Intelligent Tutoring System to Learn the Transcription of Polysemous Words in *Mooré*

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Abstract. Our research is in the domain of Computing Environment for Human Learning. It aims to build an intelligent tutoring system to learn the transcription of polysemous words in *Mooré*, a majority tone language spoken in Burkina Faso. In tone languages, polysemous words find their meaning in the pitch used. In this article, we present the results of the work on the modeling of the intelligent tutoring system to learn the transcription of polysemous words in *Mooré* by Petri net and on the experimentation of the system. The Petri net modeling that we have done has allowed to simulate the operation of our system and show that it is consistent. From this study on the Petri net, we contribute to show how this approach could be used to model intelligent tutoring system and to fix its possible blockages. Concerning the experimentation of the system, it allowed to show that the contents of the knowledge base of the system are consistent with the contents of the corpus of *Mooré* language. The analysis of users' feelings shows that the intelligent tutoring system to learn the transcription of polysemous words in *Mooré* could allow a learner to learn the transcription in *Mooré* without the assistance of a human tutor. This analysis also shows that this system would be a great contribution in the area of local language learning and that it could be used to ensure the continuity of local languages learning during periods of pandemic such as COVID 19.

Keywords: Intelligent Tutoring System · Petri Net · Tone Language · *Mooré*

1 Introduction

Intelligent Tutoring Systems (ITS) are interactive computer environment that provide personalized learning and assisted by artificial tutoring [6,15]. It consists of a domain module, a learner module, a tutoring module and a communication module [2]. The domain module allows to model the content of the learning domain, the learner's module allows to represent the learner's knowledge, the tutoring module or pedagogical module makes it possible to define the pedagogical strategy of the system and the communication allows interactions between the system and the learner. Research in this area presents an effort to model,

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implement and evaluate systems that integrate artificial intelligence techniques and cognitive theories to solve learning tasks [21]. As part of our study, we set ourselves the objective to build an intelligent tutoring system to learn the transcription of polysemous words in *Mooré*. This application that we propose to set up is a response to the learning needs of local language in Burkina Faso. In tone languages, a polysemous word is a word whose use of tones on the word gives different meanings.

To achieve our objective, we have, in a previous study, specified the suitable knowledge and processes for the design of the different modules of our system [18,19]. In this present study, we present the work on the modeling of the system by the Petri net and the experimentation of the prototype that we have developed. For modeling discrete event systems such as ITS, the Petri net is an excellent tool to simulate the operation of a system and to verify that it is deadlock-free [9]. We used this approach to model our tutoring system in order to simulate its operation and to fix its possible blockages. Modeling by the Petri net allowed us to develop a deadlock-free system. As for the experimentation of our system, the goal is to evaluate the pedagogical impact that this application could bring in the field of learning *Mooré* in particular and local languages in general. The experiment that we carried out showed that our system would be of great contribution in the field of learning *Mooré*.

According to the objective of our study, our contribution is to set up a coherent system able to provide resolution tasks to the learners and to bring them an artificial tutoring. This system will also allow to ensure the continuity of local languages learning during and after periods of pandemic such as COVID 19 which has led to the closure of some training centers.

This paper is structured around the following points: Sect. 2 defines the basic concepts used in this article; Sect. 3 presents the architecture of our ITS and describes the different modules; Sect. 4 shows the modeling of the system by the Petri net and presents the verification of its consistency; Sect. 5 shows the results of the experimentation of the system and Sect. 6 summarizes the study and presents the perspectives.

2 Background

In this section of our study, we introduce the concepts of tone language, intelligent tutoring system and Petri net.

A tone language is a language in which the pitch of tones is used to distinguish the lexical meaning or grammatical forms of certain words [4]. This adds a level of complexity to lexical meaning. Tone languages are characterized by two types of tones: punctual tone and melodic tone [5]. Melodic or modulated tones are characterized by melodic movement (ascending, descending, descending-ascending). As for the punctual tones, they are characterized by their pitch (high, medium or low) and not by their melodic movement. *Mooré* belongs to the family of languages with punctual tone. Three types of punctual tones are distinguished in the *Mooré* language:

- the high tone represented by an acute accent,
- the low tone represented by a grave accent,
- and the middle tone represented by the tilde.

For example in *Mooré*, the Fig. 1 is transcribed by the word sáagá and the Fig. 2 by the word sáagà. The word saaga in *Mooré* without the pitch does not allow to know if this word alludes to the Fig. 1 or to the Fig. 2.

Fig. 1. Rain (sáagá in *Mooré*).

Fig. 2. Broom (sáagà in *Mooré*).

The definition of these different pitches is very important in the context of our study insofar as they constitute our pedagogical objective. Likewise, they are the basis for the transcription tasks of our intelligent tutoring system to learn the transcription of polysemous words in *Mooré*.

In the domain of language learning, the Intelligent Tutoring Systems (ITS) that have been designed so far have focused on the following languages: French, English, Spanish, German, Arabic, Japanese, Chinese [6,15–17]. An ITS is a Computing Environment for Human Learning that integrates Artificial Intelligence (AI) techniques and cognitive theories in the design of its system to provide guided and personalized learning to learners [1,3]. The ITS architecture consists of four components: the domain module, the student module, the tutoring module, and the communication module [2,14]. The specification of knowledge and processes, an approach developed from CommonKADS, makes it possible to design the domain module and the pedagogical module of an ITS for tone language learning [18,19].

After presenting the basic concepts related to tone languages and intelligent tutoring systems, we introduce the Petri net approach.

The Petri Net (PN) is a mathematical tool proposed by Dr. Carl Adam Petri in 1962 to represent discrete distributed systems [10]. It is a modeling language, represented as an oriented bipartite graph. The PN is an approach that is used to diagnose modeling errors in an application [8,9,11]. In our study, we used this tool to model our system and to verify that it is deadlock-free.

3 Architecture of the ITS to Learn the Transcription of Polysemous Words in *Mooré*

The architecture of the intelligent tutoring system to learn the transcription of polysemous words in *Mooré* is based on the four-component architecture of ITS. Figure 3 below shows this architecture.

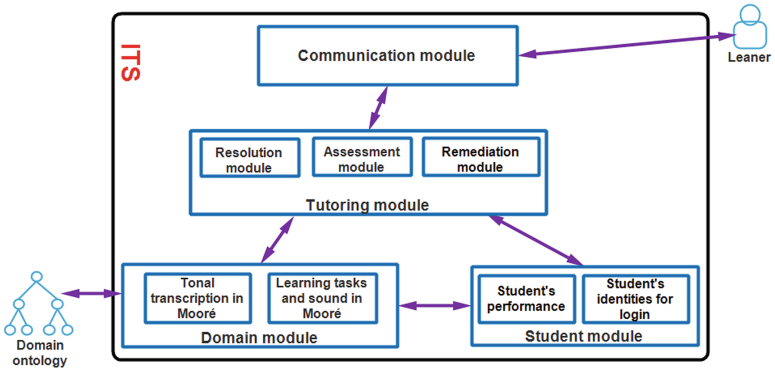

Fig. 3. Architecture of the system. The components inside each module of the ITS represent the sub-modules that compose it, the two-way arrows connecting the modules indicate the communication relationship between them.

The domain module presents the knowledge of our system. It consists of learning tasks and sounds in *Mooré*, the tonal transcriptions in *Mooré* corresponding to the learning tasks. The tutoring module represents the pedagogical strategy of our system. This module consists of the resolution module, the assessment module and the remediation module. The domain module and the tutoring module are the main modules of our system. The student module of our system represents the learner profile information against solved tasks and learner information for the login. The communication module is the interaction interface between the system and the user. In the next section, we will show that our system developed from the above architecture is consistent.

4 Verification of the System by Petri Net

Petri Net (PN) is an efficient method for the design and verification of discrete event systems [9,20]. Intelligent tutoring systems are discrete event systems. So, we used this method to design and verify our system for learning the transcription of polysemous words in *Mooré*. Figure 4 presents the PN of the system modeled.

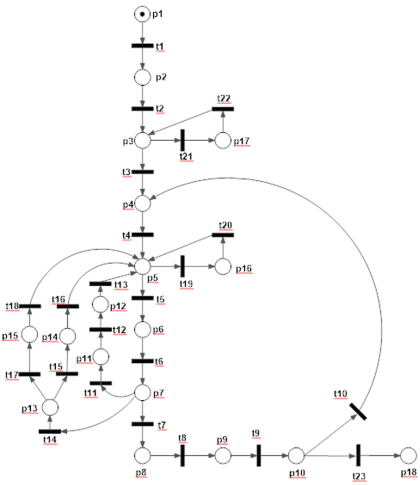

Fig. 4. Petri net of the system. It is a bipartite graph where the circles represent the places and the vertical bars the transitions.

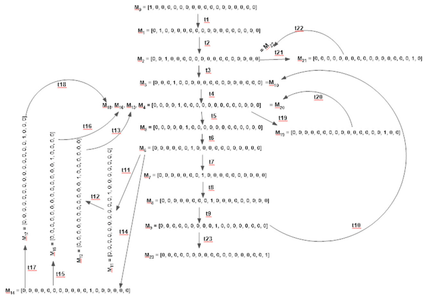

Fig. 5. Graph of accessible markings of the Petri net of the system. It presents the state of the system after each firing t_i

In Fig. 4, the places (pi) represent the input or output data of the different actions of the system and the transitions (ti) represent the actions performed by the system. Table 1 below details these different places and transitions.

For the verification, we designed a marking graph to present the markings accessible of the Petri net of the system (see Fig. 5).

Figure 5 shows all the marks in our PN at a given time. The analysis of the figure shows that after each firing, the input place of the transition changes from 1 to 0 while the output place changes from 0 to 1. These results show that our PN is binary which means that our system developed is consistent.

Table 1. Description of the different places and transitions.

Places (p_i)	Transitions (t_i)
p_1: app icon	t_1: display login screen
p_2: login screen	t_2: check login and password
p_3): home screen(Main)	t_3: load tasks
p_4: tasks presented	t_4: load image and audio
p_5: task selected, image and audio loaded	t_5: read transcription
p_6: transcribed word read	t_7: produce success feedback
p_7: transcribed word assessed	t_8: mark task solved
p_8: success feedback generated	t_9: update learner's profile
p_9: task solved marked	t_{10}: return to tasks presented
p_{10}: learner's profile updated	t_{11}: detect spelling error
p_{11}: spelling error detected	t_{12}: display spelling error
p_{12}: feedback spelling error displayed	t_{13}: transcribe again
p_{13}: tones error detected	t_{14}: detect tones error
p_{14}: feedback amalgamated tones displayed	t_{15}: detect amalgamated tones and produce feedback
p_{15}: feedback tones error displayed	t_{16}: transcribe again
p_{16}: sound emitted	t_{17}: produce tones error feedback
p_{17}: learner score displayed	t_{18}: transcribe again
p_{18}: system ended	t_{19}: emit sound
	t_{20}: end sound emitted
	t_{21}: display score
	t_{22}: return to the main menu
	t_{23}: stop the system

5 Experimentation of the System

The experimentation of the system consisted in making the application available to users for use and in collecting their feelings after using of the tool. The goal of this experimentation is to verify if:

- The content of the Knowledge Base (KB) of the system developed from the specification of knowledge and tasks is consistent with the content of the corpus of the *Mooré* language, namely the transcriptions and sounds;
- The content of the KB can allow a user to learn the transcription of polysemous words in *Mooré* and to distinguish the lexical meaning of these words;
- The pedagogical strategy defined can allow a user to learn without human tutor assistance.

To collect users' feelings, we developed questionnaires via Google Forms. The experiment concerned a total of seventeen learners and four trainers. Figure 6 and Fig. 7 below show some results of the users' feelings after the experimentation of the system.

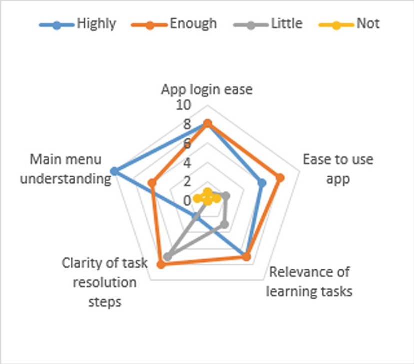

Fig. 6. Learners' feelings.

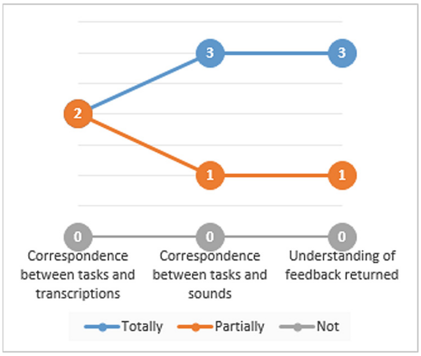

Fig. 7. Trainers' feelings.

Analysis of Fig. 6 shows that fourteen learners found the learning tasks at least sufficiently relevant, and ten found the steps to solve the tasks at least sufficiently clear. As for the analysis of Fig. 7, two trainers found a total correspondence between the tasks presented by the system and the ideal transcriptions and two trainers found a partial correspondence between the tasks and the ideal transcriptions. Three trainers found a total correspondence between the tasks and the ideal sounds integrated and one trainer found them partially corresponding. From the analysis, we find that for each question, more than seventy-five percent of users give a satisfactory answer. It is the same observation for the other results that we have not presented in this paper for summary. From these observations, we can say that the ITS to learn the transcription of polysemous words in *Mooré* could allow to learn transcription in *Mooré*. Therefore, this application developed would be a great contribution in the domain of education for the local languages learning in Burkina Faso.

6 Conclusion and Perspectives

In this article, we presented the work on the modeling of the system by the Petri net and the experimentation of the system. The modeling of the system has shown that our ITS to learn the transcription of polysemous words in *Mooré* is consistent. To achieve this result, we represented: a graphical model of the Petri net which allowed to simulate the operation of the system and a marking graph which allowed to analyze the reachability of the transitions and to show that our Petri net is binary. As for the experimentation of the system, it allowed to collect and analyze the users' feelings. The analysis of these feelings showed, among other things, that the system could allow a learner to learn transcription in *Mooré* without human tutor assistance and that this system could be used to ensure the continuity of local languages learning during periods of pandemic such as COVID 19. The future work of our study will be: the development and integration of the speech recognition activity in our system, the development of a WordNet ontology for the *Mooré* language. The WordNet ontology for the *Mooré* language would constitute an online knowledge base interoperable with our system and even with other systems.

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