Augmented Reality: Telehealth Demonstration Application

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ABSTRACT

Augmented Reality (AR) as a technology will improve the way we work and live in the future. The Microsoft HoloLens device allows for rendering of interactive virtual components into a real world space. The HoloLens is an augmented reality headset and can display these virtual components in front of the user's eyes, so the data needed to complete a real-world task will always be available. The nature of a HoloLens device lends itself useful for applications in a healthcare setting. Potential benefits come from transitioning to a more hands-free environment such as allowing the logging of data while in sterile environments without needing to sterilize repeatedly from touching paper or tablet. This project developed an augmented reality (AR) application to include a care plan tracker established by a patient's doctor to allow the patient to do daily tasks without a health care worker's supervision. The application displays the medications that the patient needs to ingest, daily tasks to complete, and health data to record. The application allows the physician to retrieve useful patient information regularly without scheduled physicals. This project sets a baseline that will provide future developers with documentation, research, and this sample application to assist in the design and construction of more complex applications in the future at the University of New Hampshire.

CCS CONCEPTS

• **General and reference**; • **Cross-computing tools and techniques**; • **Design**; • **Human-centered computing**; • **Visualization**; • **Visualization theory, concepts and paradigms**; • **Networks**; • **Network types**; • **Cyber-physical networks**;

KEYWORDS

Augmented reality, Microsoft HoloLens, programming, network, cyberinfrastructure

1 INTRODUCTION

Telehealth and telemedicine have been growing in importance in serving the population with healthcare. [1] As these new areas emerge, they are prepared for advances in Augmented Reality (AR) for incorporation into the delivery of healthcare. To this end, our project team focused on the investigation of possible use cases for the Microsoft HoloLens device in the healthcare field. The HoloLens is an AR computing platform that combines data presented in graphical form projected on a heads-up visual field in front of the user's eyes to augment the environment seen through the field glass.

The research involved in this project focuses on the development of the programming environment required to develop HoloLens applications, along with identifying best practices for the use of the HoloLens in the telehealth field. [2] The project team consulted publications and the Internet for development research, and used these strategies, along with a series of requirements gathering sessions to create an application based on input from the University of New Hampshire (UNH) Nursing Department faculty.

The application developed demonstrates a care plan for a patient at home, indicating for the patient what medication needs to be taken, exercises to be completed, and general daily tasks to document.

2 RESEARCH APPROACH

The project team began with a requirements gathering exercise involving two members of the UNH Nursing Department faculty. The discussion involved an open-ended set of questions with two members of the UNH Nursing Faculty: Ms. Marguerite Corvini and Dr. Gene Harkless. The group took the liberty to brainstorm long-term goals of an application involving the use of the Microsoft HoloLens.

The two members of the UNH Nursing faculty are members of the UNH Telehealth Practice Center, [3] a research and teaching facility focused on the effective connections between healthcare and technology. They explained the goal with their center is to move towards putting care into the hands of the patient. This would be in the form of a care plan provided by the patient's doctor. The

project team focused on the alignment of the application to be based around this concept, with the HoloLens serving as a tool for the patient that would be provided by their doctor. The patient would be given a set of instructions, the care plan, and those tasks would be completed while wearing the HoloLens to assist the patient.

We solicited from the faculty members detailed information on different types of patients that could benefit from a care plan with the HoloLens. Since this application was designed to be a proof of concept and deployment details were out of scope, we chose to build the application to handle an initial set of data and tasks as determined by a simulated doctor providing the HoloLens with specific patient actions and care plan as determined by the Nursing faculty.

Generally, patient type input data would be a simple set of questions that identified actions to create a care plan. These questions might be around the following questions:

- What are your goals and preferences for your health?
- What is a long-term goal for your health?
- What is a short-term goal for your health?
- What do you feel is important for you to do each day?

From this line of questioning, we include two examples of care plans that could be installed into the application.

Patient 1: A cardiac patient – A 60 y/o woman who had open-heart surgery three months ago and is still in recovery. She lives with her daughter (Ellie), son-in-law, and granddaughter. She developed a care plan with her provider to meet her personal goals and her health goals.

> Have breakfast with Ellie at 7 am
>
> Remember to take medication Ticagrelor 90 mg and atorvastatin 80 mg at 7 am (you can have the HoloLens project a pill picture and prompt)
>
> Do exercise 8 am. – have HoloLens project the exercises
>
> Weigh self daily; take Blood Pressure only once per week (would be cool if this could somehow be sent via the HoloLens)
>
> Take care of indoor plants 10 am
>
> Check your email messages and pay bills 11:30 am
>
> Take medication with lunch at 12 pm
>
> Help Ellie with her homework 2 pm
>
> Have dinner 5:30 pm
>
> Work on gardening plan and discuss with Ellie 6:30 pm
>
> Take Ticagrelor 90 mg, metoprolol 100 mg , amlodipine 5 mg medication 7pm – have HoloLens project pills picture and prompt

Example answers to the Person-centered plan might be as follows –

- What are your goals and preferences for your health? To manage my heart disease and go back to being active.
- What is a long-term goal for your health? To be able to ride my bike for more than 4 miles.
- What is a short-term goal for your health? To be able to cook again and spend time with my granddaughter.

- What do you feel is important for you to do each day? I enjoy gardening. I would like to get to a point where I can garden each day.

Patient 2: Patient with Mild Cognitive Impairment –This is an 80 y/o male who lives alone and has difficulty with memory issues. He has a dog, Minnow, and a neighbor who assists him. He has a daughter that lives in Vermont. He has worked with his provider to develop a plan to meet his every day personal goals as well as his health goals. It would be helpful if there is a way to check these off so that when the patient does each one, he knows that he has completed the tasks and doesn't get confused.

> Walk Minnow at 7 am
>
> Feed Minnow at 8 am
>
> Call neighbor and check in
>
> Walk Minnow at 10 am
>
> Check your email messages
>
> Take medication with lunch at 12 pm
>
> Meet up with Bill to play cards 2 pm
>
> Call daughter after she gets home from work 5:30 pm
>
> Have dinner
>
> Walk Minnow at 6:30 pm
>
> Take out the trash. Tomorrow is trash day!

Example answers to the Person-centered plan might be as follows –

- What are your goals and preferences for your health? To be able to stay in my home and live independently
- What is a long-term goal for your health? To be able to remember important things I need to do, like pay my bills and social outings.
- What is a short-term goal for your health? To be able to take care of my dog.
- What do you feel is important for you to do each day? I enjoy walking my dog every day and visiting with friends.

3 DEVELOPMENT COMPONENTS

At the onset of the project, a collection of resources was necessary. These resources included both hardware components and software packages. Any publicly-posted recipes of cookbooks on the use of the Microsoft HoloLens Gen 1 device have aged to a point where they are no longer correct in merging the hardware of the past with the software of the present.

3.1 Hardware requirements

The hardware required to develop a similar HoloLens project include the components listed below.

- Microsoft HoloLens DK1,
- An Android device,
- A computer or laptop,
- A DirectX 10 or greater-capable GPU, and
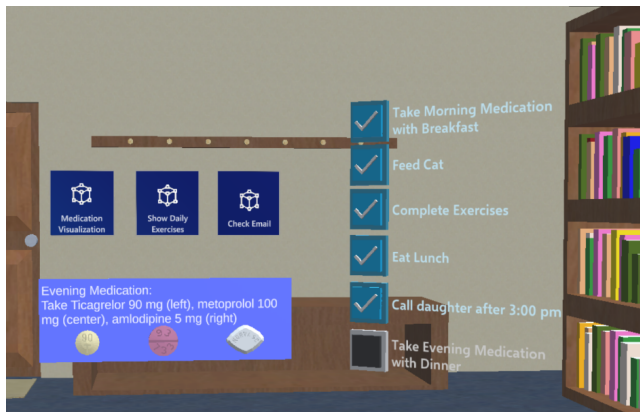- A CPU with SSE2 instruction set.

Figure 1: Microsoft HoloLens Demonstration Application Sample User Interface View

3.2 Software requirements

The software packages and base code necessary to develop a similar HoloLens project are listed below.

- Android 9.0 or greater,
- Windows 10 Enterprise, Professional, or Education,
- Unity 3D,
- Mixed Reality Toolkit (MRTK),
- Visual Studio 2019,
- HoloLens Emulator, and
- Windows 10 SDK.

4 IMPLEMENTATION

The current iteration of the project is implemented in the Unity 3D engine using assets from the MRTK provided by Microsoft. Visual Studio is used to compile the final executable and deploy it to the HoloLens device. Once the application is compiled, it is deployed and used in tethered mode with the HoloLens directly communicating with a developer's computer. Once operation is verified and tested, the application can be moved to operate untethered in a stand-alone fashion on the HoloLens device. An Android device running Android 9.0 or greater is currently used to act as a keyboard during development as opposed to using the HoloLens' virtual keyboard primarily to aid in development ease of use.

5 EXAMPLE OPERATION OF APPLICATION

Following the sample use cases identified during the requirements gathering phase, the project team built a sample application for use in the HoloLens. Since visualizing the application is difficult without a contextual background, the project team built a sample room using the Unity 3-D package in which to display the application. Figure 1 is an example of the application in operation in the sample room as viewed from the perspective of a patient wearing the HoloLens device.

6 CONCLUSIONS AND FUTURE WORK

The requirements and ideas that the project team has gathered from the UNH Nursing Department allowed us to create an application that is devoted to a care plan provided from a doctor for their specific patient type. In addition to this application, we plan to use our experience with development to create documentation and research for general HoloLens development. This documentation will allow future team members to create more advanced applications with augmented reality.

The baseline should allow future developers to more easily create more complex applications based on the research and documentation provided. The documentation allows for easy setup of a development environment and supports the deployment of code within the HoloLens ecosystem. Eventually, based on the demonstration application and future documentation, there should be useful methods to build towards future applications.

The telehealth field is one that can benefit significantly from more HoloLens developers and the project team has provided research and a demonstration application that will make that feasible in the future.

REFERENCES

[1] Baumann, Paula Kerler and Scales, Tim. "History of Information Communication Technology and Telehealth." Academy of Business Research Journal, vol. 3, 2016, pp. 48–52.

[2] Elgamal, Tarek, Chen, Bo, and Nahrstedt, Klara. "Teleconsultant: Communication and Analysis of Wearable Videos in Emergency Medical Environments." In Proceedings of the 25th ACM International Conference on Multimedia (MM'17), October 2017, pp. 1241-1242. DOI: https://doi.org/10.1145/3123266.3127920

[3] UNH Telehealth Practice Center Website. chhs.unh.edu/telehealth-practice-center. Accessed 29 Apr. 2020.

A APPENDICES

On the following page is a graphic consisting of the project poster as presented at PEARC20.

NORTHEAST CYBERTEAM

Augmented Reality: Telehealth Demonstration Application

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Introduction

- The Microsoft HoloLens device allows for rendering of virtual components into real world space for an interactive experience.
- Users gain the use of both hands with the hands-free computing capabilities associated with the HoloLens device.
- The UNH Nursing Department in the College of Health and Human Services sought the development of a demonstration application that focused on the capabilities of the HoloLens device.
- Using Telehealth as the working field, both patient and caregiver applications are readily possible in the developed environment.

Motivation

- Establish Mixed Reality Development at UNH for future student developers
- Exhibit HoloLens device capabilities through a demonstration application for the UNH Telehealth Practice Center
- The hands-free nature of using augmented reality makes healthcare an ideal use case
- Document a stable development environment to fit changing Microsoft Windows configuration needs

Application Details

- Requirements provided by members of the Telehealth Practice Center
- Care Plan for use at home involves: Exercises, Medications, Daily Tasks; The caregiver would load the care plan for the patient to take home
- Patient types include: Cardiac, Aging-in-Place, Mild Cognitive Impairment

Technology

Hardware

Microsoft HoloLens Gen1 Device

Unity UI Components

Software

Unity, Visual Studio

MRTK MIXED REALITY TOOLKIT http://aka.ms/MRTK

Application Design

- Application contains a checklist for the patient's daily activities and buttons to help complete their care plan
- The evening medication is shown after pressing the medication visualization with the initial condition that morning medication is checked on the checklist
- 3-D Models of the medication were created to match color, shape, etc. of the actual medication the patient will take

User Interface

Image shows application running on HoloLens emulator

Conclusion

- Understood the use cases where this hardware could benefit the age of telehealth treatment for caregivers in healthcare.
- Built a demonstration application with the Microsoft HoloLens following the documentation for device and development.
- The demonstration documentation is a starting point for future augmented reality developers at UNH.

Future Work

- Develop more complex applications with the Microsoft HoloLens that connect with outside resources.
- Build a general HoloLens development library using the Mixed Reality Tool Kit.
- Documentation an implementation of an ideal augmented reality user interface (UI).
- Implement more telehealth-related applications by collaborating with the UNH Telehealth Practice Center.

About the Northeast Cyberteam

The Northeast Cyberteam Program is a 4-year initiative funded by the National Science Foundation to build a regional pool of Research Computing Facilitators (RCF) to support researchers at small and mid-sized institutions in Maine, Massachusetts, New Hampshire, and Vermont, leveraging the work of national programs including XSEDE Campus Champions, ACI-REF, and others. RCFs are experts at figuring out how to match the right compute resources to the task at hand, something that can stymie researchers.

The RCFs' job is to help make use of local, regional, and national high performance computing resources when computing needs exceed the capacity of the scientist's desktop. RCFs can often be found in the research computing groups at large universities and corporations, but are scarce at smaller institutions. The Northeast Cyberteam program aims to build a methodology to address this issue. Central to the program is the idea of giving students hands-on Research Computing Facilitation experience while also advancing research and education projects that need help.

Acknowledgements

References

Baumann, Paula Kerler and Scales, Tim. "History of Information Communication Technology and Telehealth." Academy of Business Research Journal, vol. 3, 2016, pp. 48–52.

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