LANGUAGE LEARNING TOOL BASED ON AUGMENTED REALITY AND THE CONCEPT FOR IMITATING MENTAL ABILITY OF WORD ASSOCIATION (CIMAWA)

University of Siegen (GERMANY)

Abstract
The shape of modern classrooms has been witnessing considerable changes in the recent years. With the utilization of new technologies, a great potential has been offered for developing the learning environment. This development has been affecting both collaborative and individual educational activities, such as in schools and self-learning scopes respectively. Achieving this technological support of education took several forms, depending on the use of educational software or hardware. While effective learning tools utilized only one of those two components, the combination of specific computer science algorithms with suitable corresponding devices and sensors can increase not only the efficiency of the learning tool, but also its usability in real-world applications.

In the language learning context, technology enhanced educational tools have been mainly based on pure software solutions, in the form of mobile or desktop applications. Some language learning skills and activities, such as the ability to link words to a certain context, or learn new vocabulary related to that context, can be well supported by utilizing text mining and the CIMAWA approach (Concept for Imitating the Mental Ability of Word Association). The former algorithm has the ability to analyze the content of a text, while the later can link the existing words and phrases in this content to other similar or related vocabulary in a wider scope, such as online resources. This, in turn, corresponds to commonly practiced methods in learning new vocabulary of a new language by understanding the semantics of words from their context.

The utilization of those algorithms can also be enhanced by adding a hardware component to them. This hardware-based support can improve the interaction between the algorithm and real-world objects, as well as enhance the representation of the algorithm’s results to the user. Enabling word association algorithm to find words that are not only related to a certain written text but also to a real object can positively influence the learning outcome reached through the educational tool. This is due to the fact that knowledge visualization has the potential to embed and illustrate more knowledge within the same time and space. In order to achieve this effect, this paper proposes the use of Augmented Reality (AR) technology in the interaction model between the learner and the system. Augmented reality offers the ability to recognize real objects or printed texts, then project more information on those objects in the augmented world.

Thus, a new educational tool for language learning is presented in this paper. The suggested system utilizes a word association algorithm in order to link variant vocabulary samples in a learning context. Then, the results of the algorithm are presented to the learner visually through an augmented reality approach, which projects not only the related words, but also further information about them, such as the strength of their connection to the object or word in question. As a result, the language learner is supported to discover new words, visually observe their relations to another word or object; and receive additional knowledge about those relations themselves.

Keywords: Augmented Reality, Text Mining, Word Association, Knowledge Visualization, Language Learning.

1 INTRODUCTION
Modern teaching methodologies have been utilizing the advancement in technology in order to enhance the learning outcome and students’ performance. Such technology may offer tutors new opportunities for transferring information to students, observing their performance and expanding the interaction between a teacher and a student outside the space and time limits of a classroom lecture. However, those technologies are not able to replace the traditional teaching approaches completely. This is due to the importance and effectiveness of many methods in education, which have been
practiced and enhanced over the years. Preserving the core concept of a well-proven tutoring approach and supporting it with a suitable technology can inherit all the potentials of both sides.

In the field of language education, many learning activities have proven their effectiveness in classrooms. Some of those activities can stimulate the process of learning new words and phrases through the interaction with the surrounding environment. Others depend on the natural process of connecting concepts and words to each other, such as guessing the meaning of a word from the context of the sentence. All of those learning approaches include a form of interaction with the surrounding environment and its components, which are relevant for learning, whether these components are images in a book, objects in the real world or textual explanations in a document. The interaction model in traditional classrooms is based on teacher-supervised activities, enriched by multimedia resources, such as videos, audio and books. Although such resources are useful in the learning environments, they still suffer from space and time limitations. Moreover, they are often still fixed learning materials, which makes it challenging to personalize their content. Solutions exist, as intelligent tutoring systems [1] and adaptive educational hypermedia systems [2]. However, such systems are still limiting the freedom of interaction with provided materials, e.g. in terms of embedding into application contexts and the interaction with material simultaneously to creatively explore a given domain. In order to solve such problems beyond existing learning extensions, several modern have been recently studied and utilized in the educational fields [3, 4, 5]. Among the promising techniques that have been gaining a growing attention recently are augmented reality (AR) and virtual reality (VR) approaches. Since they can provide users a new interaction model with their surroundings, AR and VR have the potential to provide learners with interesting and attractive tools and learning scenarios. In this paper we utilize augmented reality in the learning domain, in order to enhance the student experience and increase the dynamicity of the learning material.

1.1 Augmented Reality (AR)

AR is the technology that enhances reality with digital recourses [5]. It allows the projection of information on real life objects, thus, offering a wide concept of knowledge visualization. Unlike virtual reality, where artificial, virtual objects exist in a completely virtual environment, the augmented reality approach utilizes the surrounding real environment and enriches it with digital projections.

AR features mobility as one of its compelling characteristics [3]. It is applied through different platforms including mobile devices or tablets which have with a camera and an operating system such as Android or iOS, where the AR mobile App can be installed. This makes the technology reachable at any time in any place, which promotes it to be used in the educational field according to the study in [6] focusing on the importance of portability in supporting learning. Taking the form of a mobile App means that AR is available to a wide scope of young users, who already are using smartphones on daily basis. This means that the time required to train students on using the technology is considerably less. Moreover, the Reinders and Wattana in [4] argue that the increase of student motivation and excitement, when learning through an AR-based mobile app, has outweighed the time invested in explaining how the app should be used. Gadelha in [7] draws the attention to the fact that utilizing such technologies can reduce the distraction of students in a classroom, due to the focus they invest in the virtual environments, in contrast to being distracted by looking outside the classroom window, for example.

The digital side of the AR learning applications allows the connectivity to further learning resources [8], due to the access it has to the online world. Such functionality can provide teachers and learners with an effective tool for personalized learning [9], in which, the projected information on the same object in the real world can vary from one student to another.

However, utilizing augmented reality applications in language learning should be integrated in the context of the learning process rather than being presented as an alternative method for learning a new language. This is due to several reasons:

1. The nature of AR as a visualization support technology, which means it cannot modify the learning content itself.
2. Students have different learning styles in general. AR should be offered as a supporting tool that takes into consideration learners’ preferences and enables them to choose the utilization on demand.
3. AR is a new approach for visualizing information through projecting them on the real objects, which is still not fully explored for the scope of learning. It is in this regard still immature in terms of being the only input tool for learning scenarios.
The current language learning approaches are effective and well-proven and can be well supported by mentors and teachers.

One of the most practiced and effective activities in language learning is understanding the meanings of new words from the context in which they exist or are used. In a traditional classroom, this process usually takes the form of reading a longer text that contains new vocabulary, then encouraging the student to understand the general idea of the text. This understanding may help the learner to guess the meaning of a new word from the meaning of other words and sentences surrounding it. In general, the learner starts associating different words and situations to one new word, which not only helps in understanding the meaning of the word, but also increases the potential of remembering this word in the future. This is because the new word has a context and is not an abstract word anymore. In this paper, word association [10] is the base method, on which the AR application is built. The intuition behind this approach is the effectiveness and popularity of word association activities in the language learning, which motivated our research towards supporting this method with the promising capabilities of AR in visualizing the context of a word or an object in the real world.

1.2 Human Word Association (HWA)

A huge number of words, which could be related to a certain term, can be overwhelming. In order to support the language learning process, providing the learner with associated vocabulary needs to reflect the learner’s human intuition of the relations between those words. One of the effective methods of discovering the human intuition of relations between words is surveys. Such surveys collect the evaluation of a human participant to the level of association between two words. This happens in the form of a question and answer process. In this approach the number of repeated answers to a certain word can reflect the relation strength between the question word and the answer one. For example, asking different participants about an associated word to “Canary” has revealed a frequent answer of “bird”. This means that the relation from “Canary” to “bird” is a strong one. On the other hand, very few people have answered with “Canary” when asked about associated words of “bird”. This means that the relation is not always the same between two associated words, but may be one-sided. When the relation has only one direction, it is called Asymmetric relation. On the other hand, relations that are the same in two directions are called Symmetric.

Evaluation of human-based association of words enables the development of systems that can mimic this association, and thus generating lists of most appropriate words that are reasonably associated with a certain word. In [11] Uhr, Klahold, and Fathi have developed the Concept for the Imitation of the Mental Ability of Word Association (CIMAWA) as an approach to evaluate the strength of relations between words in a corpus, similarly to a human ability of associating those words to each other.

Utilizing augmented reality as a method of visualizing the associated words to an object in the real world, this paper proposes a tool for language learning based on the CIMAWA approach. In the next section of the paper, the related work in literature is presented. Afterwards section 3 discusses the proposed educational tool, while in section 4, the implementation and results are documented.

2 RELATED WORK

Although augmented reality has been increasingly used in education during the recent years, its implementation in the language learning in classrooms is still limited [5].

Examples of the educational approaches that are based on AR include the work of [12] where the augmented reality application was meant to increase the motivation among English language students.

Holden and Sykes in [13] have utilized AR to encourage language learning activities outside the classroom. Their application targeted Spanish language learners.

In order to support language tutors in the process of adopting AR-based educational activities in their classrooms, Bonner and Reinders in [5] provided a survey of the current state of the art technologies in this field, along with practical implementation ideas and concepts that are suitable for language learning. Their study shows that augmented reality applications in this domain are still very limited. This is not because the technology is new, but rather because its adoption rates in real schools and classrooms faces several drawbacks, such as the technical requirements for building an AR based app, which teachers may not possess. Also, there is no clear and proven concept on how this technology can support the current language learning activities and the pedagogical approaches
behind them. For this reason, their paper presents several detailed examples that language teachers can implement in their classrooms.

Marsh and Rice in [14] present teachers with five main principles that support the implementation of AR in classrooms. Within those principles, the authors highlight that AR applications in classrooms need to build upon the existing knowledge that students have regarding the use of such technologies. This reflects that many students have already experienced AR games on their smartphones of tablets, such as Pokémon Go, which allows the tutor to easily utilize the gaming approach that are based on augmented reality in their classrooms.

Although the scope of implementing AR in the language learning domain is quantitatively limited, the qualitative aspect is well noticeable in the state of the art. This is reflected by the global increasing interest in this technology and the variant languages that are utilizing it to support their learners. Examples of this global interest include old Turkish language mementoes in [15], where the authors utilize AR in motivating language students achieve a higher interest and better results in exploring the old lingual scripts available. Along Spanish and English learning Apps, also Hindi and Marathi languages were used in a question answering system based on augmented reality in [16]. Even the Arabic version of sign language has been utilizing AR in [17], in order to translate written letters into sign language gestures. This was intended to support deaf individuals of learning the Arabic alphabet and thus reading written texts.

Despite the variety and novelty of the previous approaches, none of them have handled the human intuition of word association in order to support this learning ability with AR-based visualization of the digital resources. Our contribution in this paper features utilizing AR technology in word association activity, which is a learning process that not only self-learners can utilize, but also one that is well practiced in classrooms, allowing the proposed approach to be integrated in the current and common language learning activities.

3 PROPOSED SYSTEM AND METHODOLOGY

The proposed language learning tool in this paper has two main components:

1. The CIMAWA algorithm, which is meant to bring the learning process into the scope of natural human language learning.
2. The AR-based visualization, which provides a user-friendly and motivating access to the information extracted from CIMAWA.

Fig.1 illustrates the concept of the proposed tool. In this concept, an Android mobile app is provided to the users. Students can use the cameras of their smartphones or tablets to scan the surrounding space. Within this space, objects and images are recognized by the AR platform. Once an object is recognized, its identifier, in form of the object’s name, is parsed to the backend algorithm. Utilizing the CIMAWA approach, a list of the associated words is defined, along with the relation strength between the two words. This information is projected visually on the real world environment, surrounding the object in the image in question.
3.1 CIMAWA Algorithm

The Concept for the Imitation of the Mental Ability of Word Associations (CIMAWA) is a hybrid approach that inherits symmetric and asymmetric features of Human Word Association (HWA) in the process of defining the word association [11]. Symmetric approaches, such as Pointwise Mutual Information (PMI) [18], define the mutual relation between two words in a corpus. In other words, for words A and B, the PMI represents the relation strength from A to B and from B to A. This is because PMI takes into consideration the frequency of both words in the corpus, and how many times each single word has been mentioned. On the other hand, symmetric approaches, such as the Walter-Rapp (WR) standard [19], represents the association strength only from one word to the other, and not vice versa. This is because the WR standard is calculated with regards to the frequency of the second word, also known as the answer word, in the corpus.

In order to combine the advantages of both concepts, CIMAWA is defined by the following formula, Eq.1 [11]:

\[
CIMA\text{WA}_{ws}(A(B)) = \frac{Cooc_{ws}(A,B)}{(frequency(B))^a} + 0.5 * \frac{Cooc_{ws}(A,B)}{(frequency(A))^a}
\]  

Where: \(CIMA\text{WA}_{ws}(A(B))\) is the measure indicating strongness of the word ‘A’ in association with the word ‘B’, based on a certain window-size (\(ws\)). The widow-size is used to analyze all co-occurrences of word A and B within the text. Typically, a (\(ws\)) of 10 words (five words on left side, five words on the right side) is used based on previous studies [10, 20]. The damping factor (0.5) in the second part of the formula is intended to prevent the pure symmetric result in case of equal weights of both formula parts. Fig. 2 illustrates the CIMAWA approach [11].

Figure 1 Comparison between CIMAWA, Symmetric and Asymmetric Approaches

Utilizing this approach, the proposed tool calculates the strength of association between the name of an observed object and other related words. Then, based on this value, the link is projected in real life offering the user two types of information:
- The list of related vocabulary itself.
- The strength of these relations between words.
In order to achieve this projection, AR visualization approach has been chosen as the means to reflect this gained knowledge on the real surroundings of the user.

### 3.2 Augmented Reality Environment

Having CIMAWA as the backend algorithm, the frontend interface of the proposed tool is meant to provide users with an engaging and motivating learning experience. In the light of the current experiences in literature regarding language learning mobile Apps, we focus in this paper on the integration of the AR approach with well-practiced learning activities. This is driven by the intention of integrating the tool in language classrooms easily.

In order to achieve this goal, the proposed system runs on ordinary smartphones and tablets that use Android operating system. The availability of those devices for students means that using the tool is completely cost-free. On the other hand, the application is designed in a straightforward manner to minimize the need for operation instructions.

The role of language teachers is essential in the language learning process within a classroom. For this reason, teachers have the potential to modify the targeted surrounding environments, with which the students interact. For example, instead of an office environment that features office-related vocabulary, the teacher can use other objects and images from an outdoor scenery, in order to change the projected words. This, however, requires a certain level of training, which enables the teacher to use the platforms and adjusting the learning scenarios.

The learning tool in this paper has also been designed to enable teachers furthermore to edit the lists of related words, and their CIMAWA values if necessary. Although this contradicts the concept of equally automating the discovery and relation definition by the algorithm, we do believe that the teacher should still be able to make fine adjustments to the algorithm results in order to ensure their suitability for their classroom. Editing word lists requires also a level of training on the use of the AR platform, because available AR technologies are still not offering effective input solutions for the users. However, this is only a current problem in technology, which is expected to be solved in the future developments of the programming platforms that support AR.

### 4 IMPLEMENTATION AND RESULTS

In this paper, the chosen AR platform is Unity, which is a game building environment that supports augmented and virtual reality applications. Advanced libraries and supporting platforms are also accompanying Unity environment to add more specialized and extended features to the AR and VR applications. In this paper, we utilize the Vuforia library that offers advanced elements and functionalities to program and optimize the interaction model with the user.

A use case has been designed to describe the potential of the integration between CIMAWA approach and the AR visualization technology. In this use case, a potential student navigates the space of an office room, scanning the surrounding environment with a smartphone or a tablet. Certain objects in this office are recognized and linked to a list of related words. Based on the CIMAWA values of the relation strength, the words are projected onto the real object with physical links. Each physical link is then used to reflect the word association strength, e.g. with its thickness or length.

Examples of the working App and the resulting projections in the augmented world are shown if Fig. 3a/b, showing annotated objects and related associations, which are detected and labeled in real-time.

### 5 CONCLUSIONS AND FUTURE WORK

In this paper, a language learning tool based on AR technology has been presented. The proposed tool utilizes CIMAWA, a hybrid approach that mimics the human ability of word association, in the learning process. Combining both approaches, which is the main contribution of this paper, is proposed in order to integrate normal and common language learning activities with cutting edge technologies without the need for sophisticated preparation, training or modification procedures. The augmented reality, that utilises real world surroundings, offers a valuable and effective visualisation method. Such a method can be easily introduced for self-learners as well as classrooms and enables them to upgrade the traditional learning activity with an engaging, encouraging and easy to use technology.
In order to get use feedback and assessment, a usability test is to be conducted on the proposed tool. The proposed system can still be further enhanced by providing teachers with a more user-friendly API that allows the editing of the backend algorithms on a high level. Moreover, the prospective development of AR platforms holds a great potential to utilize effective two-way interaction models between users and the AR-based system. In such models, user input can be extended to take the form of a written text, spoken sentences or recognised sequences of gestures, which can be translated into instructions to request certain actions from the system. With that capability, the tool, introduced in this paper, can also be a base for a gamified learning approach, in which the user participates in filling missing words or connecting related vocabulary in order to collect points and pass the game levels.

![Image](image_url)

Figure 2a/b Examples of the Word Association in the AR-Based Learning Tool

REFERENCES


