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Exploiting Augmented Reality and Computer Vision for Healthcare Education: The Case of Pharmaceutical Substances Visualization and Information Retrieval

Dionysios KOULOURIS[a,1], Parisis GALLOS[a], Andreas MENYCHTAS[a] and Ilias MAGLOGIANNIS[a]
[a] *Computational Biomedicine Research Lab, Department of Digital Systems, University of Piraeus, Greece*

Abstract. Augmented Reality (AR) is already used as the primary visualization and user interaction tool in several scientific and business areas. At the same time new AR technologies and frameworks considerably facilitate both the development of innovative applications and also their wide adoption in different domains of everyday life. In the area of healthcare AR solutions make use of mobile or wearable devices and glasses to support, among others, education and healthcare professionals training. The aim of this paper is to present a prototype mHealth app for education, which uses AR and computer vision technologies for pharmaceutical substances recognition on drug packaging. The conceptual design of the system includes three main components which are responsible for a) Text recognition, b) Drug identification and c) AR operations for interactivity. The prototype application is available in Android or iOS platforms and has been evaluated in real-world scenarios. Camera and screen of the mobile phones fulfill the text recognition and AR operations, which eliminates the need for special equipment, while PubChem and 3D Model databases provide assets required for the drug identification and AR visualizations. The results highlight the value of AR for educational purposes, especially when combined with advanced image recognition technologies to build interactive AR encyclopedias.

Keywords. Education, Augmented Reality, Computer Vision, Pharmaceutical Substances, Visualization, mHealth, Information Retrieval, mHealth

1. Introduction

Advancements in Computer Vision and particularly in Augmented Reality (AR) lead to the creation of innovative solutions with an emphasis on human-machine interaction principles. AR blends with the real-world and augmented information generates engrossing experiences that create a holistic approach for information and knowledge understanding. AR technologies are capable of supporting education in various domains and especially in health and are already compatible and accepted for modern healthcare services provision [1-4]. Both patients and healthcare professionals can be beneficiaries

[1] Corresponding Author, Dionysios Koulouris, Department of Digital Systems, University of Piraeus, 80, M. Karaoli & A. Dimitriou St., 18534 Piraeus, Greece; E-mail: dnkoulouris@unipi.gr.

of the AR applications. For example, healthcare professionals are equipped with new tools that can optimize their workflow or provide to patients' remote healthcare services [2,3]. Additionally, recent studies discuss the value of AR technologies implementation in patients' management to promote wellbeing in older adults or in elderly fall prevention [5,6].

AR technologies are used to support education in different domains of everyday life [7,8]. Specifically, AR solutions in healthcare use either mobile or wearable devices and glasses to support education and healthcare professionals training [9-12]. AR technologies can also be applied for better drug management and to support patients' adherence for drug intake [13,14]. Moreover, AR is used for educational proposes related to chemistry and drug development [15-17] and can be combined with advanced image recognition technologies to build interactive AR drug encyclopedias [18,19].

The aim of this paper is to present a prototype mHealth application which uses augmented reality and computer vision technologies for pharmaceutical substances recognition on drug packaging. The proposed application provides data visualization and information retrieval of pharmaceutical substances from PubChem database for educational reasons. Such applications may lead to healthcare professionals' and students' empowerment regarding the better drug handling and management as well as to increase patients' safety.

2. Methods

The proposed mobile application is a form of educational paradigm that facilitates in learning and appropriating molecular compounds in a three-dimensional figurative way. Designed to run on commodity devices with no extra static and expensive hardware, this prototype first recognizes the medicine box that is in front and then, displays the corresponding augmented information above. For the medicine box recognition, Google's ML Kit Text Recognition[2] framework is used combined with data retrieved from the PubChem database. Visualization of augmented information (medicine and its molecule compound) is performed using the Google ARCore library[3]. To achieve interoperability and user ease of access the application was implemented in a cross platform mobile development environment[4]. Camera, screen and IMU sensors are the only device's hardware required while connection with external resources is established for medicine and 3D models database access. Architecturally the system is divided into three main components (Figure 1) responsible for a) Text recognition, b) Drug identification and c) ARCore operations. Camera and screen are the required components for the Text recognition and AR while PubChem and 3D Model databases provide assets to the Drug identifier and ARCore components.

[2] Google ML Kit: https://developers.google.com/ml-kit/vision/text-recognition

[3] ARCore: https://developers.google.com/ar

[4] Android and iOS executables with the exact same visual result

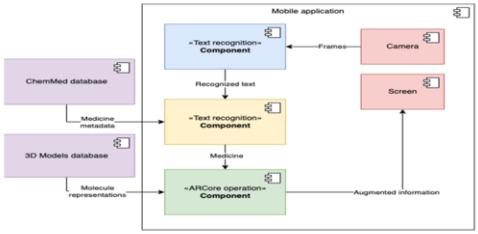

Figure 1. Proposed System Architecture

2.1. Text recognition

This component is responsible for identifying text that is visible in camera. A frame from the camera feed is given as an input to the MLKit's Text Recognition routine. The library returns sentences that are discovered along with their 2D screen coordinates. The results of each frame are provided as input to the Drug identifier component.

2.2. Drug identifier

By analyzing the input text and comparing it with the database data, this component checks if a frame contains any text that refers to a medical substance. The analysis process is performed based on a Text Medicine Analysis algorithm (TMA) which analyses the input text and indicates any medicine-related information. The steps performed by the algorithm are the following:

1. Text pre-processing (lowercase, trim, delimit)
2. Gather data from the database and search for relations
3. Retrieve and return the drug that corresponds to the text, if any. The key value of the search can be either the name of the medicine or the name of the drug (e.g. paracetamol, aspirin)
4. Identify the location of the text and also return the on-screen 2D coordinates.

Once the drug is found by the TMA algorithm, the returned result is parsed as input in the ARCore component.
This result contains the 3D model of the compound, the title and all related information of the drug retrieved from the PubChem database in a json format.

2.3. ARCore component

This component manipulates the ARCore API and visualizes the final result on the screen. The corresponding molecule compound model is downloaded in a .glb form. Based on the 2D dimensions of the text, the center of the text is calculated with the top left corner of the screen acting as the start of the axis. The model is then presented at the newly created 3D location. Model's size and orientation are pre-configured in order to maintain a common pattern. An additional drug information screen is accessible through the AR session visualizing the PubChem retrieved data based on user interaction.

3. The System in Practice

The end user solution is offered as an Android or iOS application and both executables have been developed and tested under real conditions. For the purpose of this paper, all demonstrations and screenshots are captured on an iOS device (Figure 2). The user selects the “Start capture” button and is diverted to the main screen of the app. Camera preview along with augmented 3D models for any identified medicine are rendered on the screen. Tapping at a compound will navigate to the details screen. Paracetamol was used as a demonstrative example. This tested pharmaceutical product contains disks of 500g of Paracetamol with the title of the drug being Acetaminophen. The record of Acetaminophen/Paracetamol is retrieved from the PubChem database along with the appropriate 3D model of the molecules.

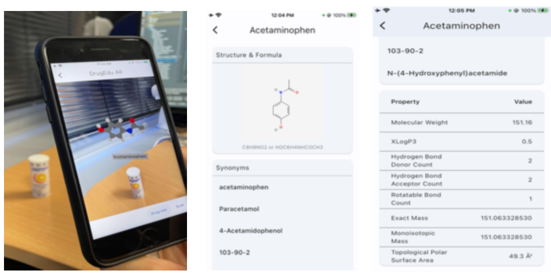

Figure 2. Demo System Use

The utilization of AR and Text Recognition offers pragmatic data visualization and comprehensive information transmission. One of the benefits that defines our solution is the ability to perform multiple drug recognitions at once. Many medicine boxes can be laid in a table and users will be able to view their molecular compounds and information just by hovering their phone above. Another aspect of this work is the interoperability and ease of access. The cross-platform design architecture allows the application to run on any OS thus increasing the field of application and use. Furthermore, data structures and architecture models are designed in such a way that not only are able to connect to the PubChem database but offer a generic interface that is able to interop with any related data storage. The general approach is to offer an environment that expedites the learning of visualized medical information by exploiting computer vision technologies: AR and Text Recognition.

4. Conclusions

DrugEduAR application was developed as an educational tool for healthcare professionals and healthcare domain students to give easy and direct access to drug information and to enhance their knowledge related to medicine products. Limitations of this work include that the system currently is fed by one knowledge base and the text recognition is tested only for English. Future work includes the further system development with additional features so users could choose the nature of the received information as well as the in-app implementation of tests and questionnaires for users’ knowledge review assessment.

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