The Augmented Tutor: how augmented reality and machine learning can be combined to create an educational tool.

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Abstract

Background: Education generally focuses on a closed corpus of information, meaning that a student is limited by a teacher and their knowledge. Open Hypermedia Systems combat this but can be lack focus. By using AI concept extraction and AR, it is possible to create an engaging and meaningful educational system.

Solution: a markerless augmented reality tutoring system was created using unity. This worked along side an automated concept extraction system which was created in python. Gamification elements were also added to increase student engagement.

Further Works: extra functionality such as multiple-choice quizzes and gamification elements such as badges could be added to enhance the educational experience of students.

Introduction

A hypermedia system provides multimedia elements, such as sound or animation, as well as hypertext elements, such as words or pictures, which are linked by multiple paths. These systems often do not follow a logical order making it them difficult to navigate. Furthermore, these systems aren't engaging for users who may find an incredibly long list of search terms and only look at the first few. Therefore, it is desirable to create a system which could automatically direct students through the syllabus, suggesting the key concepts from each module which they should study.

One solution to make the system more engaging for users is to create an augmented reality interface. As augmented reality enhances the real world, rather than drawing people away from it, students using AR technology have been found to display higher levels of engagement and greater learning gain. Therefore, there is the potential to create a powerful and highly effective tutoring system by combining augmented reality and machine learning.

Background

Augmented Reality

Augmented reality (AR) is a technology which enhances the real world by superimposing computer generated media onto a camera generated image. (Emspak, 2018). It is a technology which enhances the user's perception of the real world by merging the digital and physical worlds. (Ibáñez & Delgado-Kloos, 2018). As the only requirements for an AR system are a display, a camera, and some computational capacity, the systems can be used on low-cost technology such as smartphones or tablets (Henrysson, 2007). The use of AR in educational systems has been found to provide many

advantages including increased achievement, motivation and student satisfaction.(Altinpulluk, 2018).

Generally, augmented reality can be split into two main categories- markerless and marker-based. In marker-based AR, the marker can either be a 2D image or a feature in the natural environment. The system then tracks the position of this marker and imposes the digital content based on relative to this position. Conversely, in markerless AR uses localization technology in the device, such as GPS location or orientation. (Cheng and Chen, 2017).

Adaptive Educational Hypermedia Systems:

Adaptive educational hypermedia systems (AEHS) aim to personalise educational content and learning paths to maximise learning and efficiency for students. (Somyürek, 2015). However, it has been recognised that an obstacle to the widespread adoption of adaptive hypermedia is open corpus knowledge. (Somyürek, 2015). As open corpus knowledge is dynamically generated, it "can constantly change and expand", which can overwhelm users. (Brusilovsky & Henze, 2007). Adaptive hypermedia systems can be classified into two groups, adaptive presentation or adaptive navigation (Berlanga and García-Peñalvo, 2008).

Gamification in educational systems:

Gamification is the use of elements that are typically found in games in a non-game activity, to increase engagement and enjoyment. Examples of these elements include leader boards, reputation points and goal settings. (Chang & Wei, 2015). It has been identified that student's often to struggle to maintain focus for prolonged periods of time whilst studying whereas when playing video games, they are kept at high levels of attention, sometimes for many hours. (Fotaris et al., 2016). Therefore, the theory of using gamification in education is to create the positive feelings that games create in an educational setting.

Solution

Target Device:

AR technologies should be developed for use on devices which are portable, fast enough to display graphics and will not cause additional technical problems. (Akçayır and Akçayır, 2017). Additionally, one of the major factors in the acceptance of educational AR technology is the availability of low-cost handheld devices. (Sırakaya and Alsancak Sırakaya, 2020). Therefore, mobile devices, such as smartphones and tablets, are ideal for education systems as they are readily available to most students.

System structure and Design Overview

The 'Augmented Tutor' is comprised of two main components. Firstly, there is a system which uses machine learning techniques to automatically extract the key concepts, which was developed by a project student who I collaborated with. Secondly, there is a user interface which is implemented in augmented reality.

The concept extraction system is written in Python and reads the contents of a series of lecture slides. It then automatically extracts the key concepts from the slides, by analysing how often the

key terms appear. It then finds Wikipedia and Google URLs for each concept and generates a lesson plan. When a user first uses the system, they are asked a series of questions to gauge their existing knowledge and ability. Furthermore, when the user can remove concepts from the list that are not relevant to them or add concepts that they wish to study further.

Ideally, both of the systems would work seamlessly together. However, I encountered compatibility issues with python and unity. Therefore, an SQL database is used to bridge the gap between the two systems. The key concepts and information about the users is stored in the database, and both systems read and write this information to it.

Database:

We decided to use SQL lite to implement the database because it offered compatibility with both unity and python. Furthermore, there was a unity plugin available which offered compatibility across multiple platforms, which is essential for the widespread use of the system.

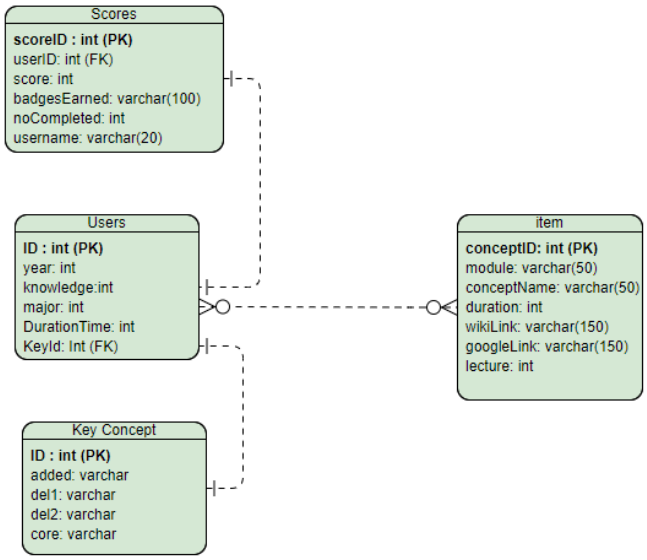

Figure 1: Entity Relationship Diagram

Figure 1 shows the entity relationship diagram of the database used by both the python and unity systems. After a discussion with the student who I was collaborating with, we agreed that the above diagram suited the needs of both of our systems.

AR System Design

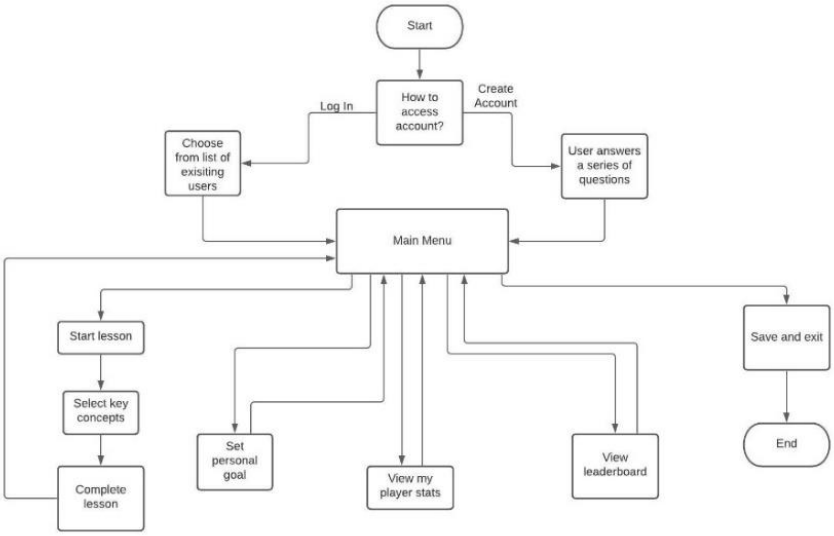

Figure 2: System Design

It has been identified that educational software should be designed in such a way that students should not be frustrated too easily as complicated software can hinder progress. (Reuter et al., 2019). Therefore, the system is structured as indicated in figure 2. Once the user has logged in, they are always redirected back to the main menu to ensure that navigation through the system is as simple as possible. Furthermore, when a user is selecting the concepts they would like to study, the available lessons are filtered by module and lecture.

I have built the system using the game engine Unity as the apps developed are compatible across a number of platforms. Furthermore, there is a lot of support and many plugins available for unity which will allow for the development and expansion of the app. I used the Vuforia SDK plugin for Unity to enable the AR user interface as this supported a wide variety of mobile devices.

The system uses Vuforia ground plane, which is a system for markerless AR. It allows for digital content to be superimposed on a flat surface, such as the floor or a tabletop. The digital content has been scaled so it can be used by a seated user as most users would be sitting whilst studying.

Viewing lesson content:

Once the user has selected what they want to study, the webpage is displayed within the same app. In augmented reality apps that use Vuforia Ground Plane, the content can be repositioned by tapping on the screen. However, when the user completes actions such as scrolling or clicking on links, it can be frustrating as the digital content can move. Therefore, to ensure that is easy for the user to interact with the webpage, the content is pinned to the front of the window rather than in the AR environment.

Gamification elements:

A student's learning can be limited when they are solely focused on their own progression and efforts. (Beck, 2019). One way to combat this is by implementing leader boards so students can see the progress of others . With relative leader boards, users only see their rank as compared with their closest ranking peers. This prevents students from feeling discouraged when they are ranked lower down. (Ortiz-Rojas, Chiluiza and Valcke, 2019).

The leader boards in my system show the three closest players above and below the user. For added clarity, the current user is indicated in the red font.

Figure 3: The leader board

Students who have the ability to be consistent and self-motivated are the most successful in online education (Salazar, 2010), therefore the system allows students to set their own points goal for the lesson. The students can see their current goal, status of their goal, and, if applicable, the number of points needed to surpass the goal from a button on the main menu. The user can also see their current points and number of lessons they have completed in the stats window.

Further works

The progress of a student can be compromised if they feel that there is no instant gratification or short-term wins (Fotaris et al., 2016). If further gamification elements such as badges and trophies were added to the system, there would be an instant sense of achievement for the users- encouraging them to keep studying.

Currently, the system mainly uses visual elements to create the learning environment. However, when experiencing an AR environment, users are often able to dedicate more focus towards retaining auditory information then they would in other learning environments (Huang et al., 2019). Therefore, in order to further test student gain from the AR system, auditory elements should be added.

In educational technology, there is the ability to provide instant feedback and consistent communication regarding a student's progress. (Salazar, 2010). This feedback is often integral to keeping student's motivated and optimising their learning gain from the system. The system could be expanded to offer the users functionality to test their understanding, such as asking a series of multiple-choice review questions.

References

Altinpulluk, H., 2018. Determining the trends of using augmented reality in education between 2006-2016. Education and Information Technologies, 24(2), pp.1089-1114.

Akçayır, M. and Akçayır, G., 2017. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review, 20(20), pp.1-11.

Beck, D., 2019. Special Issue: Augmented and Virtual Reality in Education: Immersive Learning Research. Journal of Educational Computing Research, 57(7), pp.1619-1625.

Berlanga, A. and García-Peñalvo, F., 2008. Learning Design in Adaptive Educational Hypermedia Systems. Journal of Universal Computer Science, 14(22), pp.3627-3644.

Brusilovsky, P. and Henze, N. (2007). Open corpus adaptive educational hypermedia. In P. Brusilovsky, A. Kobsa and W. Neidl, The adaptive web: Methods and strategies of web personalization. Lecture Notes in Computer Science, Vol. 4321, (pp. 671-696).

Chang, J. W., & Wei, H. Y. (2016). Exploring Engaging Gamification Mechanics in Massive Online Open Courses. Educational Technology & Society, 19 (2), 177–203.

Cheng, J. and Chen, W., 2017. Comparison of marker-based AR and markerless AR: A case study on indoor decoration system. Conference: Lean & Computing in Construction Congress (LC3), 2.

Emspak, J., 2018. What Is Augmented Reality?. [online] livescience.com. Available at: <https://www.livescience.com/34843-augmented-reality.html> [Accessed 24 June 2020].

Fotaris P, Mastoras T, Leinfellner R and Rosunally Y, "Climbing Up the Leaderboard: An Empirical Study of Applying Gamification Techniques to a Computer Programming Class" The Electronic Journal of e-Learning Volume 14 Issue 2 2016, (pp94-110)

Henrysson, A. (2007). Bringing Augmented Reality to Mobile Phones. Linköping Studies in Science and Technology, p.11.

Huang, K., Ball, C., Francis, J., Ratan, R., Boumis, J. and Fordham, J., 2019. Augmented Versus Virtual Reality in Education: An Exploratory Study Examining Science Knowledge Retention When Using Augmented Reality/Virtual Reality Mobile Applications. Cyberpsychology, Behavior, and Social Networking, 22(2), pp.105-110.

Ibáñez, M. and Delgado-Kloos, C., 2018. Augmented reality for STEM learning: A systematic review. Computers & Education, 123, pp.109-123.

Ortiz-Rojas, M., Chiluiza, K. and Valcke, M., 2019. Gamification through leaderboards: An empirical study in engineering education. Computer Applications in Engineering Education, 27(4), pp.777-788.

Reuter, R., Hauser, F., Muckelbauer, D., Stark, T., Antoni, E., Mottok, J. and Wolff, C., 2019. Using Augmented Reality in Software Engineering Education? First insights to a comparative study of 2D and AR UML modeling. Proceedings of the 52nd Hawaii International Conference on System Sciences

Salazar, J., 2010. Staying Connected: Online Education Engagement and Retention using Educational Technology Tools. American Society for Clinical Laboratory Science, 23, pp.53-58.

Sırakaya, M. and Alsancak Sırakaya, D., 2020. Augmented reality in STEM education: a systematic review. Interactive Learning Environments, pp.1-14.

Somyürek, S., 2015. The new trends in adaptive educational hypermedia systems. The International Review of Research in Open and Distributed Learning, 16.