

SaveVisions - Product Requirements Document

About the team

Team Name: Panda

Company: Alcon

Team Members:

Jiayu Chen (Lead) (jiayuchen@ucsb.edu)

Jessica Zhang (Scribe) (zhiyun_zhang@ucsb.edu)

Zilie Huang (zilie_huang@ucsb.edu)

Grace Zhang (gracezhang@ucsb.edu)

Zora Jiang

Yinglong Wang

Introduction

What is the problem?

Last year, the Centers for Disease Control and Prevention (CDC) released a group of shocking statistics about common eye disorders. In the United States, there are approximately 12 million people who are at the age of 40 and over have vision problems and about 6.8% of teenagers under 18 years old have diagnosed vision

impairments. Therefore, vision disability has become one of the most prevalent disabling conditions among American people. Under this situation, reliable and professional eye diagnosis and eye surgery are necessary so as to protect the patients' eye health.

However, not all eye surgeons are experienced enough to detect all eye problems in a limited consultation time. Since the area of eyes are tiny, eye doctors might overlook latent symptoms or not completely identify unobtrusive visual signs while diagnosing. Consequently, a diagnostic tool is urgently required to assist the ophthalmologists while diagnosing or during the surgery.

How is the problem addressed today?

Actually, there are not many advanced intelligent tools available to assist the ophthalmologists to diagnose patients about their abnormal eye symptoms and potential eye diseases. However, some helpful tools do exist to support the work of eye doctors, improving the accuracy of doctors in diagnosing patients' eye diseases. Here are the eye doctor tools and the functions of each:

1. Phoropter

The Phoropter helps determine the prescription and ensure the correction of the power of glasses and contact lenses by measuring refractive error, such as myopia,

hyperopia,etc. This tool requires the cooperation of Patients. The optometrist asks the patients which lense applied is more clear. And patients tell the doctors if they can see clearly with the applied lenses.

2. Tonometer

The Tonometer helps measure the pressure of patients' eyes. It makes sure that the patients' eyes have the right internal pressure so that their eye shapes are normal and there are no serious eye diseases.

3. Slit Lamp

While the optometrist is inspecting the eyes' external parts such as eyelid, iris and cornea, the slit lamp is able to assist the optometrist to detect any abnormality or symptoms in the anterior part of the eye.

Objective, Implementation, and Assumptions

What is our objective and who will benefit from it?

Our objective is to develop a tool to help eye surgeons to identify telltale visual signs and to alert the eye surgeons to potential complications. This tool is designed specifically for those who need either cataract or lasik surgery in order to help the surgeons to double check the patients' conditions in case there are

undetected signs. Furthermore, it can serve to help early recognition of eye diseases to preserve vision.

What are the core components of our solution?

Eye Anatomy Components Detection:

This algorithm is to help the camera detect the components of the eye anatomy, such as the pupil, lens, that are crucial to identifying the eye diseases. Before recognizing the components, the image or video captured by the camera will be filtered by Gaussian blur and then restored the sharpness in order to reduce chromatic aberration.

Eye Disease Detection:

The eye disease detection algorithm will be used to effectively identify any symptoms of the patients' eyes. This deep learning algorithm will be trained by utilizing Alcon's dataset of videos from past surgeries.

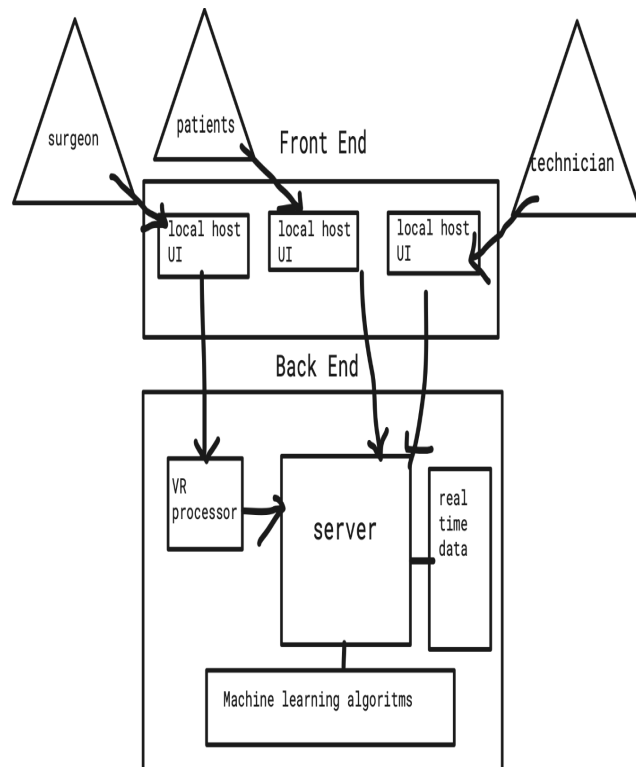
What are the necessary assumptions to be made?

This tool is assumed to be able to correctly capture the patient's eye, and nothing will obstruct the camera during the process. Furthermore, the image/video will be presented in grayscale.

System Architecture Overview

In the front end, we will have three different local host UI for three groups of people.

The first group is the surgeon, who will be able to monitor the surgery in real time. The system should tell the surgeon what possible eye diseases during the operation. The technician is the helper for the surgeon and he should be able



to see the grayed version that the computer sees. And patients should be able to login and know about their possible diseases after the operation. The surgeons' path also includes a VR processor since they do the surgery using glasses while the other two groups don't have to. In the back end the server takes models from our machine learning algorithms and real time data collected from the surgery. Then the server will feed images to users.

User Stories

User Story #1: As an eye surgeon, I can use the training algorithm model to identify the size of the pupil of my patient before I start the cataract surgery. So that I am able to find the correct size of the surgical instrument before I proceed with the surgery.

https://github.com/PandaTeamCapstone21/alcon_capstone/issues/1

User Story #2: The terminal of the surgical machine can connect to the API of our algorithm to analyze the potential risks while in the surgery.

https://github.com/PandaTeamCapstone21/alcon_capstone/issues/2

User Story #3: As a patient/surgeon/technician, I can login to the web application.

GithubLink:

https://github.com/PandaTeamCapstone21/alcon_capstone/issues/3#issue-1039950227

- **Scenario 1:** Users do not have an account yet
 - Users click the button “Create”, and are directed to the create account page.
 - Users can successfully create an account if credentials are valid.
 - Create the username and a strong password (8 characters with both letters and numbers).
 - Users fail to create an account if credentials are not valid.
- **Scenario 2:** Users already have accounts
 - Choose “As a surgeon”/ “As a patient”/ “As a technician”
 - If the login credentials match with the database on the backend, login.
 - If the login credentials do not match with the database on the backend, users get an error message “Incorrect username/password”.

User Story #4: As a patient, I can login to the web application with an existing account and find the past records for my diagnosis, which includes all the detected symptoms along with the inferred eye diseases.

Github Link:

https://github.com/PandaTeamCapstone21/alcon_capstone/issues/6#issue-1039952925

- **Scenario 1:** If the records for the patients have been uploaded
 - The records for the patients are listed with the most up-to-date one on the top, and the oldest one on the bottom.

- For each of the diagnoses, patients can click on the record and see a list of the detected symptoms during the diagnosis, with the inferred eye diseases, based on their diagnostic videos.
- **Scenario 2:** If the record of patients have not yet been uploaded
 - The message “No record” is displayed on the page.

User Story #5: As a surgeon, I can find the potential complications of the eye analyzed by the algorithm after the surgery.

Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/4

- **Scenario 1:** No complication
 - Message window will pop up: “no potential complications”
- **Scenario 2:** Potential complications exist
 - Warning message is shown to alert surgeon
 - The surgeon will be able to see a list of potential complications generated by the algorithm.

User Story #6: As a surgeon, I can see the image of telltale visual signs of the patient’s eye.

Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/5

- **Scenario 1:**
 - Message window will pop up: “no telltale visual signs”
- **Scenario 2:**

- Image of eye will be enlarged to the dimensions that clearly identifies the telltale visual signs
- Algorithm will prompt the possible problem on the screen

User Story #7: Before training the data, we need to process the data by retrieving data frames and label the data frame.

Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/7

User Story #8: Label the sample or training data manually. Determine the testing data.

Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/8

User Story #9: As a technician, I'm able to log in into my account and check activities of patients/surgeons with their account and profile.

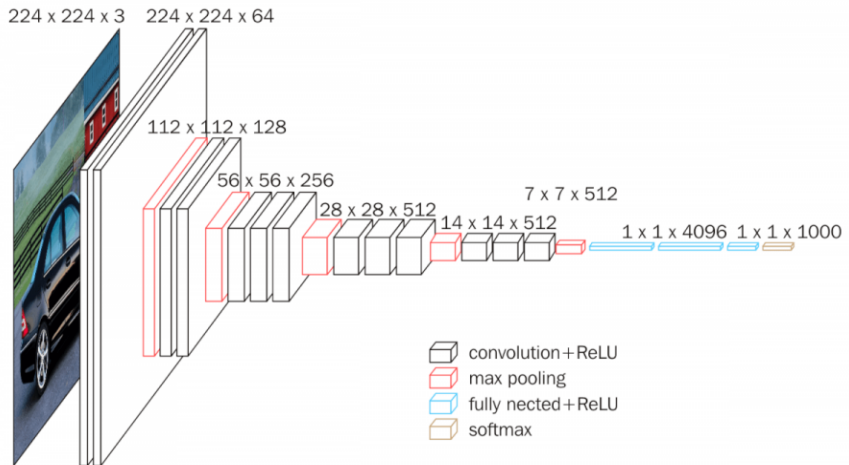
Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/9

User Story #10: As a technician, we can check in with the error message log and report and can also set server downtime to update the system.

Github link: https://github.com/PandaTeamCapstone21/alcon_capstone/issues/10

Sequential Model

1. Read the video, extract frames from the video using the *VideoCapture()* function and save frames as images. For every second, a frame of the video shall be recorded as images.
2. Handle several frames(images) manually by giving labels to them, and train the model based on those frames. In other words, identifying frames with telltale visual signs.
3. Train the convolutional neural network model with the data we labeled in the second step. We can use the pre-trained model of Keras like VGG-16 or build the deep neural network ourselves.
4. Apply the convolutional neural network model to the remaining frames of our video and check for precision.
5. Associate the frames with video time and alert the surgeon to potential complications.



Technologies Employed

Front End:

- React native (<https://reactnative.dev/>)

Back End:

- Tensorflow 2 (https://www.tensorflow.org/guide/effective_tf2)
- Cuda Toolkit (<https://developer.nvidia.com/cuda-toolkit>)
- COCO api (<https://github.com/cocodataset/cocoapi>)
- Pytorch (<https://pytorch.org/>)