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An Approach for Enhancing Drug Dispensing Process Using Mixed Reality Based on Microsoft HoloLens

طريقة لتحسين عملية صرف الدواء باستخدام الواقع المختلط بالاعتماد على مايكروسوفت هولولينز

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إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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طريقة لتحسين عملية صرف الدواء باستخدام الواقع المختلط بالاعتماد على مايكروسوفت هولولينز

An Approach for Enhancing Drug Dispensing Process Using Mixed Reality Based on Microsoft Hololens

وبعد المناقشة التي تمت اليوم **السبت 13 رمضان 1440**هـ الموافق **2019/05/18**م الساعة **العاشرة صباحاً**، في **قاعة اجتماعات كلية تكنولوجيا المعلومات** اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله تعالى ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

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وتم الاطلاع عليها، ومطابقتها بالنسخة الورقية للرسالة نفسها، ضمن المحددات المبينة أدناه:

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ملاحظة: ستقوم إدارة المكتبات بنشر هذه الرسالة كاملة بصيغة (PDF) على موقع المكتبة الإلكتروني.

والله ولي التوفيق،

توقيع الطالب

إدارة المكتبة المركزية

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Abstract

Nowadays, technology is used in every aspect of our life, leading us to a new comfortable world. Technology is considered as the key of modernity of any field of our life. Every department of pharmacy uses many types of modern technologies, starting from drug design to drug clinical studies to industrial pharmacy and through drug dispensing to medical records and so on. But what if we can go further, what if we can go beyond its normal usage, where technology introduces real solutions for our life, and mainly in pharmacy!

Mixed reality is considered one of the newest applied sciences in daily life that introduces many brilliant solutions for daily operations. Although this technology is quite old from many years, the lack of applied hardware for customers with quite cost made people and developers not use it wildly. As Microsoft viewed the current systems for HoloLens Glasses, there is no system for pharmacists or targeting drug despising. In this research, we introduce an integrated approach for drug despising in pharmacy, built on the top of mixed reality, to make pharmacists reach the maximum usage of current drug and patient information to make drug despising process more proper to patient and pharmacists.

In the proposed approach, we introduce UI design for modular system and its prototype by using Microsoft mixed reality glasses HoloLens, conjugation with other technologies that tries to introduce solutions for the problems that face the pharmacists in drug dispensing process. Starting from receiving prescription, and reviewing drug information, to providing patients with information they need. All these data will be displayed in a good order for pharmacists, while they speak to patients, in a new proposed UI and arranged order. After we introduce our approach, we will evaluate it by many evaluation methods; mainly we will make a survey with pharmacists and obtain their opinion on our proposed system and analysis.

Keywords: Mixed reality, Microsoft HoloLens, Microsoft Holograph, Drug recipe.

الملخص

وفي ظل القفزات العملاقة للتكنولوجيا في حياتنا، أصبحت التكنولوجيا أساسية في كافة نواحي حياتنا، وهذا بهدف بناء عالم جديد أكثر راحة للبشر، وإذا أردنا قياس حداثة أي مجال في حياتنا المعاصرة، فإننا نقيسها بمدى ربطها بالتقنيات الحديثة، فعلى سبيل المثال، جميع أقسام ومجالات الصيدلة، تستخدم التكنولوجيا في أدق تفاصيلها، وذلك بدءاً من عمليات تصميم الدواء، مروراً بالصيدلية السرية وإلى الصيدلة الصناعية، وخلال عملية صرف الدواء أيضاً، ولم تترك التكنولوجيا باباً إلا وطرقته وفتحته ودخلت وتربعت على عرش العمليات فيه. ولكن ماذا لو بإمكاننا الذهاب إلى ما هو أبعد من ذلك، ماذا لو قدمت التكنولوجيا حلولًا حقيقة لمشاكل حياتنا.

تعتبر تقنيات الواقع المختلط، واحد من أحدث التطبيقات العلمية في حياتنا اليومية، حيث قدمت حلولًا عبقرية لعمليات يومية متعددة، وعلى الرغم من كون تقنية الواقع المختلط قديمة نسبياً، إلا أن التطبيق العملي وبوجود عتاد حقيقي يمكن للمستخدم شراؤه بسعر مناسب، أمسى ممكناً بعكس السابق حيث كان الأمر صعب.

وقد رأينا مايكروسوفت تقدم نظارتها الأولى للواقع المعزز في العالم أجمع، حيث يمكن لأي أحد شراءها بسعر مناسب، وحيث أنه لا يوجد حاليا نظام يساعد الصيدلي في عملية صرف الدواء يعتمد على تقنيات هذا الواقع المختلط، فإننا في هذا البحث سنقوم بتقديم مقترح لنظام متكامل يساعد الصيدلي في عملية صرف الدواء مستفيداً من التقنيات الحديثة العديدة، للحصول على عملية صرف دواء أفضل.

في نموذجنا المقترح، سوف نقدم تصميم واجهات معتمدة على أنظمة متكاملة، وسيكون هنالك نموذج مبدئي لها مبني على نظارات مايكروسوفت للواقع المختلط (مايكروسوفت هولولينز) وهذا النظام مرتبط بعدة أنظمة أخرى مساعدة في محاولة لإيجاد حلول متكاملة للمشاكل التي تواجه الصيدلي في عملية صرف الدواء، وذلك بدءاً من استلام الروشتة ومراجعة معلومات الدواء، وثم تزويد المريض بالمعلومات اللازمة للدواء، كل هذه البيانات سيتم عرضها بطريقة تساعد الصيدلي أثناء حديثه مع المريض، وستكون واجهة مقترحة مع ترتيب مناسب، وبعد أن نتم هذا الأمر، سنقوم بعمل تقييم له، وفي الأساس سنعمل مقابلات مع الصيادلة ونحلل نتائجهم لكي نرى فاعلية النظام لديهم.

الكلمات المفتاحية :الواقع المختلط، مايكروسوفت هولولينز، مايكروسوفت هولوجراف، صرف الدواء.

بسم الله الرحمن الرحيم

وَكَذَلِكَ نُرِي إِبْرَاهِيمَ مَلَكُوتَ السَّمَاوَاتِ وَالْأَرْضِ وَلِيَكُونَ مِنَ الْمُوقِنِينَ

Dedication

I dedicate this work

To my mother, my father,

And to Humanity

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In the beginning, I thank Allah for all the knowledge and education I gained which led to the achievement of this thesis.

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Thanks to anyone who participated in the achievement of this thesis either directly or indirectly.

Glossary

Table 1 Medical Glossary

Term	**Definition**
ADME	is an abbreviation in pharmacokinetics and pharmacology for absorption, distribution, metabolism, and excretion.
Posology	The study of dosages of drugs, especially the determination of appropriate dosages.
OTC	Over-the-counter drugs are medicines can be sold directly to a customer without a prescription from a healthcare specialist.
Narcotic drug	any psychoactive compound with sleep-inducing properties.
ADS	Automated dispensing system is a computerized drug storage device or cabinet designed for hospitals.
Dosage form	pharmaceutical drug product in the form in which they are marketed and ready for use, with a specific combination of active ingredients and excipients, in a particular configuration, and apportioned into a particular dose.
ICU	Intensive Care Unit in the hospitals
FDA	Food and Drug Administration in USA
SAR	Structure Activity Relationship in pharmaceutical chemistry

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Chapter 1

Introduction

Chapter 1

Introduction

While pharmacists are trying to dispense prescriptions for patients, they are facing many challenges and obstacles, one of which is the blocking dispensing process to be, as it should to be. Pharmacists need many electronic services while they are talking with patients in order to dispense the prescription perfectly. There must be a computer close to them, so that they can view drug information like side effects, usage, doses (Posology information), drug interactions, how the patient can correctly take the drug, and which time should the patient take these drugs. Also the computer must view the question that needs to be asked for the patient before dispensing drugs, so that pharmacists can provide the complete medical care for patients (Spry & Lawley, 2005).

All these data should be studied and remembered by the pharmacist during the despising process. Moreover, the pharmacist must ask some critical and specific questions before the dispensing process. If the pharmacist forgets one point about a drug, it may harm the patient. To gain the full medical process and full dispensing procedures, the pharmacist must have many systems that analyze current situation with the patient (Anacleto, Perini, Rosa, & César, 2007). All required information should be viewed in a quick and well-organized way in which the pharmacist does not feel embarrassed by looking at his computer every second (Ghinea, Moradi, Asgari, & Serif, 2006). Current computer systems do not provide these requirements, to the best of our knowledge. (Vip-pharmacy, 2016) (Unfricht & Enderle, 2000).

The research is based on two fields, the Mixed Reality field and the pharmaceutical field. In the background chapter, we will introduce each part; for example in Mixed Reality paragraphs, we will introduce other related techniques like Augmented Reality, Virtual Reality and Microsoft HoloLens features and specifications. Also in the pharmaceutical part, we will mention the dispensing process and specifications.

In this thesis, we propose an arranged order of UI using mixed reality that has the following features:

- View patient information by variety of options (his picture, his ID number…etc.) and store it.
- Review drug information (OTC, Production Company).
- Artificial Intelligence (AI) that shows drug advise and instructions for the current patient situation.
- View drug scientific information (Scientific name, dose, pharmacological action).
- View drug-drug interactions, food interactions, side effects; may use algorithms for posology related to patient current state.

- Bind current drug information with other systems, like notification system, social media messaging, etc.
- How to view narcotic drug dispensing instructions.
- How to handle cosmetics and children equipment.
- Patient share data (instructions, send reassure messages to patient, send drug advs).

1.1 Statement of the problem

Current drug dispensing process is now out of date and regular process based on the pharmacist's memory storage and retrieval. Other helpful systems in dispensing process for pharmacists are used for specific purposes. These purposes are not meant to provide them with a complete solution for dispensing drugs. For example, the pharmacist needs to look at the computer screen to check drug information, and tries to move between windows to check drug interactions, drug dose and other factors that can affect drug administration process (Xiang, Chen, & Wang, 2009). When we look at automated drug dispensing systems, we found that their usage is limited to hospitals, and it does not introduce the solutions needed for pharmacists and patients. Patients need to contact with pharmacists to know how to take prescriptions, while pharmacists need to keep eye contact with the patients when they talk about the required drug information.

We suggest our approach which is an UI and arranged order of pharmacist useful information for dispensing using HoloLens with a computer information system for dispensing drugs. The interaction paradigm is close enough to natural paradigm and can minimize the errors of dispensing prescriptions. The medical data is viewed in queued screens. The first one is for the patient history and information, which has a face detection part, then the system must view the prescription drug list and its information, drug by drug. The drug information may be drug-drug interactions, dose, ADME (absorption, distribution, metabolism, excretion), food interactions, side effects, precautions and other useful information of this drug. Then the pharmacists can share any useful information with the patient, for medical or commercial use. This point of view will be very helpful to both patients and pharmacists. Rearrangement of screens in specific order will be important thing for all.

1.1.1 What to fix

Trying to solve drug dispensing errors in pharmacies is something not easy because there are many factors that cause these errors. First of all, as a registered pharmacist, I worked in a pharmacy for more than 18 months. Trying to use different solutions to fix some of dispensing errors I faced, I used computer software, but it was not very helpful. If we focus on the problems listed in Figure 1 (Cause of dispensing errors), mixed reality will fix Table 2 Problems which contains common problems

Table 2 Problems

Problem	Fixing
Communication Failure	Mixed reality will make it possible for the pharmacists to see the patient and the drug information in the same time.

Problems related to drug labeling	Proposed UI will provide a simple data view so that the pharmacists can specify the drug well.
Drug information	It's the most important part because the system will view all the data needed in arranged format to prevent drug information problems for the pharmacist.

1.2 Main Objectives

Our goal in this research is to introduce a helpful way based on mixed reality to enhance drug dispensing for pharmacists, enabling dispensing application in which the direct view of physical real-world elements are combined with that of virtual elements, and allow for more useful interaction in order to provide a more effective and satisfying service for patient and pharmacist. Figure 1: Imagination of HoloLens screen (BBC, 2015) depicts the concept of integrating mixed reality environment.

Figure 1: Imagination of HoloLens screen (BBC, 2015)

1.3 System Functions

Our research has these objectives

1- View drug information e.g. Generic or Therapeutic Substitution.
2- Improve Patient Education and Documentation.
3- Interface Electronic Prescription for Physicians.
4- Introduce patient counseling best practice.
5- Identify patients who may use the drug wrong.
6- Extend the relationship with patients by sharing soft and significative dialogs appreciation for their patronage, notifying them of new and useful pharmacy services and events and even wish them a Great Feast. Messaging is automated, personalized and available by email and SMS (Brown, Jager, Wood, & Rivett, 2006).
7- Minimize dispensing errors.

8- Simple, Scalable, Intelligent and a must for every Pharmacy.
9- Ensure correct entry of the prescription and complete.
10- Minimize errors may be come from communication failures.

1.3.1 Specific objectives

Our research has these specific objectives

1. Enhance the dispensing process, which will be done by gathering and collecting medical data and information needed to our system planning.
2. Select the useful flow and specifications for UI Design process.
3. Build a demonstration, which is in the implementation and testing step.
4. Make sure that the approach is suitable, which will be done by experts review and evaluation enhancements.

1.4 Scope and limitations

In order to manage the research within time constraints, the proposed solution will be designed and implemented. The research will implement a proof of concept prototype of our pharmacist assistant by using Microsoft HoloLens as a demonstration, which will encompass primary features and operations. The aim of the research is to design the system as a prototype to use it in experiments.

The pharmacist's assistant prototype will include some basic helpful windows components such as drug information, patient history, costs, and nutrition and advise for patient for drugs (Fisher, Hochheiser, & Douglas, 2015) (Hong & Baorong, 2011).

The research will try to connect the existing systems and opportunities in a new manner so that pharmacists can get the high use of it (Potdar, Manekar, & Kadu, 2014). Also, there are some fears of viewing large amount of lines on HoloLens, which is not a real problem, because we will view shoots of information.

The limitations are:

- The proposed solution will be partially implemented.
- The lack of full free drug sets to implement in our research.
- Microsoft HoloLens is not wildly available in stores; it will be available for customers in the future in all countries, so the real testing of the proposed solutions will be partially implemented.
- The limitations of research budget to buy more glasses. The glasses cost 3300$ for now, but Microsoft promised to make it cheaper in the future.
- The participated pharmacies will be from Gaza only; it will be difficult to test our system with wide geographical pharmacies because of Gaza siege.

1.5 Importance of the research

This research is one of the first research targeting mixed reality with pharmacy despising field. In addition, it is one of the few researches that uses Microsoft HoloLens.

This research will help to clarify the useful integration of two fields of science: Information Technology and Pharmacy, and how this integration will improve patient's life as well as the pharmacist's (Brown et al., 2006).

Imagine how many mistakes that happen daily while the pharmacist is dispensing drug to patients. Dispensing errors happen all time. It may reach almost 21% of all medication errors (Kohn, Corrigan, & Donaldson, 2000), which are the main cause of mortality in the USA (Santell, Hicks, McMeekin, & Cousins, 2003).

Dispensing errors has many faces. It may be any conflict or variation from the prescription order, such as dispensing another drug, incorrect dose, wrong dosage form, wrong quantity, or inappropriate, incorrect, or inadequate labeling (Szeinbach, Seoane-Vazquez, Parekh, & Herderick, 2007). Furthermore, confusing or inadequate directions for use, incorrect or inappropriate preparation, packaging, or storage of medication prior to dispensing are considered to be errors (Szeinbach et al., 2007). Errors occur at a rate of 4 per day in a pharmacy filling 250 prescriptions daily, which amounts to an estimated 51.5 million errors out of 3 billion prescriptions filled annually nationwide (Flynn, Barker, & Carnahan, 2003). We believe that by reducing these errors, we will improve the life of people (Tie, Man, Jing, Xiujuan, & Yadan, 2012).

1.6 Methodology

To achieve the goals of our research, we will follow these steps and processes:

1. Evaluate and investigate the existing technologies that can be used for developing pharmacist assistant software (Velarde et al., 2014).
2. Evaluate and investigate the existing software built on top of mixed reality by Microsoft HoloLens, to imagine our system.
3. Develop the Pharmacist Assistant Module which covers:
   a- Create the HoloPharm, and
   b- Create information view inside the holographic image.
4. Develop the Interaction (Hand and voice) Operations Module.
5. Integrate all modules together.
6. Finally, apply some HCI evaluation techniques, such as cognitive walkthrough (Nørgaard & Hornbæk, 2006), survey and review based evaluation, to evaluate the proposed prototype.

Everything starts when a patient enters the pharmacy. Their file may be transferred to a pharmacist or the HoloLens will face-recognize the patient to view their information and welcomes them by their name. Then the patient views their prescription paper. The glasses will try to recognize the drugs automatically, or the pharmacist will say these drugs so that the glasses can start gathering information.

Sometimes the patient needs OTC drug, so the glasses will recognize the drug by receiving its name, or when the pharmacist catches the drug box and points to Bar code so that the glasses recognize the drug and view its information.

Too many operations will happen here, all off which will be cleared in the research; for example, how to handle narcotics, baby kits and cosmetics, view advices, sharing drug data, after treatment follow-up, Posology, drug existence, saving patient information and other operations.

The main screen contains two main divisions, the first division focuses on Patient information, and the second one focuses on Drug information as in Figure 2: Pharmacist Main Screen.

Figure 2: Pharmacist Main Screen

The main screen and other screens must be validated and reviewed with pharmacists and UI experts as shown in Figure 3: Enhance the proposed UI to enhance our proposed UI.

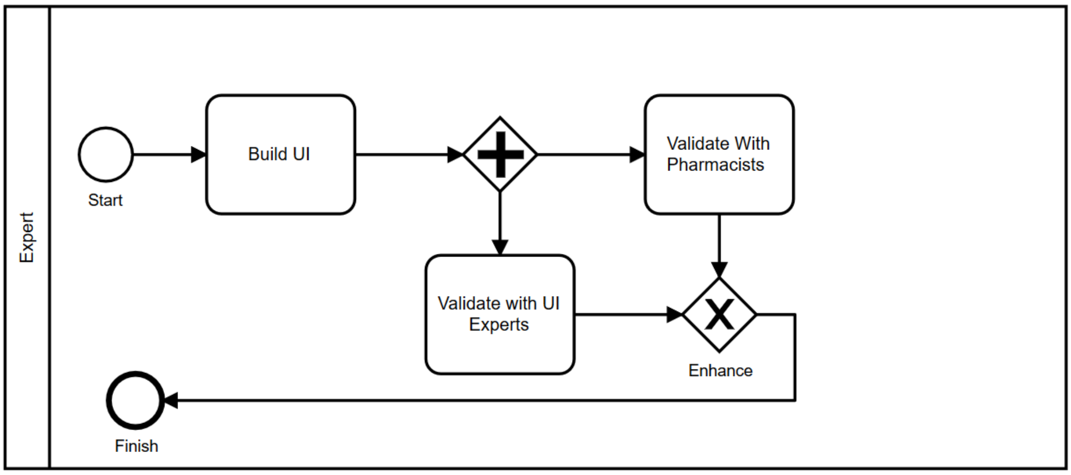

Figure 3: Enhance the proposed UI

All our research can be summarized in this diagram Figure 4: Research steps for all the steps.

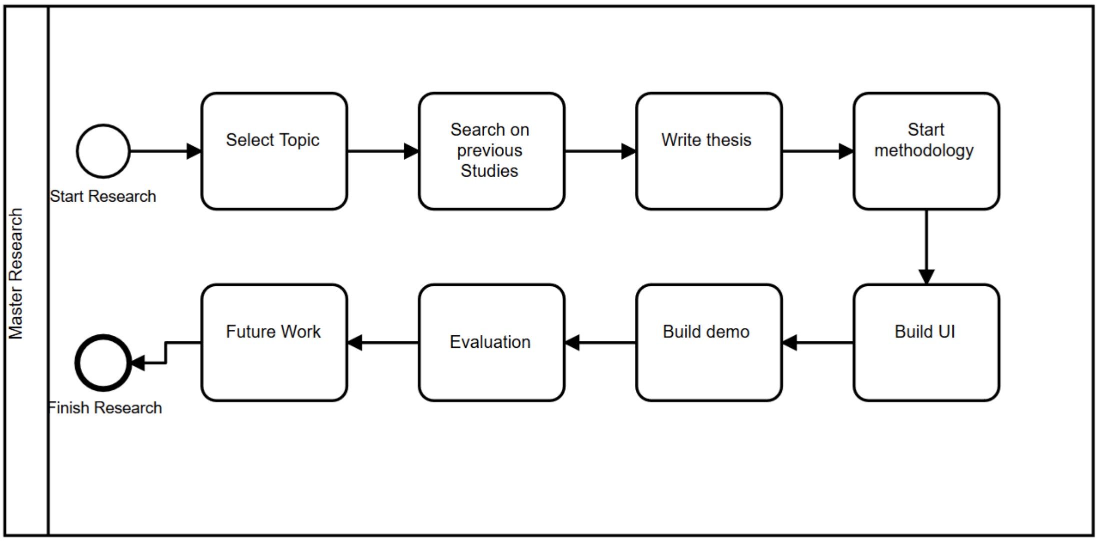

Figure 4: Research steps

1.6.1 Cognitive walkthrough

One of the usability evaluation methods is the cognitive walkthrough, that is a method where the evaluator (one or more) works into a chain of tasks and ask a set of questions from the view of the user (John & Packer, 1995).

The primary job of the cognitive walkthrough is on understanding the system's learnability for new or unusual users. The cognitive walkthrough was originally designed as a tool to evaluate walk-up-and-use systems like postal kiosks, automated teller machines (ATMs), and interactive exhibits in museums where users would have little or no training. However, the cognitive walkthrough has been employed successfully with more complex systems like CAD software and software development tools to understand the first experience of new users (Nørgaard & Hornbæk, 2006).

1.7 Evaluation

After we design our system, we intent to evaluate the final system, by using formative evaluation methods. We will make needs assessment to determine who needs the system. It will often be pharmacists in hospitals, clinics and pharmacies. After reviewing the system with them, and answering their questions, an implementation evaluation to monitors the fidelity of the program will be done.

The evaluation will focus on testing the system in real world processes. While the pharmacists dispense drug, the system will help them to narrow the error of dispensing, asking the right questions and other functions. We will compare between a dispensing process with our research, and another without our research design. The system will be tested with four pharmacists, so that we can be sure of diversity.

Then we will make outcome evaluations to investigate whether the system caused demonstrable effects on specifically defined target outcomes or not. The researcher is a registered pharmacist; he knows many pharmacists who are already ready to test the system

1.8 Budget & Resources

1.8.1 Resources

1- IUG Library.
2- Internet.
3- Software (Visual Studio, Unity, Windows 10).
4- Microsoft HoloLens glasses.
5- Other research groups working in the same area.
6- Developers Plus company development team and lab.

1.8.2 Budget

And Table 3 Budget shows the budget needed to implement the system

Table 3 Budget

#	Item	Quantity	Budget $
1.	WorkStation	1	1800
2.	Stationery	1	500
3.	Other Costs	1	2500
4.	Microsoft HoloLens glasses	1	3400
5.	Internet	1	300
6.	Battery for UPS	2	900
7.	Laptop	1	900
		Total	10300$

1.8.3 Time Table

Table 4 Time Table shows the schedule of work from previous studies ending with writing the report

Table 4 Time Table

#	Task	Period	From	To
1.	Literature survey	3 weeks	10 April, 2016	30 April
2.	Developing mixed reality module	5 weeks	30 April, 2016	7 May
3.	Connect system with other stores	3 weeks	7 May, 2016	30 May
4.	Integrate HoloLens with current approach	3 weeks	1 June, 2016	20 June
5.	Evaluation	2 weeks	21 June, 2016	7 July
6.	Writing the report	4 weeks	7 July, 2016	7 August
		Total	20 weeks, 5 Months	

Chapter 2
Background

Chapter 2

Background

2.1.1 Virtual reality (VR)

Virtual reality, which can be defined as immersive multimedia technique or computer-simulated reality, copies a world that simulates a real appearance in places in the real environment or an assumed of fictional environment, so that the customer can interact in that world.

Virtual Reality encompasses fully immersing yourself into a world that virtual and all are generating by computer. It has been existing for decades, in addition, at recent years the experience quality has drastically improved. Though there have been previous devices like VirtualBoy and CyberMaxx that have sought to provide pseudo-virtual worlds. Today there are many modern devices, such as HTC Vive and Oculus Rift, which try to give an attractive virtual reality experience. While the user wears the VR head mounted displays (HMDs), the world outside totally shuts-off and the user is in a world that is fully computer generated (Jones, 2016).

2.1.2 Augmented Reality

AR is like its name. Reality is still there, but it is augmented. It is a vivid, direct or indirect view of an environment, realistic place whose parts are augmented (or build) via computer-generated sensory input like pictures, video, sound, GPS data or graphics (Developing, 2006).

Augmented reality tries to cover of the real-world contents, but that content is not a part of it. The real-world content is not able to respond to each other (Avila & Bailey, 2016).

2.1.3 Mixed reality

It is the combining of real-world and virtual-world to create new worlds and conceptions where real and imagined objects cohabit together and interact in real time. Mixed reality affects not only in the physical world or the virtual world, it is also combine of reality and virtual reality environments, including both augmented reality and augmented virtually objects (Moustafa, Kenn, Sayrafian, Scanlon, & Zhang, 2015).

Mixed Reality is the newest of the terms. Even though Augmented Reality could be considered a form of Mixed Reality, true mixed reality is much greater. True Mixed Reality takes the augmented, virtually displayed information and adds it to the real world. These virtual additions can do more than simply augment what you are seeing or doing. Rather, they seem to become a part of the real world (Moustafa et al., 2015).

The two devices that are getting the most attention for Mixed Reality are Microsoft's HoloLens and MagicLeap. Both of these devices are expected to take virtual holograms and overlay them on the real world. This is done by using head mounted devices that you can see through, but that also provide holographic or digital images.

These digital images in Mixed Reality systems differ from those presented in Augmented Reality systems because they can be positioned as well as interact with the real world. For example, a Mixed Reality system could place a video screen (aka TV) on a wall in your house. When you are looking at the wall with the MR device, you would see the television's screen. The television screen would remain at the same location on the wall regardless of whether you turned your head or moved. Similarly, you could create a digital avatar or animal (Mixedrealitystudio, 2013).

This hologram would be able to react with the real environment. You could hold it in your hand, as shown in the Magicleap promotions with a tiny elephant. Similarly, in a mixed world game, you could battle graphical bad people that interact with the real world. These virtual bad people could hide behind real world furniture. If you were to play the game in a different room, there would be different furniture for the bad people to hide behind. Figure 5: Reality-Virtually, (Piontek, 2014) shows the difference between these technologies, using mixed reality in drug dispensing, better than other view technologies as we think, because it will allow the pharmacist to do dispensing and contacting in the same time (Banusree).

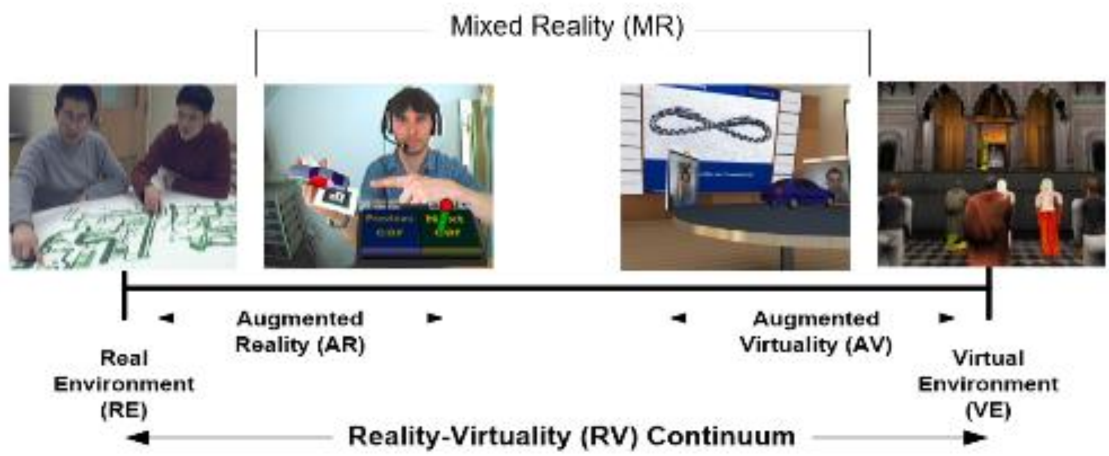

Figure 5: Reality-Virtually, (Piontek, 2014)

2.1.4 HoloLens

HoloLens is basically a small holographic computer that contains a headset which allows user to interact, view, and hear with holograms inside the current place for example a school class, a living room, a street or an office space. The headset has been developed by Microsoft to use wireless. It does not need to connect wirelessly to a PC (HoloLens, 2016). Also it uses spatial sound technology and high-definition lenses to provide that immersive and reactive experience of the holographic (Sawh, 2015). Figure 6: Microsoft HoloLens (HoloLens, 2016) shows the real device, the Microsoft HoloLens.

Figure 6: Microsoft HoloLens (HoloLens, 2016)

HoloLens has been used wildly in many fields and aspects of our life. For example Israeli army taps Microsoft HoloLens for augmented battlefield training (Ackerman, 2016). Microsoft and Volvo introduce exploration of the world of Volvo company for cars in an exhibitionist, interactive 3D experience, aiming to make a creative, interactive and amazing experience for end customers to scout about Volvo cars models and Volvo trademark in the future. End customers now are able to try the technology in Volvo cars in a more sensible way. Volvo says that they can now imagine a future where people can be able to better understand how their safety inventions can help avoid accidents, how their advanced powertrains are optimized to support people in different driving conditions, and how their new connected services can make life easier and save time (Volvocars).

In AEC-O industry, Trimble and Microsoft HoloLens work together to let individuals to efficaciously explain and react with physical and digital information and their locative relationships directly with new ways to augment today's technology with solutions that change how architects, engineers, contractors and owners work (Buildings.trimble.com, 2016).

2.1.5 Specifications

- Stand-alone: HoloLens is working without connection, either this connection is wireless or wired, to any computer or other device, it works by its own.
- Holographic: The user can see three-dimensional virtual objects and even walk around them, viewing them from every angle. The holograms created by a HoloLens device go beyond that by also enabling the user to interact with them. They also interact realistically with their real-world surroundings (Taylor, 2016).
- Computer: this glass has the hardware and the software to work as a complete computing system.

The Cameras

The Glasses have 5 visible-wavelength cameras. The first one is placed in front of the glasses, straight ahead, and the other cameras are distributed as: two on the left and two on the right. With respect to your surroundings the glasses' cameras track your head movements, and the camera in the center can save images or videos. And more, an infrared camera in the front above the face and an infrared laser projector confront the exact path. The main purpose is to scan objects. This gives a feature for the glasses that they can determine the range to any object in the surrounding place (Taylor, 2016). A quick 360-degree pirouette will map out a room with all its objects and details.

The Microphone

With voice commands, the users can start input to any app based on the microphone. For example, users with voice command could start any application and with another voice command they can terminate execution (Taylor, 2016).

Other input devices

As we mentioned there are many ways to contact with the camera, hand gestures, cameras sensing and the microphone sensing voice commands. There are many other devices that can be used such as cordless mouse (Taylor, 2016).

The Lenses

The main purpose of the glasses is that the user can see right through the lenses of the glasses so that they are transparent. But the glasses show a transparent image on the lenses. To do that, they contain an array of very invisible, fine grooves that direct the virtual images generated by the app into the user's eyes, so that virtual objects can appear at various positions and distances in the room. This creates a perfect deception. The virtual images on the lenses can appear semi-transparent or solid, and the room (real) objects is still showing while he is looking (Taylor, 2016).

Sensor Fusion

The IMU (accelerometer, gyroscope, magnetometer and others) which exists in the glasses is used to track the user's movement. The infrared laser and camera are used to map out the current environment. Both user movement stream and the camera stream are combined so that the virtual objects mesh accurately with the real environment. Virtual objects change in appearance appropriately as the user moves around. As the user moves away, they get smaller and vice versa to the object. A user can walk completely around a virtual object and see what it looks like from all sides (HoloLens, 2016).

2.1.6 How Mixed Reality Differs

But how MR Differs from Ordinary and Virtual Reality:

Augmented Reality

There are dramatically increase of products in the world that can be categorized as either VR instruments or AR instruments. VR devices try to submerge the real view with an imagined environment. The imagined environment displaces the real world totally. Otherwise in AR devices, there is hiding of the real world. The real world remains visible and heard. A transparent screen is overlaid upon it, which can display symbols, words, icons, or other virtual 2-D objects. A military pilot's heads-up display is an example of augmented reality (Avila & Bailey, 2016).

These glasses are neither an augmented-reality nor a virtual-reality device. It is the first example of a new category, which they call mixed reality. 3-D virtual objects are added to the real environment. They are three dimensional and are located where either the running app or the user places them.

2.1.7 UI Specification

Gaze

There are three ways to interact with the glasses and their apps. Gaze is the first one. The second one is gesture, and the last one is voice.

Voice

Far from gesture and gaze, voice in HoloLens is the main method that user can interact with the device. The microphone built in the glasses allows the user to make voice commands (HoloLens, 2016).

Spatial Sound

To put users in the middle of the action, glasses see holograms as three-dimensional objects in the world, hearing sounds that appear to be coming from them make them seem even more real. Adding to the sense of reality is what spatial sound is all about (Taylor, 2016).

Interacting

There are three ways of interacting with holograms: with voice, gaze, and gesture. Of these, gaze is the most fundamental, because it's hard to interact with a hologram that you cannot see. When you look directly at a hologram, a recast is computed from the direction your head is pointing. If it intersects with a hologram, you can then interact with that hologram with gesture or voice.

A cursor shows where your gaze is pointing at any moment. As a developer of an app, you control what that cursor looks like when it is not pointing at a hologram, and you can indicate to the user that they are now targeting a hologram by changing the shape of the cursor (Apps, 2016).

Voice input

As known voice is the new user UI, using voice commands, the user can duplicate many of the actions that can be made by gestures, such as manipulating it in space or selecting and then activating a hologram.

2.2 Drug Dispensing

2.2.1 Dispensing errors and near misses

When pharmacists dispensing prescriptions, they are looking to be sure that the process of the pharmacy dispensary is going to minimize the dispensing errors so that it reaches their professional satisfaction. Pharmacists are using for intended purpose many operations to ensure that, for example they use barcode scanners when dispensing medicines at dispensing stations in pharmacies, because patient safety is the main object always.

The Board recommends that if dispensing levels are in the range of 150–200 scripts per day, consideration needs to be given to the use of trained dispensary assistants and/or intern pharmacists to assist the pharmacist. If the workload exceeds 200 scripts a day, additional pharmacists or dispensary assistant may be required to ensure adequate time is allowed to dispense properly every prescription in accordance with board guidelines, technicians and hospital pharmacy technicians. Pharmacists may be assisted in the dispensing of medicines in the dispensing area of a pharmacy business or pharmacy department, in accordance with the guidelines, by suitably trained persons. The descriptions، 'dispensary assistant', 'dispensary technician' or 'hospital pharmacy technician' do not apply to a pharmacist, a provisionally registered intern pharmacist or a registered pharmacy student (Anacleto et al., 2007).

Nowadays, there are many recognized factors that breed dispensing errors. Figure 7: The of dispensing errors demonstrates the generality widespread breeds of these errors. The dispensing errors are associated with the unsafe and inefficient nature of dispensing systems and other factors directly connected with drug dispensing and delivery (Unfricht & Enderle, 2000). Many factors may be summarized as communication failures, issues related to drug labeling and packaging (Cohen, 2007):

Table 2 - Causes of dispensing errors and contributing factors associated with dispensing systems*

CAUSES OF DISPENSING ERRORS

1. Communication failures
- 1.1 ambiguous, incomplete or confusing prescriptions
- 1.2 unreadable prescriptions
- 1.3 similarity (phonetic and/or orthographic) of drug names

2. Problems related to drug labeling and packaging
- 2.1 similar labels and packages in size, shape, and color

3. Working environment and conditions
- 3.1 inadequate space
- 3.2 poor lighting
- 3.3 high temperatures
- 3.4 inadequate drug storage
- 3.5 work overload
- 3.6 little time for drug dispensing

4. Drug information
- 4.1 lack of health professional and patient knowledge about drugs
- 4.2 using outdated drug information

CONTRIBUTING FACTORS ASSOCIATED WITH DISPENSING SYSTEMS

1. Collective system
- 1.1 actions centered on nursing professionals
- 1.2 drug dispensing through requests by nurses
- 1.3 failures in transcribing medical prescriptions
- 1.4 pharmacists participate poorly in drug-related issues
- 1.5 high rates of medication errors

2. Individualized system
- 2.1 problems in reading copies of the medical prescription (depending on the type of copy)
- 2.2 failures in following dispensing guidelines
- 2.3 high dispensing error rates

3. Unit dose system
- 3.1 lack of trained professionals to prepare parenteral mixtures
- 3.2 lack of specific equipment to prepare parenteral mixtures

* Adapted from Otero MJ, Martín R, Robles MD, Codina C. Errores de medicación. Madrid: Farmacia Hospitalaria, 2002, 747p.

Figure 7: The of dispensing errors

2.2.2 Dispensing process

The dispensing process starts when a new patient enters the pharmacy, the drug dispensing process has four stages:

1- Greetings and communication.
2- Drug collecting and assembling.
3- Drug and disease discussion.
4- Finalizing.

All the steps later start after communication stage. In communication stage, it is better for the pharmacists to call the customer with their names and welcome them well. This happens if the customer was an old customer. So a customer enters the pharmacy for the second time, in this case, there must be a step called “face recognition” for them. The pharmacist can greet them well, that may lead to privacy breach (Acquisti, Gross, & Stutzman, 2011). To avoid it, we need to store their face photos in secure stare, for example encrypted as mixed reality studio suggests (Mixedrealitystudio, 2013). We can use Windows 10 UWP Basic Face Tracking feature, or can use other face recognition libraries like HoloLens_facial_recognition on GitHub (Neon-ninja).

Knowing the patient help us to view his medical history, if it is available for us. Clinical pharmacy procedures said that the patient history is too important for dispensing drug. It is actually said that time spent collecting medication history interviews from the patients was deemed efficient and worthwhile (Nester & Hale, 2002). It has many effects in dispensing process. There are many situations that the pharmacy can change a drug for a patient due to their history or situation. We mean duration of treatment, medication dose, route of administration history, and frequency, the patient's illness، the presence or absence of other medicines. In addition to another pertinent circumstances it must be taken into account, for example Metronidazole excreted in human milk and it has a bitter taste so it effects the suckling neonate (Heisterberg & Branebjerg, 1983), and it can make the milk more bitter, so it cannot be good for the baby, and the examples are too many to mention.

After this step, we come to drug dispensing step. It starts by knowing the drug list. There are two types of drug dispensing:

- First: the patient comes with a prescription.
- Second: the patient wants OTC or cosmetics or another staff.

For the first state "the patient with prescription", we hope that it is an electronic one that the doctor sends online, but until that time, the prescriptions are a paper written in many countries, especially in our country (Palestine).

These prescriptions need an image processing to read them, which can be done by the glasses in another research. Also the person's information may be stored, which can be done by its national number or by name or any process, and the system can store or register the person's data.

Also, the pharmacist must look for safety and focus on the person's name in that prescription or order and be sure about it for narcotic drugs, which can be done by combine the glasses with many systems.

In the process of dispensing a prescription, a pharmacist has to exercise an independent judgment to be sure that the drug is not harmful and adequate for the patient, as well as that it conforms to the prescriber's requirements. If the pharmacists have any suspicions, they can contact with the prescriber.

Beside the previous principle, route of administration, duration of treatment, frequency, dose and medication history, the presence or absence of other medicines, the patient's diseases، and other relevant situations must be considered, the good dispensing process, practice the following:

- Always close drug containers from which drugs are not being dispensed to prevent spillage or dispensing the wrong drug (Organization, 2004).
- Keep every day drug use record in the dispensary.
- Ensure that the prescribed drug has the useful information mainly, name and the signature of the prescriber and the stamp of the health center.
- Add date and the name of the patient to every prescription.
- If the prescription has not been written in a known (local) health center, the prescriber of the center should endorse it.
- Do not overcrowd the dispensing table, to facilitate work.
- Check the name of the prescribed drug against the container.
- Check the expiration date on the container.
- Inform the patient about the cost of the drug.
- Calculate the total cost of the drug to be dispensed on the basis of the prescription where applicable.
- Issue a receipt for all payments (Paulino, Thomas, Lee, & Cooper, 2019).

2.2.3 Scanned copy

Every pharmacist must take reasonable steps to satisfy themselves that the prescription is a bona fide and in accordance with relevant State or Territory legislation، and may dispense a prescription transmitted by facsimile or scanned copy in advance of receiving the original prescription (Paulino et al., 2019). Every original prescription must be stored to be obtained and retained in accordance with poisons legislation.

2.2.4 Labels

The design of the manufacturer's label and the medicine package determine the placement of the dispensing label on the product.

Every drug label must be firmly attached to the immediate container (including each component of multiple-therapy packs). The label should be clearly and legibly printed in unambiguous and readable language, every active ingredient, excipients, and the total information of any added preservatives or the name of the formula as mentioned in a standard reference book, and the system can obey a printer to produce this label with the following specifications:

- The patient's name or the owner's name of animal and type of it, in the case of an animal.
- Unique identifying code.
- Date of dispensing.
- The sentence 'Keep out of reach of children'.
- Detailed directions for use, mainly frequency and dose.

- The pharmacy information, for example name, telephone number and address of the pharmacy or pharmacy department that dispensed the medicines for the customer.
- Expiry date and storage directions.

2.3 Counselling patients

One of the main objectives of the pharmacists is to counsel the drug directions with the patients. Patients have the right to expect that the pharmacist will counsel them privately about their medicines, but the patient also has the right not to be counselled. The pharmacist must try all the efforts to counsel, or to offer to counsel. Whenever a medicine is supplied, lack of counselling can be a significant contributor in dispensing errors and their detection.

2.3.1 Guidelines for dispensing of medicines

Each case of dispensing drug is a special case. There are specific cases that need specific attention; for example, the medicine is from the list of controlled drugs.

There are many purposes for regular strengthening of information; for instance the drug may be cytotoxic or teratogenic. Their might major contraindications like:

- The medicine is prepared for a child.
- At regular intervals (e.g. five every month) for drugs used for long-term therapy.
- If the patient must take many drugs.
- When there is an acute disease or event (e.g. hospital admission).
- In the case of patients taking repeat prescriptions, counselling provides the opportunity to inquire if the patient is taking the medicine correctly (Australia, 2019),
- If the medicine has unwanted effects, it offers a further opportunity to detect any errors (Australia, 2019) .

2.3.2 Information to the patient

The right instructions on the label is very useful for the patient. But the pharmacist must be able to provide the patient extra data to ensure that he/she will use the drug well. That step must be done in a language that is simple and easy to the patient. In some drug cases and circumstances, the pharmacist must give detailed advice. Examples include (Australia, 2019):

- The period of drug that must be taken.
- How long the therapy lasts (e.g. why the full course of an antiviral therapy must be taken)?
- How to take the medication (e.g. chewing, swallowing or with water)?
- When medicine brand has changed (Australia, 2019)?
- Do not give your medicine to others.

- Keep medicine out of the reach of children.
- Taking the sedatives.
- Uncommon dose forms.
- The right time to take the drug (e.g. after or before the meals)?
- Uncommon frequency of use (e.g. methotrexate for abortion، alendronate).
- When prescribe a new drug.
- The best method to save the drug (e.g. far from light, avoid heat and dampness).
- When there is a change in the frequency of administration or dose.
- Taking drugs with a narrow therapeutic index.

2.3.3 Drug dispensing systems

Automated Dispensing Systems (ADS) have many features, one of which is the chance to reduce custom types of medication errors such as omitted doses, (Santell et al., 2003) (Liff, Hart, Wallace, & Berube, 1998). Also ADS has limited applications in the pharmacies. For instance, in ICU, the hospitals can use ADS, but in normal pharmacies there is no need for it. One of the reasons is that there is no patient to contact with. The ADS is invented for specific usage (Wallace et al., 2003), so the need of other systems in normal pharmacies is important. The most used systems are Windows-based pharmacy software (ex: PioneerRx (Pioneerrx, 2016)) with cutting-edge features that include Medication Synchronization, the Fill Calendar, Guaranteed Rebilling Service, Hard Copy Intake, patient-pharmacist contact and so much. The Microsoft HoloLens can easily integrate with these systems to reduce dispensing errors.

Chapter 3
State of art and
review of related work

Chapter 3

State of Art and Review of Related Work

There is Little research that targets mixed reality and its applications in real time environment as Microsoft HoloLens. This is normal because it is a new technology. For example, the first commercial mixed reality glasses are Microsoft HoloLens and it was shipped in 30 – March-2016. Microsoft has proposed some apps for its HoloLens glasses (Apps, 2016) as shown in Figure 8: Skype on HoloLens (Apps, 2016) shows the Microsoft Skype (HoloLens, 2016) which has been tested with astronaut Scott Kelly (Seppala). Skype now allows people to communicate using holograms. So that users can view the holograms that the other user is looking at and users can use holograms to explain development approaches or helpful techniques (Tsunoda, 2016).

Figure 8: Skype on HoloLens (Apps, 2016)

Another useful system used by Microsoft is called HoloStudio. It allows you to build 3D objects in 3D environment with natural gestures and movements, using holographic tools modeled from tools in the real world, creating holograms of your own design and turn them into physical objects with 3D print compatibility, trying to understanding of how users interact with 3D content (Apps, 2016), Chen, Henry, et al. Also introduced an interaction model for supporting 3D Collaboration Method over HoloLens and Skype (Chen, Lee, Swift, & Tang, 2015).

Lahtela, A., et al. have proposed medication management process based on user-centric and computer-based automated dose-dispensing system (Lahtela, Jylha, Saranto, & Naaranlahti, 2010). When the automated dose dispensing system is implemented into practice. Because of this implementation, they get a model for decision-making in medication management process and several benefits, like hygienic medication doses, smaller medication warehouses at wards and in the pharmacy (Anacleto et al., 2007).

Another research by (Cha, Kim, & Kim, 2010) leads to design drug information system by mixing drug information, allergy, usage direction, drug side effects, alternative drug information, and patient's medical archives and process which built on the job rules, patient's medical registration card may include clinical history, and patient's basic information. After collecting this information, drugs written in the prescription are examined after physician's examination. Information for the examination uses drug information and alternative drug information provided by the drug information system. Antagonism, synergism, indifference, and addictively between drugs written in the prescription are also investigated. Moreover, drug substances and content control information and alternative drug information for allergy or side effects are provided.

Recently, a bespoke is a web-based software package was created to simplify the direct supply of trial medications to trial participants from a pharmacy based in the Medicines Monitoring Unit (MMU). The result shows that it is an active method of administering the complex drug supply requirements of a large-scale clinical trial with advantages over existing arrangements. Up to 65,467 packs of medication have been dispensed using the system to 3978 patients. Up to 238 packs per day have been dispensed without any mistakes (Rogers, Flynn, McDonnell, Mackenzie, & MacDonald, 2016) which gives us as idea that these systems can be useful in the medical field .

A Patent by Johnson, Matthew, et al., focusing on Pharmaceutical dispensing systems and graphical user interfaces associated with, it includes a frame having first and second opposed sides, a plurality of cells configured to house pharmaceutical pills, a first touch screen display on the frame first side, and a second touch screen display on the frame second side. A plurality of dispensing shelves configured to receive filled pill containers are accessible from the second side of the frame for removal of pill containers therein. The pharmaceutical dispensing system includes a processor and memory coupled thereto. A computer program resides in the memory and is executable by the processor for displaying a cell inventory graphical user interface (GUI) within the first touch screen display, and a series of GUIs within the second touch screen display that include status information about a prescription order at a respective stage of completion by the pharmaceutical dispensing system. This proposed system can be attached with Microsoft HoloLens, but it has different perspective that the pharmacist need in regular pharmacy (Johnson, Lindsey, Dunigan, Lallinger, & Hammond, 2015).

Other fields of medicine starts to use Mixed Reality and Teaching, for example (Romaniuk, Lamb, Mitchell, Bayer, & Wainman, 2017) use Mixed Reality in Anatomy Education, previous studies show that when students start learning anatomy from normal 3D computer models or using diagrams of specimens, and pictures and test scores are approximately 30% which is lower than when the anatomy is learned from solid models when students are tested on cadavers, by using mixed reality devices, like Microsoft HoloLens Figure 9: Mixed reality in Anatomy Education, it allows us to create interactive, convincing, and 3D models in real space. These mixed-reality anatomic objects have the potential to be as efficient as our solid models in learning anatomy and thus may replace the traditional tools of anatomic teaching. This presentation will demonstrate anatomic specimens in all ways, including MR applications in an interactive setting to emphasize the benefits and problems of each form of learning object.

Figure 9: Mixed reality in Anatomy Education

To the best of our knowledge, Mixed Reality is not used by pharmacists is their pharmacies in this work, we will suggest how to use it well.

3.1 Pharmacist patient relation

There are many researches described pharmacist patient relationship, how it should be and what problems they face when contacting, for example (Worley et al., 2007) showed that as Pharmacists professional roles have maturated to include provision of education, and pharmaceutical care services. The research results in a focus on collaborative pharmacist-patient professional relationships, in which both pharmacists and patients have roles and responsibilities. The research found that the adjusted response rates for the pharmacist and patient groups were 34.9% (173/496) and 40.8% (196/480), respectively. Pharmacist and patient role dimensions exhibited adequate reliability coefficients. Results showed that pharmacists and patients have similar views regarding pharmacists' "information sharing" roles in the relationship, but for the most part, patients agree less about pharmacists "responsible behavior," "creating a patient-centered relationship," and "interpersonal communication" roles. Regarding patient roles in the relationship, pharmacists and patients have different views about patients' "information sharing," "responsible behavior," "interpersonal communication," and "active communication related to health care" roles. Results suggest that pharmacists more strongly agree that these are patient roles in the relationship than patients do.

The final word is that if pharmacists and patients agree on the shape of the relationship, the final outcomes of this relationship will be enhanced. more research must be done to monitor trends in pharmacist's and patient's views of their relationship roles and to create enhanced strategies as needed to ensure that pharmacists and patients are following the right relationship instructions, which can be done faster with the usage of technology.

Another study to Understand and enhance the quality of medication management is done by (Wilson et al., 2007) to specify the prevalence of pharmacist patient speech on prescription drugs cost and drug adherence among elderly adults nationwide. It found that 41% of seniors reported buying 5 or more medications, and more than half has 2 or more prescribing physicians. 32% overall and 24% of those with 3 or more chronic conditions reported not having talked with their doctor about all their different medicines in the last 12 months. Of seniors reporting skipping doses or stopping a medication because of side effects or perceived non-efficacy, 27% had not talked with a physician about it. Of those reporting cost-related nonadherence, 39% had not talked with a physician about it. Thirty-eight percent of those with cost-related nonadherence reported switching to a lower priced drug, and in a multivariable model, having had a discussion about drug cost was significantly associated with this switch.

Accordingly, there is communication problems between seniors and their physicians around prescription drugs. This communication gap is an important safety and quality issue, and takes on added salience as physicians and patients confront new challenges associated with coverage under new Medicare prescription drug plans, these challenges can be minimized in the pharmacy in the presence of good systems that can enhance drug dispensing process.

An important study in New Mexico by (Sleath, 1996) to investigate the relationship between the pharmacist and patient in New Mexico community pharmacies. Almost three hundred and forty pharmacy personnel-patient dialogs were reviewed. Pharmacists reacted with only 57% of patients who were picking up their prescriptions. Pharmacists were significantly more likely to use a participatory style with older patients and with patients who were picking up refill prescriptions. Pharmacists used an overall involved style with only thirteen percent of the patients who contacted with. The average length of pharmacist-patient encounters was just less than 2 min (114 s). Pharmacist-patient interactions were significantly longer if:

1- Pharmacists gave more drug information to patients.
2- Pharmacists used more of a participatory approach with patients.

One important finding that pharmacists did not interact with 43% of the patients who were picking up their prescriptions despite the fact they are required to by law (Sleath, 1996). Therefore, almost half of pharmacist-patient interactions could be classified as regular relationship or sluggish relationships where neither the pharmacist or the patient is taking control of the relationship and/or there are failed expectations. There are many reasons for this finding, one of these reasons can evolve pharmacist-patient dialogs over time. The new expectations that pharmacists and patients are developing for one another have only just recently come into existence.

3.1.1 Medication errors

A study by (Chapuis et al., 2010) tried to measure the effect of ADSs on the process of medication errors that is related to administration, preparation, and picking of therapies in a medical ICU. As well, the study evaluated the clinical significance of such user satisfaction and errors. After two months monitoring period, they executed an automated dispensing system in one of the U (study unit) chosen randomly, with the other unit being the control.

The total error rates were expressed as a percentage of total chances for error. And the severity of errors was classified according to National Coordinating Council for Medication Error Reporting and Prevention categories by an expert committee. A total of 1,476 medications for 115 patients were observed. User satisfaction was assessed through self-administered questionnaires completed by nurses. After automated dispensing system implementation, we observed a reduced percentage of total opportunities for error in the study compared to the control unit (13.5% and 18.6%, respectively); however, no significant difference was observed before automated dispensing system implementation (20.4% and 19.3%, respectively; not significant). Before-and-after comparisons in the study unit also showed a significantly reduced percentage of total opportunities for error (20.4% and 13.5%). An analysis of detailed opportunities for error showed a significant impact of the automated dispensing system in reducing preparation errors.

Most errors caused no harm (National Coordinating Council for Medication Error Reporting and Prevention category C). The automated dispensing system did not reduce errors causing harm. According to a report by The Institute of Medicine, medical errors were associated with up to 98,000 deaths and more than 1 million injuries each year in the United States. These errors can result in poor outcomes, which increase harm or death. According to the Pennsylvania Patient Safety Reporting System, up to fifteen percent of errors reported cite automated dispensing cabinets as the source of the drug involved in the error. Nearly 58% to 70% of hospitals nationwide use automated dispensing cabinets (Cramer, 2017)

In 2009 a study done on pharmacies in Sweden market was re-regulated (Hammar, Ohlson, Hanson, & Petersson, 2015). It's now based on several private pharmacy companies, but before this year, there was one state-owned pharmacy chain. Four new dispensing systems arises to displace the existing system that had previously been used at all country pharmacies for more than two decades.

This case study tried to examine the impact of applying new information systems for dispensing at pharmacies. The vendors of the four dispensing systems in Sweden were interviewed, and a questionnaire was sent to the managers of the pharmacy companies. Also, a questionnaire was sent to 350 pharmacist who used the systems for dispensing prescriptions.

The strict time frame set by political decisions to implement the new dispensing systems, involved players completely new to the challenges, markets, lacked clear regulation and standards for functionality and quality assurance, was complex and resulted in variations in quality. Fifty eight percent of pharmacists perceived their current dispensing system as supporting safe dispensing of medications, twenty six percent were neutral and fifteen percent did not perceive it to support a safe dispensing. Most pharmacists (eighty percent) had experienced problems with their dispensing system during the previous month. The pharmacists experienced problems included reliability issues, usability issues, and missing functionality.

In this case study exploring the implementation of new information systems for dispensing prescriptions at pharmacies in Sweden, weaknesses related to reliability, functionality and usability were identified and could affect patient safety. The weaknesses of the systems seem to result from the limited time for the development and implementation, the lack of comprehensive and evidence-based requirements for dispensing systems, and the unclear distribution of quality assurance responsibilities among involved stakeholders.

There are many inventions and great machines that can help in drug dispensing process, for example (Kim, 2015) suggests A drug dispensing system includes at least one drug dispensing device including a plurality of dispensing modules for receiving and dispensing drugs, a plurality of installation blocks for allowing the dispensing modules to be mounted there, and a controller for controlling dispensing of drugs from the dispensing modules, a plurality of drug refilling stations, a drug refilling unit for performing a drug refilling operation, a refilling authentication device for authenticating refilling information regarding the drugs refilled by the drug refilling unit, and a communication unit for transmitting authentication information regarding the first dispensing module confirmed by the refilling authentication device, a server for receiving the authentication information regarding the first dispensing module from the communication unit, and a database for storing the authentication information regarding the first dispensing module received from the server.

One of the best patent by (Liff et al., 1998) whom speaks on Drug dispensing system, suggests an automated drug dispensing system includes a cabinet adapted to store a variety of prepackaged pharmaceuticals in a plurality of bins for filling patient prescriptions. Each variety of pharmaceutical is associated with a particular code. Each bin stores a particular variety of packaged multiple-dose pharmaceutical. A controller receives request signals and in response generates dispense signals. Each bin includes a dispenser coupled to the controller for dispensing the packaged pharmaceuticals therefrom in response to a dispense signal sent from the controller. After a package is dispensed, a code reader determines the code of the dispensed package and verifies whether the code on the dispensed package matches the code of the requested package.

Some other systems can apply for solid and semisolid preparations, (Stephens & Stephens, 2016) A medication dispensing system has a fluid and a plurality of pills. A bottle is provided and the fluid is contained within the bottle. The bottle has an outer wall and an inner wall. The inner wall defines a plurality of compartments with respect to the outer wall. Each of the compartments is fluidly discrete from an interior of the bottle. Each of the pills is removably positioned within an associated one of the compartments and each of the pills may be selectively consumed in conjunction with the fluid.

A recent study for ensuring safe drug dispensing in places that apply the applications, environment hardware, and liveware (Nesbitt, Rasiah, Levett-Jones, & Gilligan, 2017), found that Pharmacists perform a variety of patient-orientated functions that require expert knowledge to achieve optimal medication safety and efficacy. As pharmacists are the custodians of medication supply, there is an increasing interest in the factors that influence their performance and that have the potential to lead to medication errors. Previous literature suggests that pharmacists' performance may be affected by multiple factors, including workplace circumstances, education, and other personal attributes such as mental and physical health. However, this remains an under-researched area. Certainly, limited attention has been given to the interplay between those factors and pharmacists' performance, ultimately, and patient safety.

Around 20% of healthcare errors are related to problems with medicines; however, there is a need for an improved understanding about the incidence of, and factors contributing to, adverse incidents and near misses in community pharmacies

Another primary reason for the lack of clarity is that even where an incident-capturing system exists, the 'blame culture' and fear of disciplinary action by an employer or regulatory body, or fear of litigation, lead to under-reporting. The Incident Decision Tree is one of a range of tools developed to provide a clearer framework for decision-making following a patient safety incident, and also prompts an awareness of system failures in error management.

Dispensing medications involves a number of repetitive, self-paced, interdependent sequential tasks, and mistakes can have potentially serious consequences. A body of research has demonstrated that the human aspects of a complex work system, such as a community pharmacy, are vulnerable and that errors can result from a dynamic interplay of factors. An approach that has the possibility to help in the study of dispensing errors is to use setup forms of human error to help sort the contraction between human and system factors that adversely affect performance.

In our work, we focused on using MR to enhance the relation between the patient and the pharmacist to decrease dispensing errors.

3.1.2 The SHELL Model

From its creation, the creators modify the SHELL model to clarify the scope of factors in aviation systems that interact with the human operator, and different acronyms, in 1972, Edwards said that all aviation accidents are happened because four factors: hardware, software, liveware and environment. This original SHELL model allows for examination of the interactions between an individual and the other components of the system. Edwards further explained that each individual component (e.g. liveware) or a relationship between liveware and the other components (e.g. liveware–hardware, liveware–software or liveware–environment) is the source of all aviation accidents.

Later, it was identified that the original SHELL model did not encompass the interactive nature of the person–person relationship and, in 1993, Hawkins modified it to include the liveware–liveware relationship. This became the SHELL model; it is worth noting that the SHELL framework does not include the interfaces that do not involve human factors (e.g. hardware–environment). The SHELL model depicts the inter-relationships evident in the working environment. The different edges reference that the elements of the system are permanently changing and will never match equally; however, the purpose is to reduce this mismatch between each of the system elements.

The SHELL model provides a useful systems-based approach for supporting our understanding of factors that influence medication safety in the community pharmacy. While empirical studies are lacking, this paper describes how the application of the SHELL model can reveal determinants of error that can be targeted towards interventions to improve patient safety. The insights from the paper will be relevant to practicing pharmacists and business owners, as well as education providers and regulatory bodies charged with the responsibility for preparing future pharmacists.

3.1.3 Simulators

Some other simulators can be useful to enhance practice, and maybe it can be applied in the future, MyDispense is an interactive community pharmacy simulation program designed to build students' confidence related to community pharmacy practice. MyDispense was implemented in the Advanced Pharmacy Practice course at St. Louis College of Pharmacy during the P3 year as an activity and assessment for competency in the community pharmacy setting. In order to make future curriculum improvements, the objective of this study is to evaluate the usefulness and applicability of the MyDispense program into a required course (Kebodeaux & Sewell, 2016), the results: 98 responses (43% response rate) were collected from students who completed

MyDispense as a part of the required course. 69% of respondents stated MyDispense was straightforward to learn, 75% stated MyDispense was more realistic than similar cases on paper, and 78% appreciated the opportunity to learn without the consequences of a prescription error. Students felt that MyDispense should be implemented either throughout the curriculum 31% or prior to the community IPPE course 23%. Students' total understanding of MyDispense was not influenced by prior community pharmacy experience.

Implications: the previous study assess the effect of MyDispense with a group of P3 students in an Advanced Pharmacy Practice course. This information can be used to help execute MyDispense in other pharmacy school curricula.

The medication dispensing cart have a connected computer and monitor, a work surface with pull out keyboard, and plural drawers arranged as a vertical series of cassettes that can be added as needed. The battery powered device uses software and pass codes for controlling access to each drawer, and requires a second pass code for any drawer designated to contain narcotics. All records are kept of who dispenses what medication and when for each cart in a system of carts. The cart in the system is in wireless communication with a system administrator. Emails alerting the system administrator of low battery power, of a cart switching to off, of an attempted break-in, and of inventory and usage data are sent automatically by email (Reckelhoff, 2014).

3.1.4 MR model

Interactive medication dispensing system

This invention provides a medication dispensing system that instructs the user through visual and audio cues, such as the illumination of individual medication cups that are arrayed in accordance with a daily and weekly schedule in separate orifices within the dispenser body. It monitors compliance by determining when an indicated cup is accessed, removing from, based upon at least one of manipulating a lid and/or placing into, or replacing into the correct orifice based upon the indication. The cups can be refilled based upon an indication, and/or can be provided in a removable prefilled refill tray. The dispenser can include an on-board processor that stores a current configuration including the treatment schedule. The configuration can be programmed/re-programmed, and compliance can be monitored, via a wired or wireless server connection that communicates with interested parties, and that supports a graphical user interface. Communication, messaging and/or display systems also can be integrated.

Multi-compartment pillbox is used from patients who must take medication in pill form, it used often a to help organize the task of taking the proper medication at the proper time, and daily manual pillbox us used from patients who must take many pills per day at different times of the day, it has four compartments for one day. These compartments are designated Breakfast, Lunch, Dinner, or, Bed AM, NOON, PM, Bed, or some other set of designations, for instance, by time. The four compartments may be integral, or may be individual small boxes that are retained in a day-frame, so that each can be individually manipulated. Pill organizers typically may have seven of such daily four compartment boxes, arranged according to the seven days of the week. Such weekly organizers may typically include a frame that removably retains each of seven daily pillboxes, so that each one can be individually removed and manipulated. Rather than four compartments, a daily system may have more or less compartments, depending on the complexity of the patient's medication regime (Shavelsky, Flowers, & Aiello, 2015).

A modern report displayed that ADS built on ward-based will minimize costs and also errors. However, the clinical effect in ICUs remains to be specified.

There must be a secure internet connection to the dispensing station for access by a potential prescription medication recipient, for visual and auditory communication there must be at least two webcams which is between the location of the dispensing station and the pharmacy personnel through the internet to allow identification of the correct identification, medication and communication with the correct potential prescription medication recipient, and to ensure visual validation and recording of all documentation from the physician's office or potential prescription medication recipient, and a biometric reader disposed at the dispensing station for identifying a potential prescription medication recipient. A prescription dispensing system having a dispensing station for holding an inventory of prescription medications, by healthcare personnel in a physician office and by pharmacy personnel at the pharmacy distribution center in a remote location. The system may include various enhancements to allow accurate dispensing of the proper medication and direct secure internet communication between the pharmacist and the authorized recipient of the medication (Butler, 2014).

3.1.5 Summary

There are many divisions that can be looked in to write our research. The first division is other MR apps. There are general apps (education, entertainment, …etc.) and apps for medical functionality, but no one for pharmaceutical drug dispensing.

The second division is medication management process which helps the pharmacist in drug dispensing process. For example, it helps them in information sharing part with the patient. Basically there is communication problems between patients, pharmacists and physicians around prescription medications

The last division is Pharmaceutical dispensing systems, which has the SHELL model that can be bind with MR glasses and help to minimize packing errors.

All the previous divisions are trying to fix one part of the problem from its own view, but there is no solution that combine all the solutions together to introduce a complete answer for real life situations.

We combined the knowledge from medical systems, the design from current missed reality apps, and combine it with other peripheral and assistive systems to introduce better solution

Chapter 4
Methodology

Chapter 4

Methodology

There are many specifications and guidelines to dispense prescriptions and to handle the customers and patient's requests. Some dispensing levels are more than 150 scripts per day, so there are a lot of pressure and a lot of situations to handle. We will try to add these guidelines to our proposed system, and we describe them below. The system can be peripheral to other global systems in pharmacy, for example SuiteRx, which is an intelligent Pharmacy Software (IPS). It introduces a comprehensive solution that integrates document management, delivery, POS, inventory management, web portal capabilities and compounding into one seamless application, Supporting Retail, Compounding, Long-Term Care, Specialty and 340B pharmacies (SuiteRx).

4.1 Dispensing errors and near misses

Pharmacists dispensing medicines need to ensure that the operation of the pharmacy dispensary is such that the risk of errors is minimized to their professional satisfaction. Pharmacists are using barcode scanners when dispensing medicines at dispensing stations in pharmacies and pharmacy departments and used them for the intended purpose.

The Board recommends that if dispensing levels are in the range of 150–200 scripts per day, consideration needs to be given to the use of trained dispensary assistants and/or intern pharmacists to assist the pharmacist. If the workload exceeds 200 scripts a day, additional pharmacists or dispensary assistant may be required to ensure adequate time that is allowed to dispense properly every prescription in accordance with board guidelines, technicians and hospital pharmacy technicians. Pharmacists may be assisted in the dispensing of medicines in the dispensing area of a pharmacy business or pharmacy department, in accordance with the guidelines, by suitably trained persons. The descriptions، 'dispensary assistant', 'dispensary technician' or 'hospital pharmacy technician' do not apply to a pharmacist, a provisionally registered intern pharmacist or a registered pharmacy student.

4.2 Proposed UI

Our proposed UI is set to make the process of dispensing easier and more effective with the pharmacists, and we think this is the best UI for Mixed Reality devices.

The main screen has two parts. The first one is for patient's information, and the second one for drugs' information, which almost all the pharmacists need to contact well with the patient, and dispense the drug as in (Figure 10: Main Screen).

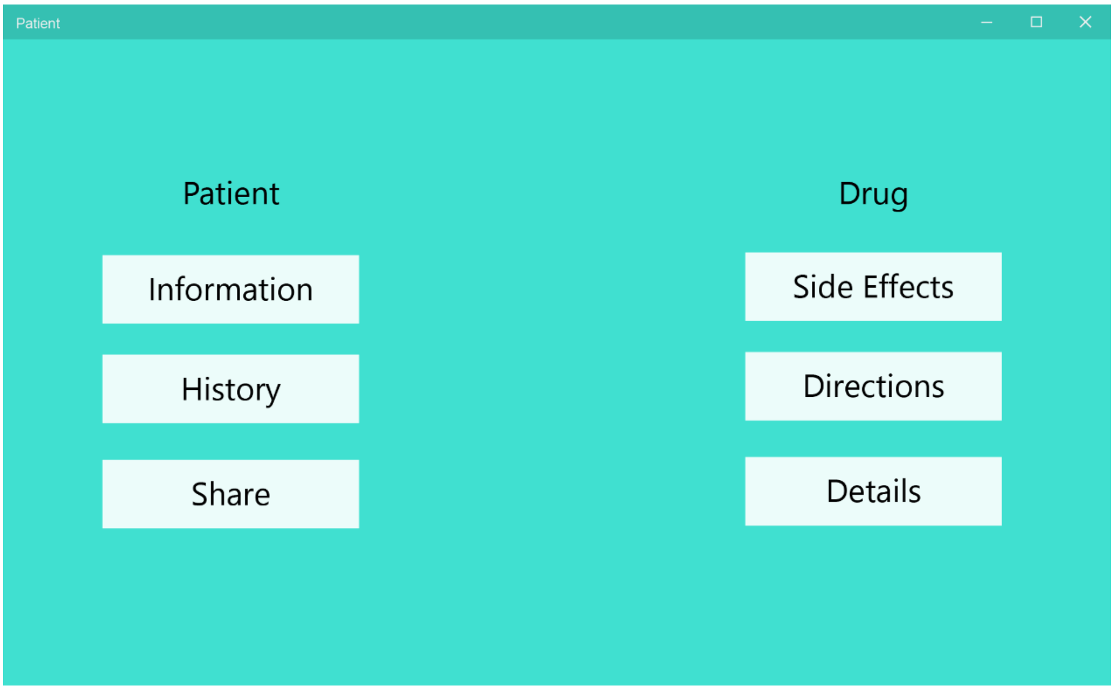

Figure 10: Main Screen

The patient screen has its information, and the pharmacist can see the patient's history and can share their information with them or other drug information. Moreover the pharmacists can edit the patient's information (Figure 11: Patient Information).

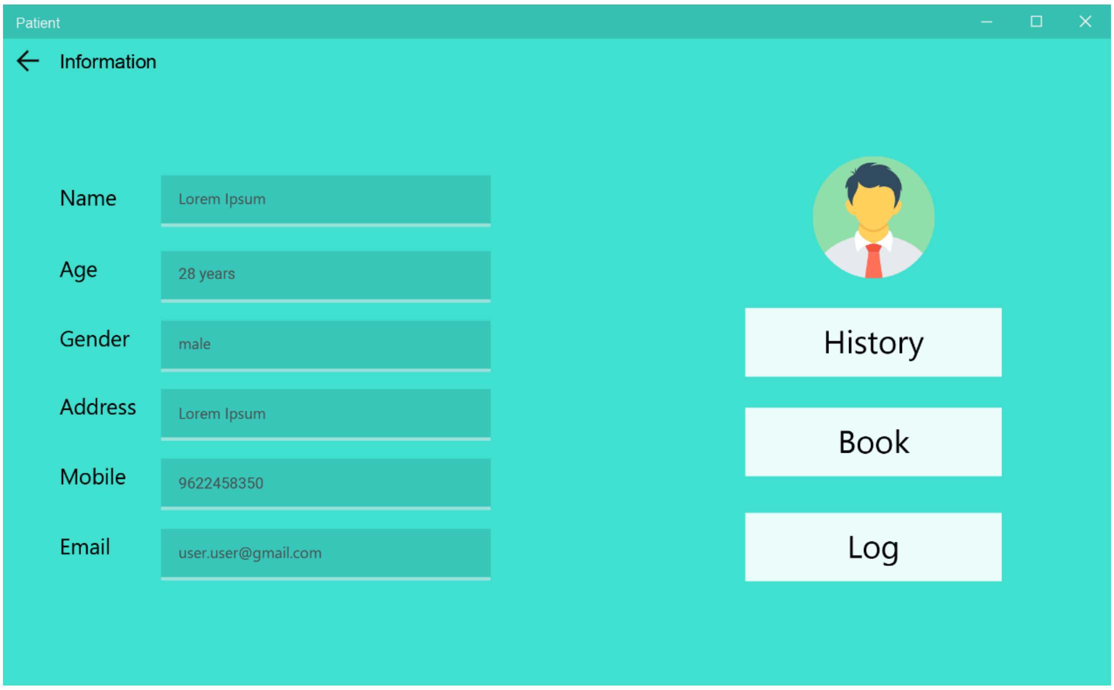

Figure 11: Patient Information View

The patient's history UI shows the whole drug information, so that the pharmacists can know how to dispense the drug based on the patient's medical knowledge. The pharmacist must know the diagnosis and why the patient took the drug, because there is an odd usage of some medications in certain diseases (Figure 12: History).

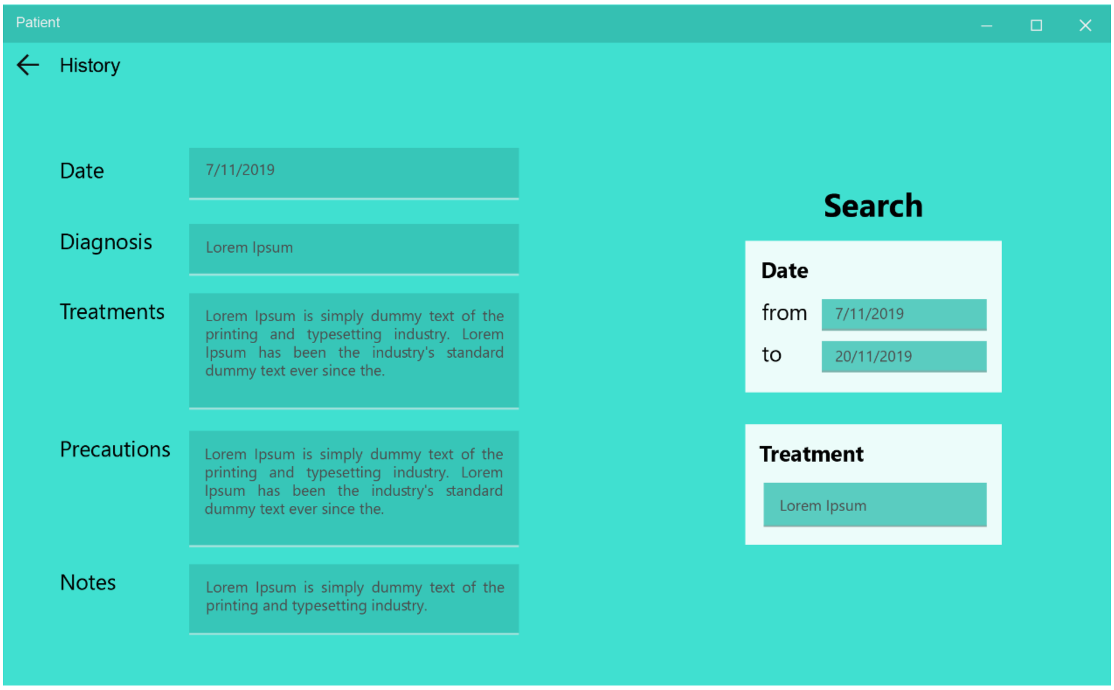

Figure 12: History View

More screens for Drugs; the first one shows the list of drugs in the prescription, and we can go from this screen to other screens like side effects (Figure 13: Drug Information).

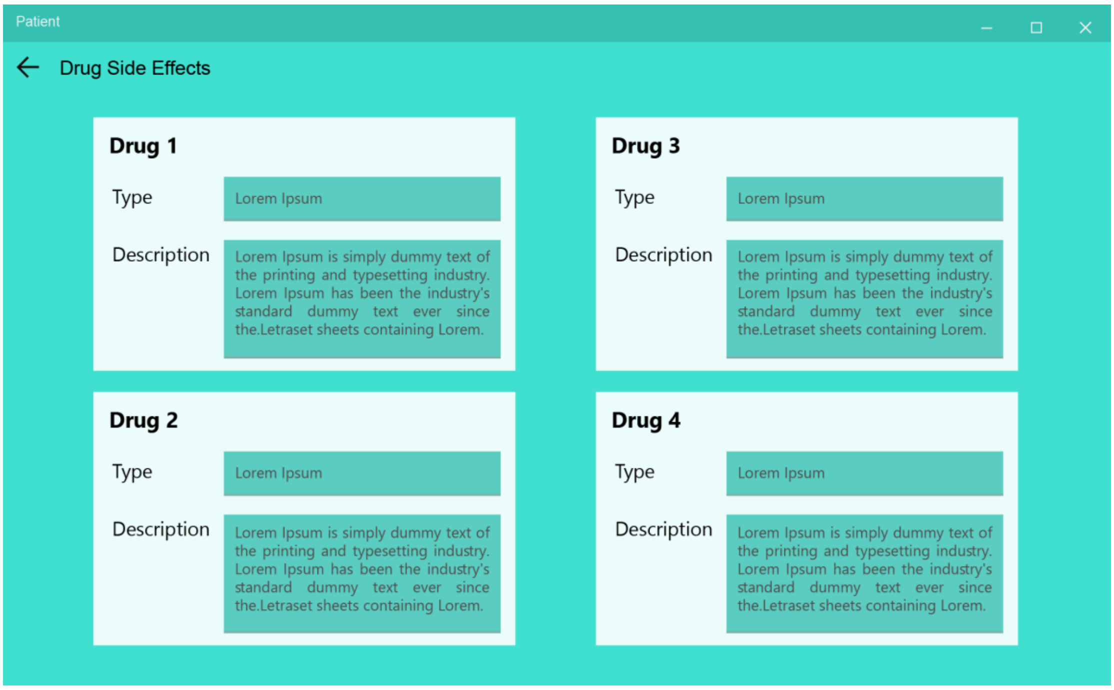

Figure 13: Drug Information View

Or we can go to drug information so that the pharmacist can transfer it right to the patient (Figure 14: Drug Details Screen),

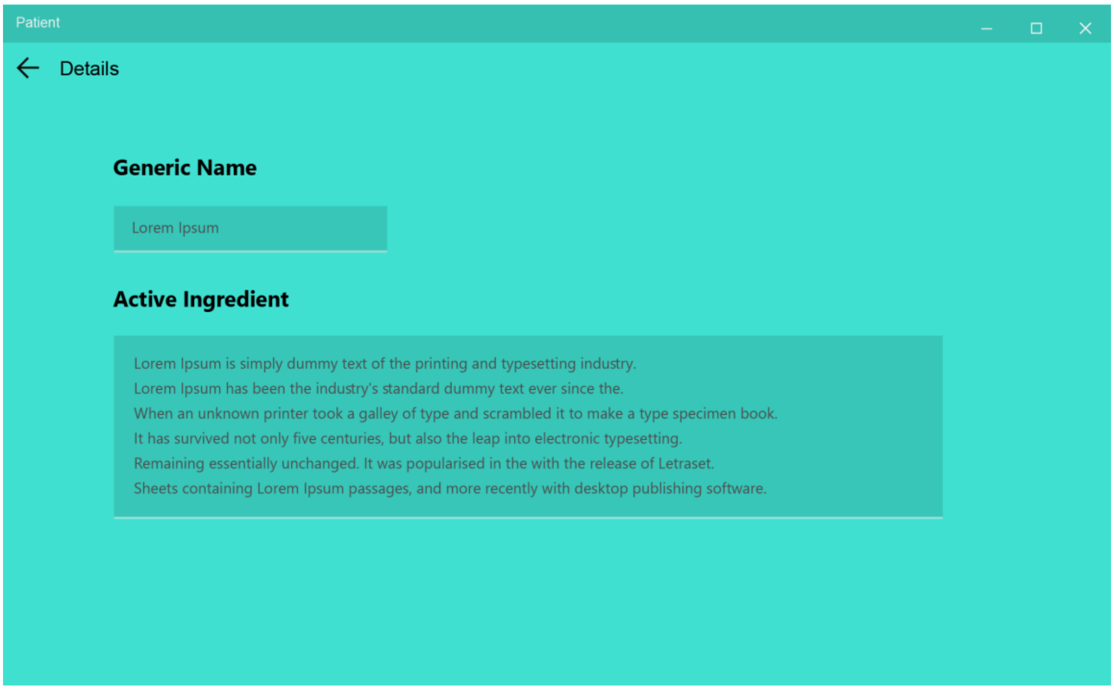

Figure 14: Drug Details Screen

or its dose and directions (Figure 15: Other).

Figure 15: Other Views

Chapter 5

Implementation and Evaluation

Chapter 5

Implementation and Evaluation

Experiments and Results

In these paragraphs we present and analyze the experimental results to provide evidence that our approach can improve the drug dispensing process. We will provide information about the proposed system as a prototype version, and the testing process, and finally the evaluation.

5.1 The Experiment

5.1.1 Experiments Setup

To ensure that the same experiment happened when repeated, we list the tools used in experimental environment. The experiment here points to building the demonstration of our UI.

5.1.2 Experimental Environment

Our experiments have been done on a machine with properties that are shown in Table 5 Machine environment properties which is used to build the prototype.

Table 5 Machine environment properties

System Model	HP ProBook
Processor	2.60 GHz Intel Core i5-8230M
Memory Modules	8 GB RAM
Operating System	Windows 10 Fall

5.1.3 Experiments Tools

To implement our work, we need different components at different stages in our simulation. So, various kinds of software tools have been used, which are Microsoft Visual Studio 2017, C# and Windows SDK 10.0.17134.0, and Microsoft HoloLens Emulator. Those tools are described below:

- **Windows SDK:** contains the latest libraries, headers, metadata, and tools for creating Windows 10 apps.

- **Microsoft HoloLens Emulator:** allows to test MR apps on your PC without a real HoloLens and comes with the HoloLens development toolset.
- **C#:** Used to write codes for the webservices reading and for app coding.
- **Microsoft Visual Studio 2017:** it's the IDE used for coding, testing and deployment the demonstration.

5.2 Pharmacological Knowledge

The researcher himself is a registered pharmacist with 3 years of experience in working in normal pharmacies, and in especial pharmacies (rehabilitation center). The current process, problem and their solving are from his wide experience in the field.

Medical Webservices

In order to test our prototype, first, we needed a medical database to get real information for real time situations, so we used many databases that introduce different services, these services are:

5.2.1 MAPI US API

This service puts its technology, biochemical, design background and medical to be used in MAPI US, an API that returns information about pharmaceutical drugs. Its database can autocomplete a drug's name, list associated dosages, and list active ingredients (Iterar, 2017).

This service autocompletes the drug name, to make it easy for pharmacists when they try to enter drug names http://mapi-us.iterar.co/api/autocomplete?query=hep, (Na for Sodium, Cl for chloride, Hep. for Heparin, U for units, Dex. for dextrose)

the return data is

["query":"hep","suggestions":["Hep.Na","Hep.flush lock ","Hep.Na preservative free","Hep.plastic container, flush lock ","Hep.Na in plastic container","Hepatolite","Hep.Na 1,000 U and Na Cl 0.9% in plastic container","Hep.Na 2,000 U and Na Cl 0.9% in plastic container","Hep.Na 5,000 U and Na Cl 0.9% in plastic container","Hepatamine 8%","Hep.Na 20,000 U and dextrose 5% in plastic container","Hep.Na 10,000 U and dextrose 5% in plastic container","Hep.Na 25,000 U and dextrose 5% in plastic container","Hep.Na 2,000 U in Na Cl 0.9% in plastic container","Hep.Na 10,000 U in Na Cl 0.45%","Hep.Na 5,000 U in Na Cl 0.45%","Hep.Na 10,000 U in Na Cl 0.9%","Hep.Na 25,000 U in Na Cl 0.9%","Hep.Na 12,500 U in Na Cl 0.9%","Hep.Na 10,000 U in Dex. 5%","Hep.Na 12,500 U in Dex.

5%","Hep.Na 25,000 U in Dex. 5%","Hep.Na 5,000 U in Na Cl 0.9%","Hep.Na 12,500 U in Na Cl 0.45% in plastic container","Hep.Na 25,000 U in Na Cl 0.45% in plastic container","Hep.Na 25,000 U in Na Cl 0.9% in plastic container","Hep.Na 1,000 U in Na Cl 0.9% in plastic container","Hep.Na 5,000 U in Na Cl 0.9% in plastic container","Hep.Na 1,000 U in Dex. 5% in plastic container","Hep.Na 5,000 U in Dex. 5% in plastic container","Hep.Na 2,000 U in Dex. 5% in plastic container","Hep.Na 25,000 U in Dex. 5% in plastic container","Hep.Na 12,500 U in Dex. 5% in plastic container","Hep.Na 10,000 U in Dex. 5% in plastic container","Hep.Na 20,000 U in Dex. 5% in plastic container","Hepatasol 8%","Hepsera","Heptalac"]]

This service brings drug doses http://mapi-us.iterar.co/api/heparin/doses.json, U is for UNITS, the return data is

["1,000 U/ML","1,000 U/100ML","2,000 U/100ML","2,500 U/ML","2,000 U/ML","3,000 U/ML","4,000 U/100ML","4,000 U/ML","5,000 U/100ML","5,000 U/ML","5,000 U/0.5ML","6,000 U/ML","7,500 U/ML","10,000 U/100ML","10 U/ML","10,000 U/ML","10,000 U/0.5ML","15,000 U/ML","20,000 U/ML","40,000 U/ML","100 U/ML","200 U/100ML","500 U/ML","500 U/100ML"]

This service brings drug substances
http://mapi-us.iterar.co/api/Hepatolite/substances.json

The return data is

["Technetium tc-99m disofenin kit"]

5.2.2 RxClass API

The RxClass RESTful web API is a global web service created for accessing the RxNorm data. Representational state transfer (REST) is a style of software architecture for distributed hypermedia systems such as the World Wide Web. As known, REST-style architectures consist of clients and servers. Clients initiate requests to servers; servers process requests and return appropriate responses. Requests and responses are built around the transfer of "representations" of "resources". A resource can be essentially any coherent and meaningful concept that may be addressed. A representation of a resource is typically a document that captures the current or intended state of a resource.

The RxClass RESTful web API is a simple web service implemented using HTTP and can be thought of as a collection of resources, specified as URIs. Some characteristics of the RxClass RESTful web API:

The base URI for the web service is https://rxnav.nlm.nih.gov/REST/rxclass

The web service can return the data in XML or JSON formats.

The format is specified by appending the extension (.xml or .json) to the URI before the query parameters, for example, to return data in JSON:

https://rxnav.nlm.nih.gov/REST/rxclass/class/byId.json?classId=B01AA

The web service only supports the HTTP method GET, since the web service function is to retrieve RxClass data.

The following table lists the RxClass API resources. The query string fields are described in the detailed sections for each resource.

5.2.3 ChEMBL

The ChEMBL database (url= https://www.ebi.ac.uk) url/chembl/api/data/docs is the largest primary Open Data source of manually extracted and curated SAR data from the medicinal chemistry literature. The primary relationship captured in the ChEMBL database is the association between a ligand and a biological target in the form of an experimentally measured activity end-point, e.g. half maximal inhibitory concentration.

The properties of a successful drug though do not solely derive from a single potency against a specific target, thus the ChEMBL database also contains many additional bioassays, such as efficacy in functional assays, ADME and toxicity end-points and physicochemical properties. Further curation and standardization of data are carried out and additional calculated properties and annotations are added, e.g. names and synonyms, target information, calculated properties, structure representations, and drug mechanism of action.

The ChEMBL database (release 20) consists of 63 tables. The tables and the relationships between them can be seen in the ChEMBL release schema diagram Figure 16: ChEMBL Diagram.

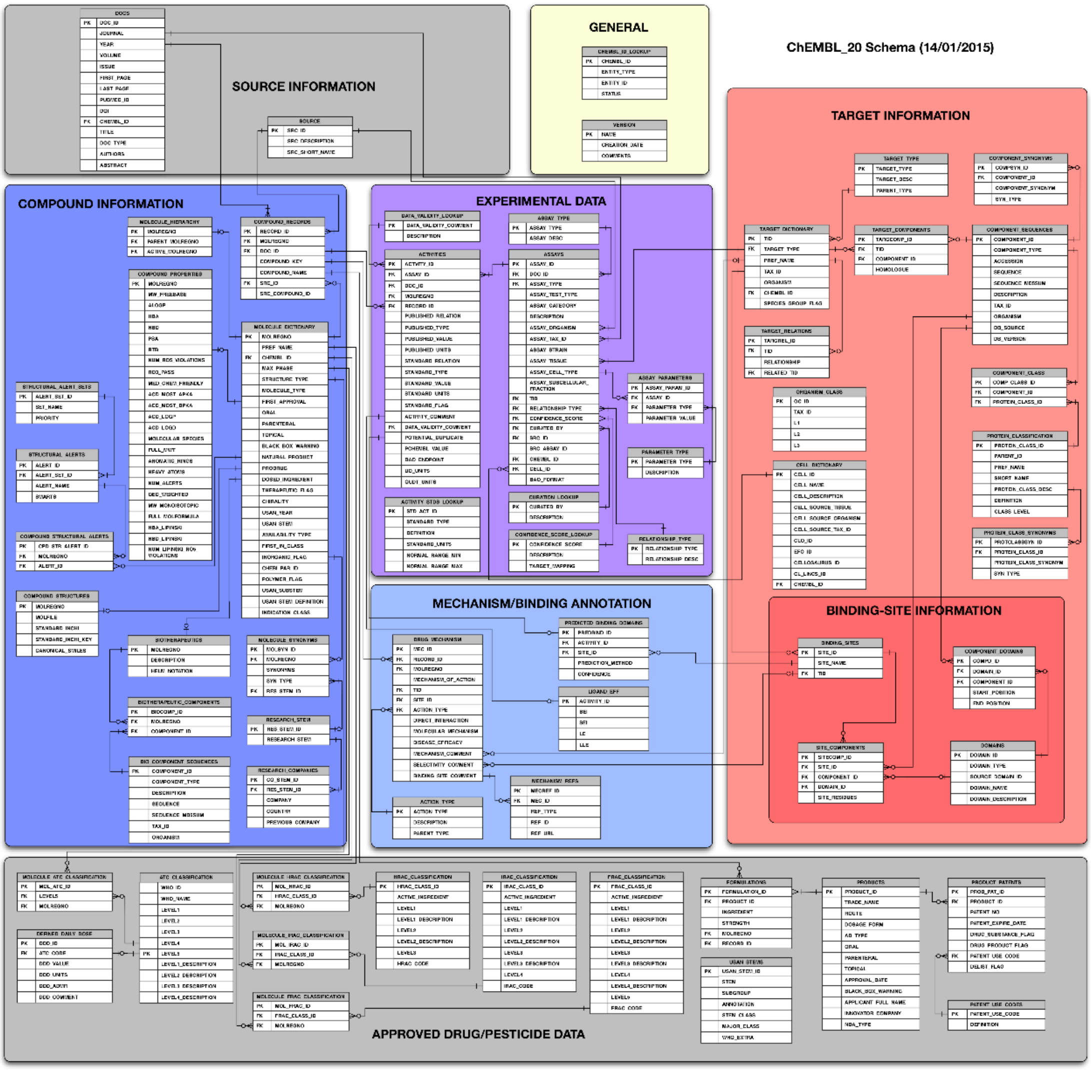

Figure 16: ChEMBL Diagram

And ChEMBL web service resources as shown in Table 6 ChEMBL web service resources

Table 6 ChEMBL web service resources

Example	Description	Name
url/chembl/api/data/activity	Activity values recorded in an Assay	Activity

url/chembl/api/data/assay	Assay details as reported in source Document/Dataset	Assay
url/chembl/api/data/atc_class	WHO ATC Classification for drugs	ATC
url/chembl/api/data/binding_site	Target binding site definition	BindingSite
url/chembl/api/data/biotherapeutic	Biotherapeutic molecules	Biotherapeutic
url/chembl/api/data/cell_line	Cell line information	CellLine
url/chembl/api/data/chembl_id_lookup	Look up ChEMBL Id entity type	ChEMBL-IdLookup
url/chembl/api/data/document	Document/Dataset from which Assays have been extracted	Document
url/chembl/api/data/mechanism	Mechanism of action information for FDA-approved drugs	Mechanism
url/chembl/api/data/molecule	Molecule/biotherapeutics information	Molecule
url/chembl/api/data/molecule_form	Relationships between molecule parents and salts	MoleculeForm
url/chembl/api/data/target	Protein and non-protein defined in Assay	Target
url/chembl/api/data/target_component	Target sequence information (A Target may have 1 or more sequences)	Target-Component
url/chembl/api/data/image/CHEMBL1	Graphical (svg, png, json) representation of Molecule	Image
url/chembl/api/data/protein_class	Protein family classified of TargetComponents	Protein-Classification
url/chembl/api/data/substructure/CN%28CCCN%29c1cccc2ccccc12	Molecule substructure search	Substructure
url/chembl/api/data/similarity/CC%28=O%29Oc1ccccc1C%28=O%29O/70	Similarity search	Similarity
url/chembl/api/data/source	Document/Dataset source	Source

5.2.4 RxNorm

This service provides normalized names for clinical drugs and links its names to many of the drug vocabulary commonly used in pharmacy management and drug interaction apps, including those of MediSpan, First Databank, Gold Standard Drug Database, Micromedex and Multum. RxNorm can mediate messages between systems not using the same software and vocabulary which are done by providing links between these vocabularies.

RxNorm includes the National Drug File - Reference Terminology (NDF-RT) from the Veterans Health Administration. NDF-RT is a terminology used to code clinical drug properties, including mechanism of action, physiologic effect, and therapeutic category.

Nlm.nih.gov

This website has 93852 medicines listings as submitted to the FDA, but nowadays, this online service does not provide a full listing of labels for allowed prescription medicines, this service and other services can be useful for our or other medical apps because they provide drugs based on FDA approval.

Project Structure (Figure 17: Projects) in Visual Studio

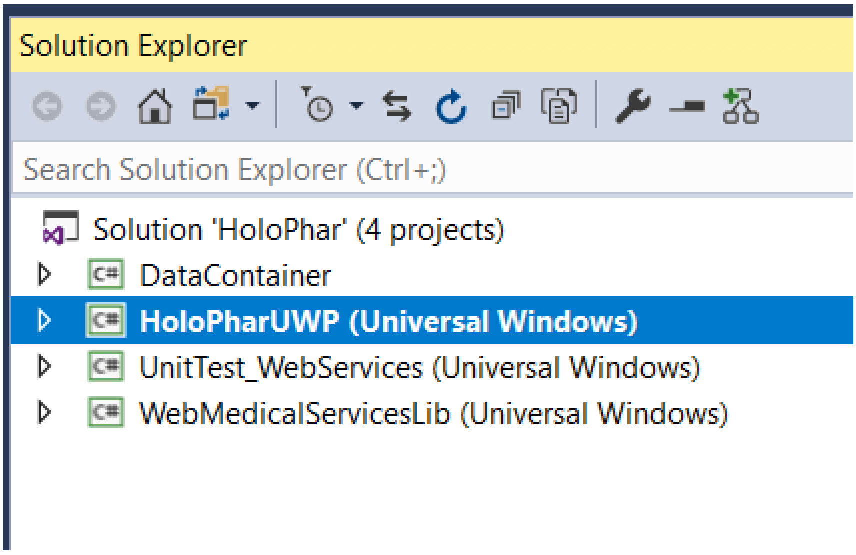

Figure 17: Projects

The solution consists of four smaller projects and they are:

DataContainer: which is the project that contains database classes and operations. We used SQLite DB to store patient information.

HoloPhatUWP: which is the main project that shows the demonstration project to be used in drug dispensing.

UnitTest_WebServices: this project runs unit tests on webservices.

WebMedicalServicesLib: gathering medical data from webservices, which is done by converting web raw data (like JSON or XML) to normal C# classes and lists to be used in the main project.

5.3 Importing Data

To import data, we created many services that are bind to webservices, and return C# classes, more than 10 services to get medical information from the internet (Figure 18: Sample Code Read from JSON).

```
/// <summary>
/// Get drug doses based on it's name
/// </summary>
/// <param name="p1"></param>
/// <returns></returns>
1 reference
public async Task<List<string>> DrugActiveIngredientsAsync(string p1 = "")
{
    var res = await ReadJSON("http://mapi-us.iterar.co/api/{0}/substances.json", p1);
    JArray a = JArray.Parse(res);
    List<string> li = new List<string>();
    foreach (var c in a)
    {
        li.Add(c.ToString());
    }
    return li;
}
```

Figure 18: Sample Code Read from JSON

5.3.1 4.4 Data Store

We used SQLite database to store data of the drugs and the patients in the project (Figure 19: Data Store) which are stored locally.

```
public static void InitializeDatabase()
{
    using (SqliteConnection db =
        new SqliteConnection("Filename=HoloDB.db"))
    {
        db.Open();

        String tableCommand = "CREATE TABLE IF NOT " +
            "EXISTS Users ( [ID] integer(5) UNIQUE NOT NULL,[Name] nvarchar(100) ,[Mobile] nvarchar(100) ,[A
        SqliteCommand createTable = new SqliteCommand(tableCommand, db);
        createTable.ExecuteReader();



         tableCommand = "CREATE TABLE IF NOT " +
            "EXISTS PatientHistory ( [ID] integer UNIQUE NOT NULL,[UserID] int REFERENCES [Users] ([ID]) On
         createTable = new SqliteCommand(tableCommand, db);
        createTable.ExecuteReader();
    }
}
```

Figure 19: Data Store

5.3.2 User Interface

The user interface is based on XAML syntax, which is the main language in UWP (Universal Windows Platform) projects. The user interface is built based on the previous UI introduced in Chapter 3

State of Art and Review of Related Work (Figure 20: Main screen),

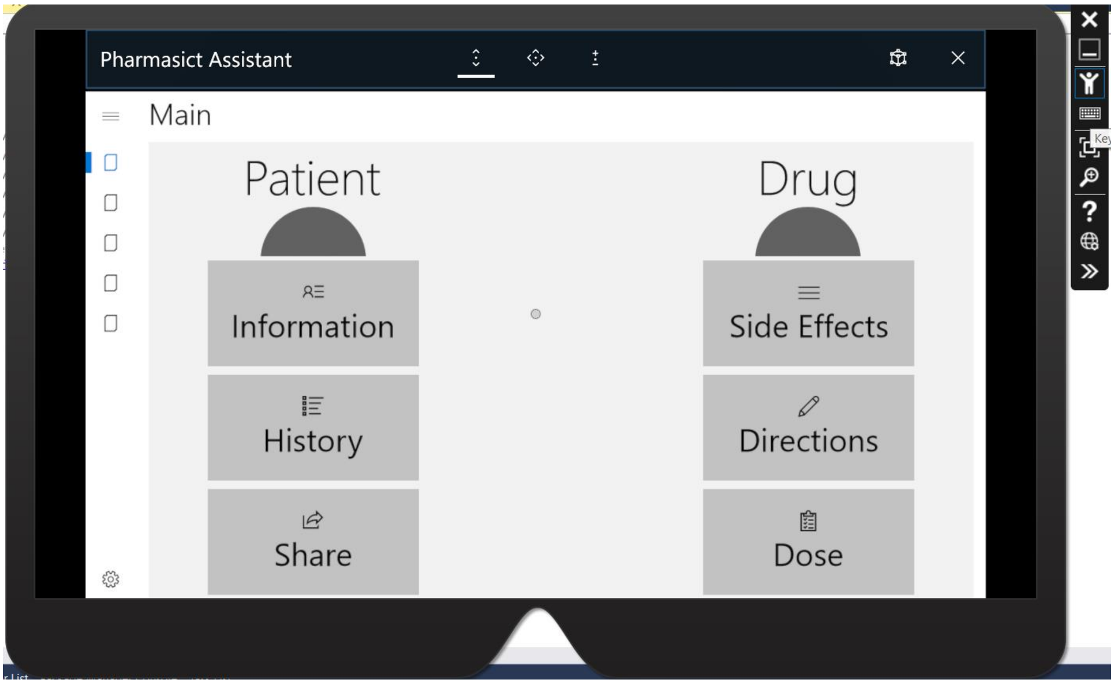

Figure 20: Main screen

Which may have face recognition step for the patient and may be OCR reader for the drug recipe if it is not electronic (Figure 21: Drugs Entry),

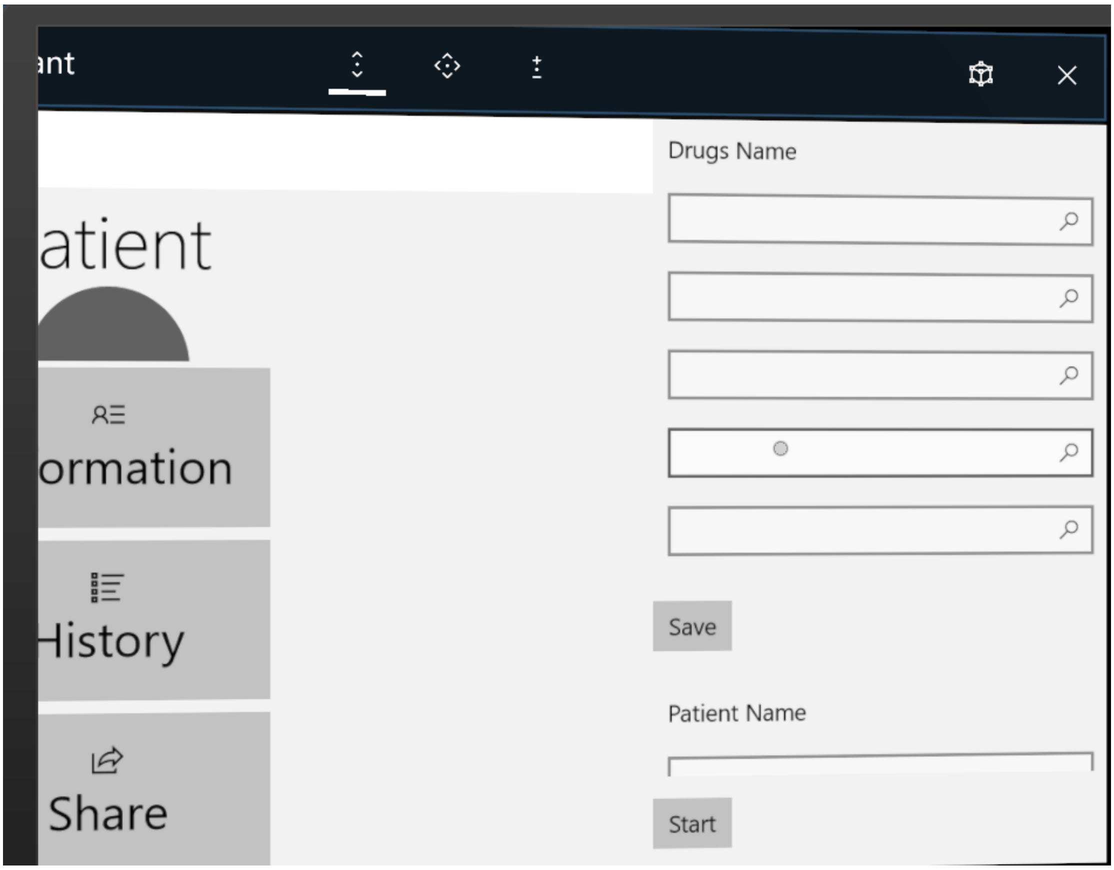

Figure 21: Drugs Entry

and for Patient Details Page (Figure 22: Patient Information).

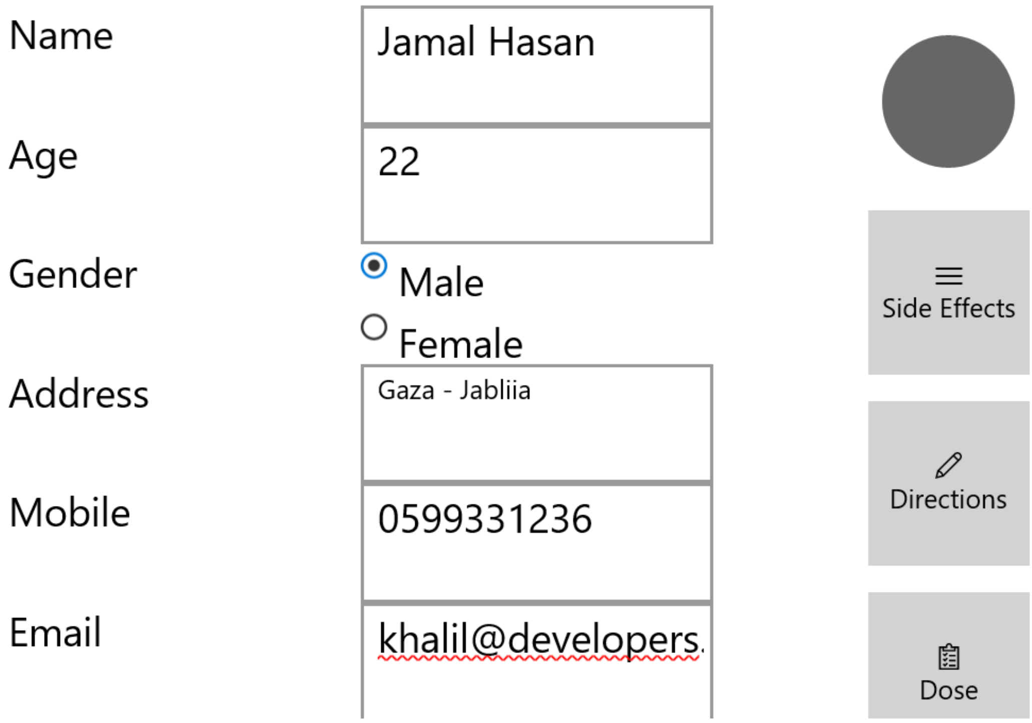

Figure 22: Patient Information

5.4 Evaluation

To test if a system that is based on mixed reality can help the pharmacists on drug dispensing process, we need to create a real system that can apply the assistant processes for the pharmacists, because it is a prototype not a complete system, we used special tests for our approach.

We choose Microsoft HoloLens as model to test our system; it is a commercial device, and can be ordered any time.

To start developing we need to specify our system requirements. The system will have two parts, the first one is for the patient processes and the second one for the drug processes.

The patient processes will show the patients' information, their history if needed and to share any drug information with them. The drug processes will show directions of drug, side effects, and the dose.

Our UX research evaluation tries to be sure that the current suggested UIs are useful and exactly what pharmacists need. And do the users frustrate by this feature? Do pharmacists have trouble understanding how to use the proposed system?

Evaluative research is done to assess the existing design and its sample on UWP application. The types of questions that evaluative research can help the answers include:

Is the design solving the problem for pharmacists?

5.5 Expert Review

The experience relies heavily on a very rich aesthetic. Because an expert review affords more flexibility than a heuristic evaluation, we performed it with the help of expertise in UX and with pharmacists. Our proposed UI must be viewed by experts to see their opinion. The UI at last is the final output that must be important in our study, the experts must be:

1- Pharmacists

2- Human-computer interaction UX\UI experts

The pharmacists must evaluate the functions of the UI, and describe if it fits for their daily job or not? What we must add or remove the UIs? Is the arrangement logical or not for the UI?

A good design can be more illuminating than a thousand words, so this is what we are going to check, with the pharmacists. In the first expert review meeting we started as:

1- we showed a demonstration on Mixed Reality.

2- we showed a demonstration for our system.

3- then we asked if it will be helpful to get a complete system based on Mixed reality to assist the pharmacists in drug dispensing process.

and the questions were:

What is the degree of importance of these operations that can be useful working with patients in drug dispensing process:

- patient information
- medical history
- drug interactions
- medical news
- drug effects
- share drug information with patient
- instruction of usage

I will show some items, and by looking into these items, please tell me which is more important in the process of drug dispensing, and please arrange them.

Are there any suggested ideas for the current screens' arrangement?

Do you suggest any current screen addition or removal?

Do the main screen items are enough for usage, or they need some enhancements based on real life data experiment?

Any additions?

After that, we, as experts, our questions were:

We showed a demonstration on Mixed Reality.

We showed a demonstration for our system.

Will it be helpful to get a complete system based on Mixed reality to assist the pharmacists in drug dispensing process?

I will show you some screens, and please see its controls and item, do they fit for them or not?

What are the suggested updates we need to consider in the screens?

Any additions?

5.5.1 Results

After interviewing two pharmacists, and discussing the current system features and process, the results were as shown in Table 7 Experts Review and we take this scale

Result > 50% => Bad

Result > 50% > 65% => Simple

Result > 65% > 80% => Good

Result > 81% > 90 => => Very Good

Result < 90% => Excellent

Table 7 Experts Review

Question	Pharmacist 1	Pharmacist 2
degree of importance	Very Good	Excellent
patient information	Good	Good

medical history	Good	Simple
drug interactions	Good	Good
medical news	Good	Good
drug effects	Good	Good
share drug information	Bad	Good
instruction of usage	Good	Good
arranged items	Good	Very Good
suggested ideas	No	No
screen suggests	No	No
Any additions?	No	No

And after the interview with two UI-UX experts, and discussing the current UI and system flow, the results were as shown in Table 8 UI-UX Experts Review

Table 8 UI-UX Experts Review

Question	Expert 1	Expert 2
helpful to get a complete system based on Mixed reality.	Yes, and Implement MR in any system	Yes
I will show you some screens, and please see its controls and item, do they fit for them or not.	Some screens need to enhance typography	Some screens need to arrange items and fonts
What are the suggested updates we need to consider in the screens?	Try to simplify the screens	nothing
Any additions?	No	No

5.5.2 Discussion

After talking to the experts, their opinion was very useful. There are some adjustments that must be made, but they are quite a few. The only feedback that needs more effort is to simplify the screens, for simplifying screens. We tried to decrease written data on them, and after that we reviewed the screens again with the experts. Their opinion was that they are good enough. As a result, we added scrolls for texts, which fix the problem for the experts.

In addition, our system must combine other peripheral devices and system, for example accounting system, and other medical databases (narcotics, OTC, and etc.), which will have a huge impact on the service.

As Typography in mixed reality in Microsoft's documentation(al.), typographic rules in mixed reality are the same as anywhere else. Text in both the physical world and the virtual world needs to be readable and legible. Text could be on a wall or superimposed on a physical object. It could be floating along with a digital user interface. Regardless of the context, we apply the same typographic rules for reading and recognition Figure 23: Typography example in .

Figure 23: Typography example in HoloLens

Furthermore, we build contrast and hierarchy by using different sizes and weights. Defining a type ramp and following it throughout the app experience will provide a great user experience with consistent information hierarchy Figure 24: Type examples.

Figure 24: Type examples

The developers must not use two different font families or more in one context, because it will prevent the conformity and uniformity of the experience and make it harder to consume information.

The recommended font size for the user's comfort will be two meters -the optimal distance for placing holograms. We can use this distance as a basis to find the optimal font size Figure 25: Optimal distance, two meters for displaying text..

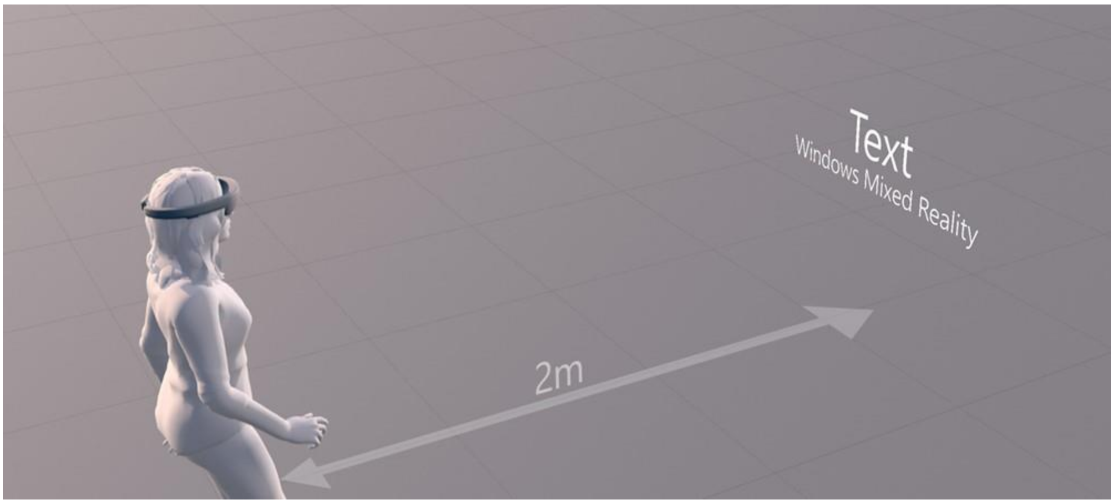

Figure 25: Optimal distance, two meters for displaying text.

Chapter 6

Conclusion and Future Work

Chapter 6

Conclusion and Future Work

This chapter concludes the research, and the main contribution of the thesis. After that, we suggest some recommendations, and finally; it gives some ideas for future work.

6.1 Conclusion

Mixed reality technologies will have a great impact in the future of the world. It will make a huge shift in all aspects of any field. Therefore, we suggested a UI for using the mixed reality in pharmacy especially in drug dispensing process.

We started by looking on previous studies and the existing systems so that we know how to make a unique study that has no similarity with any study. The only device based on mixed reality that is available for commercial use was Microsoft HoloLens Glasses which has some great apps and system that we can focus on to see how apps are made for this new technology, which can be very useful for our imagination and for UI suggestion later.

After that we started collecting all the information for drug dispensing process, which can be useful during real time situations. This information varies from drug related data as drug-drug interactions and side effects, and other related methods of dispensing like medical history and narcotics and so on.

After collecting the information needed for our system, we suggested the main UI for the system, which we believe it will be good for pharmacists in almost all of their daily situations in any pharmacy and we build a small demonstration based on UWP.

The suggested UI needed to be evaluated by pharmacists and UI-UX experts which what we do in the next step and their feedback was positive, and all their ideas and suggestions were recorded and taken into consideration.

6.2 Recommendations

The flowing are some recommendations that can be formulated to adopt the goal of this thesis:

1- There must be a complete system to be used directly in pharmacists not just a proposed system and UI.
2- The system must be connected with the newest drug datasets and other medical databases.

3- More features must be added to the system.

6.3 Future Work

According to the results and our final UI and the limitations that we faced in our thesis because we couldn't get Microsoft HoloLens glasses, this work can be improved in multiple directions:

- Use Microsoft HoloLens glasses to check the proposed UI in real pharmacy.
- Use the system in many pharmacies and in different types as in hospitals and pharmacies.
- Use the features of new mixed reality devices like Version 2.0 of Microsoft glasses.
- Expand the system and bind it with other peripherals and systems.

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