Shared Augmented Reality Experience of 3D Molecules for Chemistry Students

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Abstract:
Augmented Reality (AR) and Artificial Intelligence (AI) can be harnessed inside of a smart phone to enhance the education experience. The purpose of this project is to create a shared AR experience that allows users to manipulate 3D representations of molecules, using only their mobile devices. The mobile application was created using Google's ARCore software to provide an AR baseline environment and Unity 3D editing software to build the application. It allows students to take concepts from the real world that are metaphysical in nature and give them an on-screen 3D model to visualize and maneuver in a virtual environment mirroring their own. The mobile application is meant to be a tool for students to improve their chemistry content knowledge using the phones in their pockets inside the classroom and on the go.

Introduction:

Chemistry remains a difficult subject for students to grasp, which leads to high failure rates. Chemistry requires students to understand concepts at the macroscopic level, i.e. what they can see, and the sub-microscopic level, i.e. what they cannot see. Students often struggle to make these links and find it difficult to switch their thinking between the different levels (1). Physical model kits are often used to help conceptualize the sub-microscopic level, but they come with their own disadvantages.

AR has become a leading tool in the field of educational technology (2). AR offers many benefits over traditional teaching methods such as accessible learning materials, higher student engagement and interest, and improved collaboration capabilities (2). Additionally, AR does not require specialized equipment but can be utilized through smartphones and tablets. According to a Pew Research Center study in 2015, 73% of teens have access to a smartphone, while 58% of teens have or have access to a tablet computer (3).

The aim of our application is to bridge the difficulties of learning chemistry with the inherit advantages of AR. A TopHat study in 2017 showed that 94% of students want to use their cellphones for academic purposes (4), so there is strong motivation to leverage the power of AR in the form factor of a smartphone. Combined with cloud-based AI technologies, students will have the ability to capture an image of a 2D molecule and transform it into a virtual 3D structure represented in their real space. This will serve to aid students in switching between the conceptual levels mentioned above and bring the sub-microscopic level to life in a truly innovative and engaging experience.

Application Development:

Unity 3D was chosen as the platform for app development for two main reasons. First, it allows for the development of a single code base that can be deployed to both Android and iOS, which meets our goal of a multi-platform product. Second, it supports the development of AR applications with the availability of pre-built libraries. Our selected choice is ARCore.

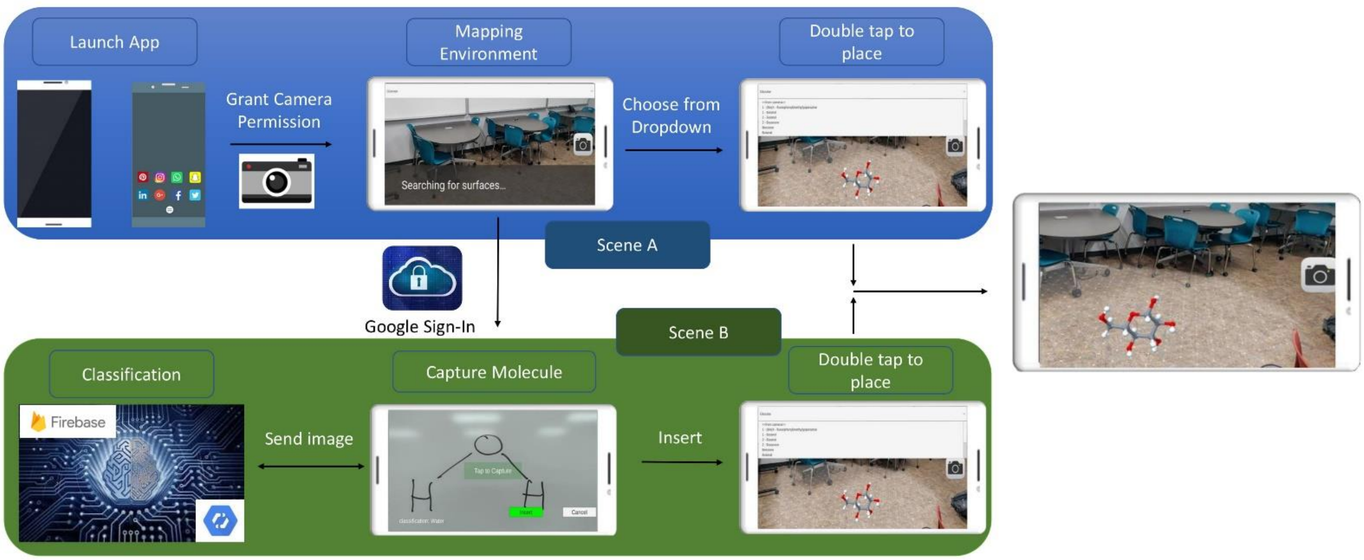
ARCore is an open source software development kit contributed by Google that specializes in creating an AR application within a smartphone. It uses three design mechanisms to create a core structure for a shared AR experience (5): motion tracking, environmental understanding (surface detection), and light estimation. When a virtual 3D molecule is spawned in this AR environment by the user, it will be attached to an anchor component which will maintain its position and orientation in real space. The 3D molecules are created based on molecular information from the PubChem database (6). Previously created molecules are cached in the application files, while newly encountered molecules are immediately fetched from the database and dynamically converted to their appropriate structure.

The team's application also offers its users the ability to take a picture of an image and, if it meets classification criteria, convert it into a corresponding 3D virtual structure. This feature utilizes Google's

Firebase as a Mobile Backend-as-a-Service for authentication, storage, and proxying to an AI service that performs image recognition.A

Application Architecture:

The functionality of the application has been split across two scenes depicted in Figure 1 below. Scene A (highlighted in blue) provides the AR experience environment, while Scene B (highlighted in green) uses image recognition to allow the user to identify unseen molecules. When the app is initially opened, the user must grant permission for camera access. Once given access the app lands onto Scene A, which automatically maps the environment in search of a suitable surface to facilitate the AR experience. Once established, the user can select pre-loaded molecules from a dropdown and place them in their environment. The user interface (UI) provides a button that allows the user to move to Scene B, which requires a Google account for authentication to the Firebase database. Once granted, the user can capture an image of either a 2D or 3D molecule. If the predicted value meets a predetermined threshold, then a classification label is displayed to the user and the user has the option to insert it back into the AR environment of Scene A.



Project Outline:

Based on experience and knowledge learned from previous research projects, the team started by constructing two new prototype applications based in Unity 3D, one focusing on the AR experience and the other focusing on image recognition of 2D/3D molecules. After these prototypes were tested and their features confirmed to function independently, the team then merged them into a single Unity 3D application, separated between two scenes. Navigation between the two scenes is possible with UI elements, and the user can pass successful molecule recognitions back to the AR environment in order to create a virtual model.

The team's main goal moving forward will be to implement the ability for users to experience a shared environment. This feature would require a network connection that can be leveraged to send and store molecule and anchor point information into our Firebase database, which would then be shared between all users with network access. This shared environment among multiple chemistry students and devices would provide added benefit to the learning experience and, to our knowledge, is not offered within the AR or educational technology field. Additionally, the app will need to implement features for data persistence to allow users to seamlessly move between scenes without losing their learning environment.

Resources

1. "Developing and using models: From macroscopic to sub-microscopic", *Royal Society of Chemistry*, https://www.rsc.org/cpd/resource/RES00001450/from-macroscopic-to-sub-microscopic/RES00001448#!cmpid=CMP00003565, Accessed 22 Feb. 2019

2. "Augmented Reality in Education: The Hottest EdTech Trend 2018 and How to Apply It to Your Business." *Eastern Peak*, 24 Apr. 2018, easternpeak.com/blog/augmented-reality-in-education-the-hottest-edtech-trend-2018-and-how-to-apply-it-to-your-business/.

3. Lenhart, Amanda, "Teens, Social Media & Technology Overview 2015", *Pew Research Center*, Apr. 2015, http://www.pewresearch.org/wp-content/uploads/sites/9/2015/04/PI_TeensandTech_Update2015_0409151.pdf, Accessed 5 Mar. 2019

4. "Cellphones in School are Essential to Learning, Say Students", *Top Hat*, 12 Dec. 2017, https://tophat.com/blog/cellphones-in-school-student-survey/, Accessed 22 Feb. 2019

5. "ARCore Overview", *Google*, 28 Feb. 2019, developers.google.com/ar/discover/, Accessed 8 Jan. 2019

6. "The PubChem Project." *National Center for Biotechnology Information. PubChem Compound Database*, U.S. National Library of Medicine, pubchem.ncbi.nlm.nih.gov/, Accessed 8 Jan. 2019