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Remarks on conversion of sentences from active voice to passive voice: Algebraic analysis of mathematical model approach

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Abstract

The aim of this paper is to investigate and survey some fundamental functions, which are related to homomorphisms, properties that can be used to change active voice into passive voice. These functions are explained with the relevant examples. Some observations are also made about how the inverses of these functions can behave. Finally, we raise a number of new and distinct problems that allow for further research and analysis to fully comprehend grammatical structures.

Keywords: Active and passive voice, group, homomorphisms, transformations

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1. Introduction

By formal approach to multilingual associated with the training data for language-dependent, Muller [3] gave a phonological probabilistic context free grammar method. His method describes the word and syllable structure of German words. There are many methods in order to *Qualitative Evaluation* in the languages. For instance, *Qualitative Evaluation*, which is carried out in the language of English and German, is made by Word complexity, Onset and coda complexity, Syllable complexity (see, for details, [3, 4], and also [6]). With this method, Muller [3] gave an approximation method for supervised learning and automatic detection of syllable structure. This method is to demonstrate that probabilistic context-free grammars can be used to gain important phonological information about syllable structure, as well as providing qualitative information and data about evaluations of the model trained on a real-world task that gives the Model's performance. Muller illustrated the "syllabic structure of the word Abfall" according to the phonological grammar for Germ, using an interesting figure that includes a tree diagram.

The importance and use of formal studies in Linguistics have increased surprisingly in recent years. Especially with the discovery of useful and innovative relationships between formal studies in Linguistics and mathematical models, it has allowed linguistic researchers, mathematicians and researchers from other disciplines to work more intensively and deeply in this field. Thus, in recent years, very important mathematical methods and models have been discovered and started to be used in formal studies in Linguistics. In particular, with the method and technique found by Pandey and Dhami [6], a model has been tried to be given for context and word meaning, syntactic categories, sentence structure rules and trees. It includes binary operations and homomorphisms built on mathematical groups

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containing Boolean groups in order to turn an active sentence into a passive sentence with the method they give. Hence, the aim of Pandey and Dhami [6] was to analyze all combinations of a sentence and to create Boolean groups for each sentence. Here, the components of the sentence were subgrouped, which determined that the sequences of sentences formed permutation sets. Application of isomorphism theorems, permutation trees among important subgroups and their mapping are provided. This was used as a mathematical model for converting sentences from active to passive. As a result, these two researchers wrote a computer program to enable software developers to develop grammar software for sentence transformations (*cf.* [1]-[6]).

2. Grammatical structure of the sentence

The grammatical structure of the sentence of almost every language is very different. For example, the sentence in English linguistics is given by the following mathematical equation:

$$Subject(S) + Verb(V) + Object(O),$$

the sentence in Turkish linguistics is given by the following mathematical equation:

$$Subject(S) + Object(O) + Verb(V),$$

etc., where the operation + denotes concatenation of two words with a space character.

As for the tenses used in grammar, of course, this grammar may vary due to the conjugation of verbs in different languages according to the mathematical equation. Verb conjugations are also known to differ in different linguistics. In addition, some verbs may not have a conjugation. Some verbs have the same conjugation.

Considering these situations, how can an active sentence, which is denoted by $\mathcal{A}$, be transformed into a passive sentence, which is denoted by $\mathcal{P}$, in any linguistics grammar. For this, of course, the following questions can easily arise: what types of mathematical models, what types of mathematical techniques, what types of mathematical equations and binary operations with related functions or homomorphism can be used?

For instance, we give the following example converting an active sentence into a passive sentence ($\mathcal{A} \to \mathcal{P}$) in Turkish linguistics and in English linguistics, respectively:

$\mathcal{A}$: Melis elbise dolabının camını kırdı.

$$Melis(S) + elbise\ dolabının\ camını(O) + kırdı(V).$$

Let us give abbreviations of such sentences with the following abbreviation:$\to$

$$S + O + V.$$

$\mathcal{P}$: Elbise dolabının camı Melis tarafından kırıldı.

$$Elbise\ dolabının\ camı(O) + Melis(S) + tarafından(A) + kırıldı(V).$$

where A denotes an adverb of the sentence.

Let us give abbreviations of such sentences with the following abbreviation:$\to$

$$O + S + A + V$$

and

$\mathcal{A}$: Melis broke the glass of her wardrobe.

$$Melis(S) + broke(V) + the\ glass\ of\ her\ wardrobe(O). \tag{2.1}$$

Let us give abbreviations of such sentences with the following abbreviation:$\to$

$$S + V + O.$$

Thus

$$\mathcal{A} \rightarrow \mathcal{P}.$$

$\mathcal{P}$: The glass of the wardrobe was broken by Melis.

$$The\ glass\ of\ her\ wardrob(O) + was\ broken(V) + by(A) + Melis(S).$$

Let us give abbreviations of such sentences with the following abbreviation:→

$$O + be + V_3 + S,$$

where V_3 denotes the 3rd conjugation of the verb. Thus

$$\mathcal{A} \rightarrow \mathcal{P}.$$

By using mathematical tools based on algebraic properties, Pandey and Dhami [6] gave a transform a string $\mathcal{A}$ of active voice words into a string of passive voice words $\mathcal{P}$. Now, we summarize this interesting method which was given by Pandey and Dhami [6], briefly as follows and blend it with tables from examples:

The basic sentence structure for the English language is given by

$$S + V + O.$$

The above sentence in passive voice is given by

$$O + be + V_3 + S.$$

That is

$$\mathcal{A} \rightarrow \mathcal{P}.$$

In English language, some verbs do not require an object and so-called "intransitive verbs". Therefore, sentences involving intransitive verbs do not convert to passive voice since there is no object to emphasize. Similarly, in the Turkish language,

$\mathcal{A}$: Güneş doğdu.

This type of sentences involving intransitive verbs cannot also be converted to passive voice. Likewise in English, the translation of this sentence:

$\mathcal{A}$: The sun has risen.

$\mathcal{A}$ does not have a passive form as the act is done by the subject itself. Consequently

$$\mathcal{A} \nrightarrow \mathcal{P}.$$

The set $\mathcal{N}$ is defined by

$$\mathcal{N} = \{\text{I, we, you, he, she, they, me, us, you, him, her, them, noun}\}, \tag{2.2}$$

which is generated a cyclic group of subjects and objects of order 13, as given by the following table (*cf.* [6]):

I	We	You	He	She	They	Them	Her	Him	You	Us	Me	Noun
a^1	a^2	a^3	a^4	a^5	a^6	a^{-6}	a^{-5}	a^{-4}	a^{-3}	a^{-2}	a^{-1}	$a^0 = e$

Table 1. Cyclic group of subjects and objects of order 13

It is clear that

$$a^1 * a^{-1} = e,$$

e denotes the identity element and a^{-1} is inverse of a^1 with respect to the binary operation $*$. Thus,

$$a^1 = I,$$

with the aid of the binary operation $*$, we have

$$a^{-1} = Me.$$

Similarly inverse of the elements involving "We, You, He, She, They" with respect to the binary operation $*$ are given by "Us, You, Him, Her, Them" (*cf.* [6]).

For the following set $\mathcal{M}$:

$$\mathcal{M} = \{\text{the, a, an}, \ldots\}, \tag{2.3}$$

Pandey and Dhami [6] gave an algebraic structure $\mathscr{A}$ for the set $\mathcal{N}$ and $\mathcal{M}$ in which $\mathcal{N}$ is closed with respect to the binary operation $*$ with $\mathscr{A}$, as

$$Melis(S) + broke(V) + the\ glass\ of\ her\ wardrobe(O).$$

By the aid of binary operation $*$, Pandey and Dhami [6] gave also the following set for all verb forms

$$V = \left\{ \begin{array}{c} v_{11}, v_{12}, v_{13}, v_{14}, v_{21}, v_{22}, v_{23}, v_{24}, v_{31}, v_{32}, v_{33}, v_{34}, \\ v_{11}^{-1}, v_{12}^{-1}, v_{13}^{-1}, v_{14}^{-1}, v_{21}^{-1}, v_{22}^{-1}, v_{23}^{-1}, v_{24}^{-1}, v_{31}^{-1}, v_{32}^{-1}, v_{33}^{-1}, v_{34}^{-1} \end{array} \right\}, \tag{2.4}$$

where v_{ij} denotes ith tense and jth form of tense and also v_{ij}^{-1} denotes invers of v_{ij} with respect to the binary operation $*$.

In order to explain explicitly the set, given in the equation (2.4), we need the following modified table, which was given in [6]:

Verb form \Variable(v_{ij})	Verb form	**Inverse element**
v_{11}	Go	Gone
v_{12}	Is, am, are going	Being gone
v_{13}	Have, has gone	Been gone
v_{14}	Have been, has been gone	....
v_{21}	Went	Gone
v_{22}	Was, were going	Being gone
v_{23}	Had gone	Been gone
v_{24}	Had been written	....
v_{31}	Shall, will write	Be written
v_{32}	Shall be, will be going	....
v_{33}	Shall have, will have gone	Have been gone
v_{34}	Shall have been, will have been gone	....

Table 2. Forms of actual elements for the verb "go"

By using Table 1 and Table 2 for S, V, and O associated with $\mathscr{A}$, an algebraic space on the group of subjects S can be defined by the following two binary operations $\circledast$ and $*$:

$$\mathbf{a} = ((S) \circledast (V)) * (O), \tag{2.5}$$

where $\mathbf{a} \in \mathscr{A}$, S denotes the set of subject elements, V denotes the set of verb elements and O denotes the set of object elements. $\circledast$ and $*$ represent respective exterior operations between these sets.

For instance, the action of the equation (2.1) under the equation (2.5), we have

$$Melis(S) + broke(V) + the\ glass\ of\ her\ wardrobe(O),$$

the structure **a** can be permuted in 6 ways, which gives a new string of elements. For other examples see also [6].

With aid of Table 1, the transformation f on a group S is explicitly defined by

$$f\left(a^{i}\right) = \left(a^{i}\right)^{-1} \tag{2.6}$$

(*cf.* [6]). With aid of the equation (2.4), the transformation g on a group V is explicitly defined by

$$g\left(v_{ij}\right) = \left(v_{ij}\right)^{-1} \tag{2.7}$$

(*cf.* [6]). Here we note that in the Table 2 there are four elements of the set V, which have not their inverses. Due to the equation (2.7), the image of these elements map into null element.

Here we also observe that f and g preserve the action of the operations $\circledast$ and $*$. For the algebraic approach, f and g are homomorphism. Especially, the kernel of g is given by the following set:

$$K(g) = \left\{v_{ij} : g\left(v_{ij}\right) = \phi\right\} = \{v_{14}, v_{24}, v_{32}, v_{34}\} \tag{2.8}$$

(*cf.* [6]).

Let

$$T : \mathcal{A} \to \mathcal{P}. \tag{2.9}$$

The action of $\mathbf{a}$ in (2.5) under the transformation T is given by

$$T(\mathbf{a}) = T\left(S_i \circledast V_{jk} * O_p\right) = \left(O_p^{-1} \otimes V_{jk}^{\backslash\backslash\backslash} * S_i^{-1}\right) = p, \tag{2.10}$$

where $V^{\backslash\backslash\backslash} = V_3$, which is represented the 3rd form of verb.

From equation (2.10), if we put the values in this we have,

$$T(\mathbf{a}) = T\left(a^5 \circledast v_{21} * O\right) = \left(O^{-1} \otimes \left(v_{21}^{-1}\right)^{'''} * a^{-5}\right) = \mathbf{p}.$$

Combining the above transformation with the Table 1 and Table 2, we arrive at the following result:

$$\mathbf{p} := \underbrace{\text{The glass of the wardrobe}}_{O^{-1}}\ \underbrace{\text{was broken}}_{\left(v_{21}^{-1}\right)^{'''}}\ \text{by}\ \underbrace{\text{her}}_{a^{-5}}.$$

At this point, for the operations the following mathematical structure question comes to mind:

What is the relations among the operations $+$, $\circledast$ and $*$?

3. Further open questions for the transformations

In the previous section, we gave some insight to the transformations of active voices to passive voice sentences. Conversely, how can we interpret the function T^{-1}? Is it possible to construct the function T^{-1}? What is the value of

$$T^{-1}(\mathbf{p}) = \mathbf{a}?$$

4. Future investigations

In this section, we attempt to extend the transformations by converting direct speech to indirect speech or vice versa to investigate the possibility of a reported speech tool to aid ESL, which means that English as a Second Language is learning English in a country where English is dominantly spoken or the official language, students that have difficulty in grasping complex speech conversions which require change in sentence structure in addition to utilization of different tense forms. We will also look into whether speech conversions can be combined with our previous conversion equation.

How can we define a new transformation function similar to that of (2.9). That is, what is the action of "**a** := She told me that I can write my manuscript." under the new transform to the indirect speech which denotes by "**p** := I was told by her that I could write my manuscript."

Furthermore, the adaption of a possible equation to other languages will be investigated and studied as well as the scope of such application to different language families.

As for the mathematical application, since the transformations T, f, and g are defined on the cyclic group, they preserve the group operations. It is also well-known that these functions are named homomorphism. We observe the way kernel of these homomorphs and the application of isomorphism to this grammatical framework. Moreover, we also investigate whether there is an inverse version of the newly formed transformation or the homomorphism and if so, which grammatical structures are preserved that way? We aim at answering these questions to facilitate the lives of language learners and break the language barriers.

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