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TOWARDS A ROBOT ASSISTANT IN VOCABULARY LEARNING

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Abstract: *In this work, we present the specifications and discuss implementation issues of a robot that is capable of helping foreign language learners, including students with special needs, to acquire the vocabulary they have to learn as part of their conventional study in the foreign language. A basic difference between the robot we propose and other robots that offer help in learning vocabularies is that in our case, the robot has the ability to read the vocabulary from the student's book and identify its structure automatically, i.e. to recognize for each term what the term is, what the translation of the term into the student's native language is, its explanation in the foreign language, examples of use of the term, etc. The proposed robot takes advantage of feedback and reinforcement learning practices. In addition, it automatically determines the learning outcomes based on the vocabulary it reads and the individual needs of each learner (Personalization), whom it recognizes visually. Its help for vocabulary learning is implemented through the evaluation and gamification. In particular, the robot, using smart dialogs, raises a variety of questions relevant to the content of the vocabulary that the student has to learn and it evaluates the answers. This process can be repeated until the learning objectives are fully achieved. With regard to the gamification, the robot, after automatically adapts a set of suitable games to the content of the required vocabulary, it selects some of them to suggest to the student according to his / her individual needs.*

Key words: *robot tutor, vocabulary learning, personalization, face recognition, smart dialogues, speech synthesis, speech recognition*

1. INTRODUCTION

In recent years, the rapid advances in many areas of technology, like knowledge-based reasoning, voice recognition, speech synthesis, smart dialogues, image sensing, motion planning, and machine learning, have made it possible for robot-teachers to appear [1].
The complex issue of teaching using robots is addressed from various viewpoints and requires a multidisciplinary effort, including contributions from pedagogy, psychology, computational linguistics, artificial intelligence, Human-Robot Interaction, etc. [2]. Thus, the international bibliography is particularly rich in relevant works covering a wide range from hardware and software manufacturing to the study of pedagogical and teaching principles that should govern the operation of a robot-tutor. For example, [3] studies robot programming strategies and how they are used in the educational context. The influence of different social behavior on preschool children's perception of stories narrated either by a humanoid robot or by a human teacher is explored by [4]. A robot-based pedagogy particularly for students with special education needs (SEN) is explored by [5]. Key factors that could promote the widespread dissemination of robot-teachers are identified by [6]. The main design requirements so that robot hardware and the software can be used by students with visual impairment are discussed by [7]. Impressively, studies suggesting that the rapid evolution of robots will soon replace the teacher in the classroom [8] have also appeared. In [9], users' perceptions of teaching assistant robots and the possible motivations that impact the users' intention to use the robots are investigated. In [10], it is argued that robot

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adaptation needs to go beyond variations in preprogrammed behaviors and that robots should in effect learn online how to become better tutors. Books that cover state-of-the-art topics on the practical implementation of intelligent assistants in everyday applications are already widespread [11]. Ethical issues and long-term consequences of implementing classroom robots for teachers and children in primary education are examined by [12].

In particular, robots are widespread in foreign language learning as they are considered they reduce language anxiety in comparison to a human-teacher [13, 14]. Technical challenges in using robots as language tutors are identified in [14]. Studies on child-robot interaction on vocabulary learning are reviewed by [16]. Field trials of using robot in an English learning classroom where the robot plays as a partner of a teacher are reported in [17]. A case of learning English vocabulary by children 3-5 years old who are not English speakers has been investigated by [18] with encouraging results.

In this context, we propose a robot that will be functioning as an assistant to foreign language learners when they study vocabularies. In the following, we call the aforementioned robot, a Vocabulary Teacher or VT for short. The need to build such an assistant becomes clear if you take into consideration the foreign language learning process. More specifically, a foreign language learner has in each chapter to learn a set of new words. Most foreign language learning books, in each chapter, contain a dedicated vocabulary section. The magnitude of the vocabulary varies according to the study level of the foreign language, reaching C level (Proficient User) of more than 100 words in each chapter. Therefore, the student has in each chapter to learn a significant number of words. For each of these words, students should learn the correct pronunciation, the explanation in the foreign language, the translation into their native language, examples of usage and other information, such as what part of speech is the word, what are the synonyms, what are the antonyms, etc. Obviously, learning a vocabulary demands a significant workload, especially, taking into consideration the crucial role of memorizing in this kind of study.

Therefore, learning a vocabulary is a difficult task and usually requires the co-operation of a person who plays an auxiliary role in checking each word to confirm whether the student is aware of it or needs to study it further. Our goal is to produce a robot that, taking into account basic pedagogical and teaching principles [18, 19], will well replace the abovementioned human assistant.

The rest of the paper is structured as follows. Section 2 presents the basic requirements of VT. In section 3, we discuss auxiliary functions that are essential for the implementation of the basic requirements. Implementation issues are described in section 4. Conclusions and further work are summarized in section 5.

2. REQUIREMENTS

In this section, we present the requirements for VT.

2.1. Vocabulary Reading

First of all, let us clarify that the purpose of VT is to help the student acquire the vocabulary the student has to learn as part of his/her regular study of foreign language learning rather than to help him learn some other vocabulary. Therefore, VT is required to be able to find out exactly what vocabulary each student has to learn. This information will be given through appropriate dialogues between VT and student. During these dialogues, the student will give information such as what is the first and what the last word of the vocabulary to learn, or in the case that the vocabulary constitutes an entire section, what is the identification (numbering) of this section. Then, the VT reads the vocabulary. Vocabulary reading consists of the following individual functions. It first takes a photo from the student's book. Then, it converts the photo to text, and finally, it recognizes the text, i.e. converts the text into a vocabulary. After this phase, VT will know for each term of the vocabulary, what is the phrase (or word) representing the term, its pronunciation, the explanation of the term in the foreign language, the translation of the term into the language of the student, examples of the use of the term and other elements that may the vocabulary includes for the term.

2.2. Examination

After reading the vocabulary, VT is on hand to check whether the student knows the vocabulary. The examination will be held again through speech. VT will ask questions about the terms of the vocabulary, receive and evaluate the answers. The questions will be polymorphic. For example, a term could be given and requested to be translated or given the translation of a term and requested the term itself. All possible combinations will be feasible. Depending on the structure of the vocabulary, VT will be able to pronounce a term and ask for examples of use or to give an example of usage and to request the translation of the term or to give the meaning of a term to the foreign language and to request the translation of the term, etc. VT will also be able to request and evaluate the pronunciation of the term by the student. In addition, VT will be able to examine the terms in the order they appear in the vocabulary or in random order. The questions that will be shaped by VT will take into account both the student's preferences and weaknesses or strengths. Therefore, VT will be able to make dialogues in order to determine the student's preferences when examining the particular vocabulary. The development of these dialogues will also take into account the student's past preferences. For example, VT will be able to ask if the student wants to listen to the term and respond with the translation or vice versa. The exam will be repeated until the student acquires fully the vocabulary. In each iteration, VT will take into account both the performance of the student during the immediately preceding examination and the general performance of the student from the beginning of the collaboration between VT and the student.

2.3. Learning games

VT will be able to dispose to the student a set of vocabulary learning games. To this end, VT has the ability to adapt automatically the games to the vocabulary under study, e.g. VT will be able to recommend to the student a memory game that will refer to the specific vocabulary. In its recommendations to the student about which game to

choose, VT will be taking into consideration the evaluation of the specific vocabulary, the general evaluation, and the student's preferences.

3. AUXILIARY FUNCTIONS

The following functions are essential for the implementation of the aforementioned requirements:

3.1. Student Recognition

VT will be able to identify its students using face recognition. A student may be introduced to VT by another student. However, the first student of VT will be able to introduce himself to VT.

3.2. Intelligent Dialogues

In relation to all the issues that arise from VT learner communication in the context of vocabulary learning, VT will be able to talk "smartly".

3.3. Vocabulary Reading

As we have already mentioned, the vocabulary is being read in three phases. First of all, a vocabulary image is taken. The image is then converted into text and finally, the text is recognized. Taking the image and converting it to the text are considered straightforward functions and do not need further discussion at this level. Text recognition will be based on the knowledge of the structure of the vocabulary. For this purpose, an appropriate XML-based language will be developed to help describe the structure of vocabularies. Mainly depending on the publisher, each vocabulary has a particular structure, i.e. vocabularies from the same publisher have typically the same structure whereas vocabularies from different publishers come with different structures. For example, a possible vocabulary structure is as follows: The vocabulary entry starts with the chapter identification number followed by a dot, followed by the term identification number, e.g. 7.6 (Chapter 7, vocabulary entry 6). Next, the term follows. The end of the term is represented by the character '/'. Next comes the pronunciation of the term, which is also terminated by the '/' character. The part of the speech comes next within brackets followed by the explanation of the term in the foreign language ending with the character ':'. Then the translation follows and finally, examples are given, each in a new line. Initially, VT will support the basic publishers of English language books released in Greece, and will then be extended to other languages and publishers.

3.3. Personalized help

The VT will keep a record of each student so that it knows both his / her preferences and a detailed assessment of the student's possibilities and weaknesses. Preference data will be derived from conclusions drawn from dialogues with the student. For example, VT will remember which of the available vocabulary learning games is preferred by the student. The student's abilities and weaknesses will be mainly exported by the "Examination". Thus, VT will know that a term is well known by the student because when the student was asked about the term, he responded immediately or because the student made use of the term in the dialogues with VT or because the student easily gave examples of using the term. He will also know that the student has responded correctly to the meaning of a term only after three failed attempts, so VT will consider that the term has not been fully acquired.

4. VT-STUDENT INTERACTION

The VT-student interaction takes place in three phases: at the first meeting, in Education, and in the Assessment. In all these phases a person is addressed to the VT using a set of predetermined phrases and/or phrases containing keywords. Predefined phrases carry clear commands that VT recognizes and responds accordingly. If a predefined sentence is not used, but a sentence containing keywords, VT will attempt to convert it into a predetermined phrase by asking the interlocutor to confirm it. The initial language of communication will be English.

4.1. The first meeting

At this stage a person can be introduced himself to VT as a student. In this case, VT will register a new student, i.e. it will ask the person's name and will perform face registration so that it will be able to recognize the student later. For each enrolled student, VT maintains a complete history of vocabularies in learning which has contributed. From the history, VT extracts information about what terms a student knows with precision and on what terms the student is having difficulty. Since VT will not have any registered student, then a person can be introduced as a student on his own. Otherwise, a person should be recommended as a student by another already registered as a student. At this stage, VT also asks the student for his / her email address.

4.2. Education

A student can speak to the VT asking for help in learning a vocabulary. In this case, VT after recognizing the student will ask him to indicate in his book what the vocabulary he has to learn is. VT will then scan the vocabulary and proceed in recognition of its structure. Then, VT is examining the student's history, and choose a vocabulary examination method. Examination methods vary according to the information VT gives and the information it requests, e.g. gives the term and asks for interpretation or gives the interpretation and asks for the term. Besides, examination methods may be varied in the order in which the terms are examined, e.g. in the same order that they appear in the vocabulary or in random order, etc. If while examining a vocabulary, VT will calculate a poor performance, then it recommends the student a series of games that are specifically aimed at learning of that vocabulary. Once the student has studied his vocabulary by playing, he returns to continue the examination by VT.

4.3. Assessment

The student can ask VT to evaluate his performance for a vocabulary, a set of vocabularies, or a period of time. The VT sends in response an appropriate email report that includes comparative results.

5. IMPLEMENTATION ISSUES

In order for VT to identify the structure of vocabularies, we are developing an XML-based language that will be used to describe the structure of the vocabularies contained in English language books of most major publishing houses in Greece. Our goal is to expand the

language such that it will acquire the ability to describe the structure of any vocabulary.

As far as learning games are concerned, we have already developed a range of games including memory games, correlation questions, and original vocabulary learning games. These games will automatically adapt to the vocabulary previously identified by VT.

Student recognition will be based either on Kairos face recognition API [20] or on the Amazon relevant API [21].

The DOCOMO Dialogue Java SDK can be used to integrate a Java application with the DOCOMO Dialogue API in order to embed Chabot functionalities [22]. We are planning to implement smart dialogues between VT and the student using DOCOMO.

For speech recognition and speech synthesis, we are oriented to use the specification of java speech API [23] and probably the FreeTTS implementation [24].

Concerning the implementation, our objective is to develop a platform-independent software which will also run on desktops, mobiles, etc.

6. CONCLUSIONS AND FURTHER WORK

In this work, we propose a robot that will act as a vocabulary learning assistant. More specifically it will help the student to study the vocabulary she/he has to study as part of her/his everyday study. This will be achieved by reading the vocabulary from the student's book and understanding its structure. In order to achieve this, we are working on both the pedagogical and didactic aspects of the operation of such a robot as well as the technical aspects of its implementation.

REFERENCES

[1] S. Akashiba *et al.*, "Implementation of Teacher-Robot Collaboration Lesson Application in PRINTEPS," *Procedia Computer Science*, vol. 112, pp. 2299–2308, Jan. 2017.

[2] T. M. Ballard, D. Hanson, B. Lutz, and L. Malone, "Building Good Robots: A Case in Successful Open-Source Learning," p. 8.

[3] F. A. Bravo, A. M. González, and E. González, "A review of intuitive robot programming environments for educational purposes," in *2017 IEEE 3rd Colombian Conference on Automatic Control (CCAC)*, 2017, pp. 1–6.

[4] D. Conti, A. Di Nuovo, C. Cirasa, and S. Di Nuovo, "A comparison of kindergarten storytelling by human and humanoid robot with different social behavior," in *HRI '17. Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction - HRI '17*, New York: ACM, 2017, pp. 97–98.

[5] T. Hughes-Roberts and D. Brown, "Implementing a Robot-Based Pedagogy in the Classroom: Initial Results from Stakeholder Interviews," in *2015 International Conference on Interactive Technologies and Games*, 2015, pp. 49–54.

[6] F. Mondada *et al.*, "Bringing Robotics to Formal Education: The Thymio Open-Source Hardware Robot," *IEEE Robotics Automation Magazine*, vol. 24, no. 1, pp. 77–85, Mar. 2017.

[7] G. H. M. Marques *et al.*, "Donnie robot: Towards an accessible and educational robot for visually impaired people," in *2017 Latin American Robotics Symposium (LARS) and 2017 Brazilian Symposium on Robotics (SBR)*, 2017, pp. 1–6.

[8] S. H. Ivanov, "Will Robots Substitute Teachers?," Social Science Research Network, Rochester, NY, SSRN Scholarly Paper ID 2801065, Jun. 2016.

[9] E. Park and S. J. Kwon, "The adoption of teaching assistant robots: a technology acceptance model approach," *Program*, vol. 50, no. 4, pp. 354–366, Sep. 2016.

[10] E. Senft, S. Lemaignan, M. Bartlett, P. Baxter, and T. Belpaeme, "Robots in the classroom: Learning to be a Good Tutor."

[11] G. G. Lee, H. K. Kim, M. Jeong, and J.-H. Kim, Eds., *Natural Language Dialog Systems and Intelligent Assistants*. Springer International Publishing, 2015.

[12] S. Serholt *et al.*, "The case of classroom robots: teachers' deliberations on the ethical tensions," *AI & Soc*, vol. 32, no. 4, pp. 613–631, Nov. 2017.

[13] W.-C. So *et al.*, "Robot-based intervention may reduce delay in the production of intransitive gestures in Chinese-speaking preschoolers with autism spectrum disorder," *Mol Autism*, vol. 9, May 2018.

[14] P. Vogt, M. de Haas, C. de Jong, P. Baxter, and E. Krahmer, "Child-Robot Interactions for Second Language Tutoring to Preschool Children," *Front Hum Neurosci*, vol. 11, Mar. 2017.

[15] J. Kanero, V. Geçkin, C. Oranç, E. Mamus, A. C. Küntay, and T. Göksun, "Social Robots for Early Language Learning: Current Evidence and Future Directions," *Child Development Perspectives*, vol. 0, no. 0.

[16] Z.-J. You, C.-Y. Shen, C.-W. Chang, B.-J. Liu, and G.-D. Chen, "A Robot as a Teaching Assistant in an English Class," in *Sixth IEEE International Conference on Advanced Learning Technologies (ICALT'06)*, 2006, pp. 87–91.

[17] "Playing with a robot to learn English vocabulary," *ResearchGate*. [Online]. Available: https://www.researchgate.net/publication/265051545_Playing_with_a_robot_to_learn_English_vocabulary. [Accessed: 15-Jun-2018].

[18] S. Roy, E. Kieson, C. Abramson, and C. Crick, "Using Human Reinforcement Learning Models to Improve Robots As Teachers," in *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, New York, NY, USA, 2018, pp. 225–226.

[19] "Transformed Pedagogical Environment: Humanoids for Social Skilling of Mentally Challenged Children," *ResearchGate*. [Online]. Available: https://www.researchgate.net/publication/316569382_Transformed_Pedagogical_Environment_Humanoids_for_Social_Skilling_of_Mentally_Challenged_Children. [Accessed: 15-Jun-2018].

[20] R. Belyeu, "Kairos: Serving Businesses with Face Recognition," *Kairos*. [Online]. Available: https://www.kairos.com/. [Accessed: 27-Jul-2018].

[21] "Amazon Rekognition – Video and Image - AWS," *Amazon Web Services, Inc.* [Online]. Available: https://aws.amazon.com/rekognition/. [Accessed: 27-Jul-2018].

[22] "DOCOMO Dialogue Java SDK," *ProgrammableWeb*. [Online]. Available: https://www.programmableweb.com/sdk/docomo-dialogue-java-sdk. [Accessed: 27-Jul-2018].

[23] "Java Speech API," *Wikipedia*. 23-Apr-2017.

[24] "FreeTTS," *Wikipedia*. 16-May-2018.