-SG{big}kubwa +NUM+3-SG{one}moja

\$ mti wangu mkubwa huu mmoja

OK. Add to this string the verb 'ota'!

mti wangu mkubwa huu mmoja +N+3/4-SG{tree}mti +POSS+3-SG{my}angu
+ADJ+3-SG{big}kubwa +DEM+3-SG{this}huu +NUM+3-SG{one}moja

\$ mti wangu mkubwa huu mmoja unaota

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'miti'!

mti wangu mkubwa huu mmoja unaota +N+3/4-SG{tree}mti +POSS+3-SG{my}angu +ADJ+3-SG{big}kubwa +DEM+3-SG{this}huu +NUM+3-SG{one}moja +V+3-SG-SP+PR-NA{grow}ota

\$ miti

OK. Combine this noun with adjective 'kubwa'!

miti +N+3/4-PL{tree}mti

\$ miti mikubwa

OK. Add to this string a possessive pronoun 'angu'!

miti mikubwa +N+3/4-PL{tree}mti +ADJ+4-PL{big}kubwa

\$ miti mikubwa

OK. Add to this string a numeral!

miti yangu mikubwa +N+3/4-PL{tree}mti +POSS+4-PL{my}angu +ADJ+4-PL{big}kubwa

\$ miti mikubwa minne

OK. Add to this string a demonstrative pronoun!

miti yangu mikubwa minne +N+3/4-PL{tree}mti +POSS+4-PL{my}angu +ADJ+4-PL{big}kubwa +NUM+4-PL{four}nne

\$ miti mikubwa hii minne

OK. Add to this string the verb 'ota'!

miti yangu mikubwa hii minne +N+3/4-PL{tree}mti +POSS+4-PL{my}angu +ADJ+4-PL{big}kubwa +DEM+4-PL{these}hii +NUM+4-PL{four}nne

\$ miti mikubwa hii minne imeota

OK. Now exercise structures with other noun classes. Type 'funzo'!

miti yangu mikubwa hii minne imeota +N+3/4-PL{tree}mti +POSS+4-PL{my}angu +ADJ+4-PL{big}kubwa +DEM+4-PL{these}hii +NUM+4-PL{four}nne +V+4-PL-SP+PERF-ME{grow}ota

\$ miti mikubwa hii minne imeoteshwa

OK. Now exercise structures with other noun classes. Type 'funzo'!

miti yangu mikubwa hii minne imeoteshwa +N+3/4-PL{tree}mti +POSS+4-PL{my}angu +ADJ+4-PL{big}kubwa +DEM+4-PL{these}hii +NUM+4-PL{four}nne +V+4-PL-SP+PERF-ME{grow}ot+CAUSesh+PASSwa

In the exercise above (40), only the concordance of two noun groups (1/2 and 3/4) was practised, and these are regular cases. The learner types first a given noun, and after executing it the response (if typing is correct) guides to the next step. When the maximum string of six constituents is ready, the learner is guided to type a given noun of the next noun group. The tour goes on through all the different noun groups, including the exceptional cases.

Some exceptional cases are in (41).

(41)

\$ bibi

OK. Combine this noun with adjective 'zuri'!

bibi +N+HUM+9/6-SG{lady}bibi

\$ bibi mzuri

OK. Add to this string a possessive pronoun 'enu'!

bibi mzuri +N+HUM+9/6-SG{lady}bibi +ADJ+1-SG{good}zuri

\$ bibi yenu mzuri

OK. Add to this string a numeral!

bibi yenu mzuri +N+HUM+9/6-SG{lady}bibi +POSS+9-SG{your}enu +ADJ+1-SG{good}zuri

\$ bibi yenu mzuri mmoja

OK. Add to this string a demonstrative pronoun!

bibi yenu mzuri mmoja +N+HUM+9/6-SG{lady}bibi +POSS+9-SG{your}enu +ADJ+1-SG{good}zuri +NUM+1-SG{one}moja

\$ bibi yenu mzuri mmoja

OK. Add to this string the verb 'tembea'!

bibi yenu mzuri yule mmoja +N+HUM+9/6-SG{lady}bibi +POSS+9-SG{your}enu +ADJ+1-SG{good}zuri +DEM+1-SG{that}yule +NUM+1-SG{one}moja

\$ bibi yenu mzuri mmoja anatembea

OK. Now do the same exercise using plural forms. Start by typing 'mabibi'!

bibi yenu mzuri yule mmoja anatembea +N+HUM+9/6-SG{lady}bibi +POSS+9-SG{your}enu +ADJ+1-SG{good}zuri +DEM+1-SG{that}yule +NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA{walk}tembea

\$ mabibi

OK. Combine this noun with adjective 'zuri'!

mabibi +N+HUM+9/6-PL{lady}bibi

\$ mabibi wazuri

OK. Add to this string a possessive pronoun 'enu'!

mabibi wazuri +N+HUM+9/6-PL{lady}bibi +ADJ+2-PL{good}zuri

\$ mabibi yenu wazuri

OK. Add to this string a numeral!

mabibi yenu wazuri +N+HUM+9/6-PL{lady}bibi +POSS+6-PL{your}enu +ADJ+2-PL{good}zuri

\$ mabibi yenu wazuri wawili

OK. Add to this string a demonstrative pronoun!

mabibi yenu wazuri wawili +N+HUM+9/6-PL{lady}bibi +POSS+6-PL{your}enu +ADJ+2-PL{good}zuri +NUM+2-PL{two}wili

\$ mabibi yenu wazuri wale wawili

OK. Add to this string the verb 'tembea'!

mabibi yenu wazuri wale wawili +N+HUM+9/6-PL{lady}bibi +POSS+6-
PL{your}enu +ADJ+2-PL{good}zuri +DEM+2-PL{those}wale +NUM+2-
PL{two}wili

\$ mabibi yenu wazuri wale wawili wanatembea

OK. Now exercise structures with exceptional concordance. Type 'ndugu'!

mabibi yenu wazuri wale wawili wanatembea +N+HUM+9/6-PL{lady}bibi
+POSS+6-PL{your}enu +ADJ+2-PL{good}zuri +DEM+2-PL{those}wale
+NUM+2-PL{two}wili +V+2-PL3-SP+PR-NA{walk}tembea

We note that *bibi* is animate (human), and belongs to noun group 9/6. The possessive pronoun inflects according to this group (class 9 in singular and class 6 in plural), but all other constituents according to classes 1 (singular) and 2 (plural).

A slightly different case is *ndugu* in (42).

(42)

\$ ndugu

OK. Combine this noun with adjective 'pole'!

ndugu +N+HUM+9/10-SG{brother}ndugu

\$ ndugu mpole

OK. Add to this string a possessive pronoun 'ako'!

ndugu mpole +N+HUM+9/10-SG{brother}ndugu +ADJ+1-SG{gentle}pole

\$ ndugu yako mpole

OK. Add to this string a numeral!

ndugu yako mpole +N+HUM+9/10-SG{brother}ndugu +POSS+9-SG{your}ako
+ADJ+1-SG{gentle}pole

\$ ndugu yako mpole mmoja

OK. Add to this string a demonstrative pronoun!

ndugu yako mpole mmoja +N+HUM+9/10-SG{brother}ndugu +POSS+9-SG{your}ako
+ADJ+1-SG{gentle}pole +NUM+1-SG{one}moja

\$ ndugu yako mpole huyu mmoja

OK. Add to this string the verb 'shughulika'!

ndugu yako mpole huyu mmoja +N+HUM+9/10-SG{brother}ndugu +POSS+9-
SG{your}ako +ADJ+1-SG{gentle}pole +DEM+1-SG{this}huyu +NUM+1-
SG{one}moja

\$ ndugu yako mpole huyu mmoja anashughulika

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'ndugu'. Note that singular and plural are the same!

ndugu yako mpole huyu mmoja anashughulika +N+HUM+9/10-SG{brother}ndugu
+POSS+9-SG{your}ako +ADJ+1-SG{gentle}pole +DEM+1-SG{this}huyu
+NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA{be_busy}shughulika

\$ ndugu

OK. Combine this noun with adjective 'pole'!

ndugu +N+HUM+9/10-SG{brother}ndugu

\$ ndugu wapole

OK. Add to this string a possessive pronoun 'ako'!

ndugu wapole +N+HUM+9/10-PL{brother}ndugu +ADJ+2-PL{gentle}pole

\$ ndugu zako wapole

OK. Add to this string a numeral!

ndugu zako wapole +N+HUM+9/10-PL{brother}ndugu +POSS+10-
PL{your}ako +ADJ+2-PL{gentle}pole

\$ ndugu zako wapole watatu

OK. Add to this string a demonstrative pronoun!

ndugu zako wapole watatu +N+HUM+9/10-PL{brother}ndugu +POSS+10-
PL{your}ako +ADJ+2-PL{gentle}pole +NUM+2-PL{three}tatu

\$ ndugu zako wapole wale watatu

OK. Add to this string the verb 'shughulika'!

ndugu zako wapole wale watatu +N+HUM+9/10-PL{brother}ndugu +POSS+10-
PL{your}ako +ADJ+2-PL{gentle}pole +DEM+2-PL{those}wale +NUM+2-
PL{three}tatu

\$ ndugu zako wapole wale watatu wanashughulika

OK. Now continue exercising structures with exceptional concordance. Type 'kifaru'!

ndugu zako wapole wale watatu wanashughulika +N+HUM+9/10-PL{brother}ndugu
+POSS+10-PL{your}ako +ADJ+2-PL{gentle}pole +DEM+2-PL{those}wale
+NUM+2-PL{three}tatu +V+2-PL3-SP+PR-NA{be_busy}shughulika

In the exercise above (42), *ndugu* belongs to noun group 9/10. The concordance of the possessive pronoun follows this group, but the constituents follow classes 1 and 2.

Still a third type of exceptional animate concordance is described in (43).

(43)

\$ kifaru

OK. Combine this noun with adjective 'nono'!

kifaru +N+7/8-SG+AN{rhinoceros}kifaru

\$ kifaru mnono

OK. Add to this string a possessive pronoun 'etu'!

kifaru mnono +N+7/8-SG+AN{rhinoceros}kifaru +ADJ+1-SG{fat}nono

\$ kifaru wetu mnono

OK. Add to this string a numeral!

kifaru wetu mnono +N+7/8-SG+AN{rhinoceros}kifaru +POSS+1-SG{our}etu
+ADJ+1-SG{fat}nono

\$ kifaru wetu mnono mmoja

OK. Add to this string a demonstrative pronoun!

kifaru wetu mnono mmoja +N+7/8-SG+AN{rhinoceros}kifaru +POSS+1-
SG{our}etu +ADJ+1-SG{fat}nono +NUM+1-SG{one}moja

\$ kifaru wetu mnono huyu mmoja

OK. Add to this string the verb 'tembea'!

kifaru wetu mnono huyu mmoja +N+7/8-SG+AN{rhinoceros}kifaru +POSS+1-
SG{our}etu +ADJ+1-SG{fat}nono +DEM+1-SG{this}huyu +NUM+1-
SG{one}moja

\$ kifaru wetu mnono huyu mmoja anatembea

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'vifaru'!

kifaru wetu mnono huyu mmoja anatembea +N+7/8-SG+AN{rhinoceros}kifaru
+POSS+1-SG{our}etu +ADJ+1-SG{fat}nono +DEM+1-SG{this}huyu +NUM+1-
SG{one}moja +V+1-SG3-SP+PR-NA{walk}tembea

In (43) above, the animate (non-human) noun belongs to noun group 7/8, and the possessive pronoun, as well as all other constituents, inflect according to classes 1 and 2. Animate (human) nouns inflect in the same way, as shown in (44).

(44)

\$ kiziwi wetu maskini huyu mmoja anaomba

OK. This is a full sentence with a long noun phrase. Now do the same exercise using plural forms. Start by typing 'viziwi'!

kiziwi wetu maskini huyu mmoja anaomba +N+7/8-SG+HUM{deaf}kiziwi +POSS+1-
SG{our}etu +ADJ+A-UNINFL-SG{poor}maskini +DEM+1-SG{this}huyu
+NUM+1-SG{one}moja +V+1-SG3-SP+PR-NA{pray}omba

10 Considerations on user-friendliness and extension of the system

A technically smart approach does not guarantee that the learning system is user-friendly (Lonfils and Vanparys 2001). For example, in the examples above, the user might not want to see all the detailed analysis of the strings. Also the style of responding is a delicate issue. Some would like to know whether the string is correct or not and no further explanations. Others would be delighted to see some encouragement and humour in responses. Some prefer long training sessions, and others like short ones.

This paper does not suggest an ideal training system. Its purpose is to describe what kinds of solutions can be implemented in devising an intelligent computer-assisted language learning (ICALL) system. The key solution in the system is the use of a language analyzer and a comprehensive vocabulary as a basis, on which the interactive learning system can be constructed. The advantage of the system is that the learner does not encounter limits in using vocabulary. Also many kinds of guided learning sessions can be constructed.

So far the system is tailored for training the most difficult parts in learning Swahili, that is, the concordance patterns and word order. It does not check the correctness of whole sentences. It checks the correctness of concordance between the subject and the main verb if the verb follows directly after the noun phrase, but not if there are other sentence elements in between.

If needed, training can be extended also to cover the concordance of any subject and object construction, as well as relative constructions. This, however, would benefit greatly from the proper disambiguation and syntactic mapping, which was not done in the implementation discussed here.

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