Tool for extracting, managing and visualizing Strabismus metrics

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Abstract. Strabismus is a condition that affects about 4% of the world's population. In severe cases, strabismus can lead to blindness and in large specter is impacting the quality of life of patients. In addition to affecting vision, the aesthetic appeal of strabismus can generate sufficient public embarrassment to influence the patient's entire academic, personal and professional develop- ment. In most cases the condition can be treated. In order to support strabismus specialists, we propose a computational tool for metric extraction, data management and visualization specialized in the disease.

Keywords: Strabismus · Computational · Metrics.

1 Introduction

1.1 Purpose and Motivation

Computer Science and related areas has vastly contributed to aid in health diagnostics and treatments. There are several studies published daily on scientific methods that relate computing topics such as 'machine learning', 'artificial intelligence' to topics and areas of medicine. Ophthalmology is not an exception. There are several opportunities to positively impact by addressing eye health conditions with computer techniques. However, some of the scientific innovations depend on the availability of data. Therefore, this is our main motivation, to build a tool that generates useful visualizations for 'Strabismus' specialists and that allows the management of data such as images and parameters about each patient, in a structured and opinionated way to be the data. potentially used in future research.

1.2 Strabismus

When we look at an object, we perceive depth and are able to follow it if there is displacement in space. Behind this event is a delicate and complex physical and neurological process: Light passes through the cornea and Crystallin (eye lens), which focuses on objects) and follows through a transparent, gelatinous substance called vitreous humor until it ends up in the retina, which is a complex tissue composed of several layers of cells that will make the process of converting light into electrical impulses and send this information to our brain.

The retina has distinct processing capabilities with the fovea being the region with the highest photoreceptor density and having preference over other regions for image centering. Through a complex system of brain circuits, the fovea of both eyes aims to the same object in space. Maintaining this alignment will depend on the fine adjustments of the eye-moving muscles. We have a set of 6 muscles for each eye, 2 horizontal, 2 vertical and 2 oblique that allow the eye to rotate to any position within a field of approximately 150 degrees. When there is a loss of alignment of the fovea in relation to the non-voluntarily fixed object, we can call this condition strabismus. [1]

Strabismus is a condition commonly diagnosed during childhood. The first suspicion of the disease commonly arises with parents or pediatricians, and the ophthalmologist is the most recognized and indicated authority to generate an accurate diagnosis and prescribe treatment.

2 Technical Reference

2.1 Computer Vision

While computer graphics can be understood as transforming data into an image (image synthesis), Computational Vision, in turn, is the opposite way: transforming images into data (in some cases: information). Computer vision can be used in various fields, either in identifying objects for screening, or in recognizing dermatological disease characteristics, face recognition, etc ... [2]

2.2 OpenCV & DLib

We use two principal frameworks for our computer vision needs: OpenCV and Dlib. The following are brief descriptions of both extracted from their own official websites.
OpenCV is an open source library focused on Computational vision, licensed under the BSD license. The library has over 2,500 algorithms, supports interfaces with C ++, Python, Java and Matlab languages, works on various operating systems such as Windows, Linux, macOS x, Android, among others. The project has over 45,000 contributors, supported by companies like Google, Microsoft, Yahoo, Intel, Sony ...

The library is written in C ++ language with optimized algorithms, which includes a comprehensive set of classic and state-of-the-art machine vision and machine learning algorithms. These algorithms can[3]

Dlib is a modern C++ toolkit containing machine learning algorithms and tools for creating complex software in C++ to solve real world problems. It is used in both industry and academia in a wide range of domains including robotics, embedded devices, mobile phones, and large high performance computing environments. Dlib's open source licensing allows you to use it in any application, free of charge.[4]

2.3 Web Application

We developed a web application coded in Python language (backend) and html5 + Javascript (front end). The application also uses the Flask framework and SQLite. Flask is a 'micro-mean' web application framework that allows developers build and serve a web application quickly. [5] About SQLite, as describe its official website: SQLite is the most used database engine in the world. SQLite is built into all mobile phones and most computers and comes bundled inside countless other applications that people use every day. [6]

3 Methodology

The tool in this proposed study can be understood in three parts: Management, Visualization and Metric Extraction.

3.1 Management

The user of the tool (probably specialist in Strabismus) can register new patients, edit their information and remove their registration. Each patient has their own set of information registered by the user. The information currently provided in the tool is:

Table 1. Patient's data fields.

Field Name	Amount	Data Type
Patient Id Age	Unique	Number
Date of Registration	Unique	Date
Face Images	Multiple	Entity (Face Image)

For each patient face image, the following parameters are available:

Table 2. Patient's face data fields.

Field Name	Amount	Data Type
Image	Unique	Binary (Digital Image)
Date of Registration	Unique	Date
Strabic	Unique	(Yes / No)
Strabismus Type	Unique	Categorical (list of types)
Fixing Eye	Unique	(Left Eye / Right Eye)
Shift Eye	Unique	(Left Eye / Right Eye)
Shift Diopters	Unique	Number
Method employed to calculate the shift	Unique	Categorical (list of methods)
Distance Between Patient and Focus Point	Unique	Number
Clinical Observations	Unique	Test

Therefore, the management-related part of the tool deals with patient information, face photographs, and clinically extracted strabismus metrics.

3.2 Visualization

Regarding visualization of Strabismus information, the tool in this proposed study provides: parametrical visualizations and visualizations of computationally processed images.

Following is an example of a parametrical visualization. The diopter of the ocular shift of a patient is related to his age, thus evidencing the progress of the pathology.

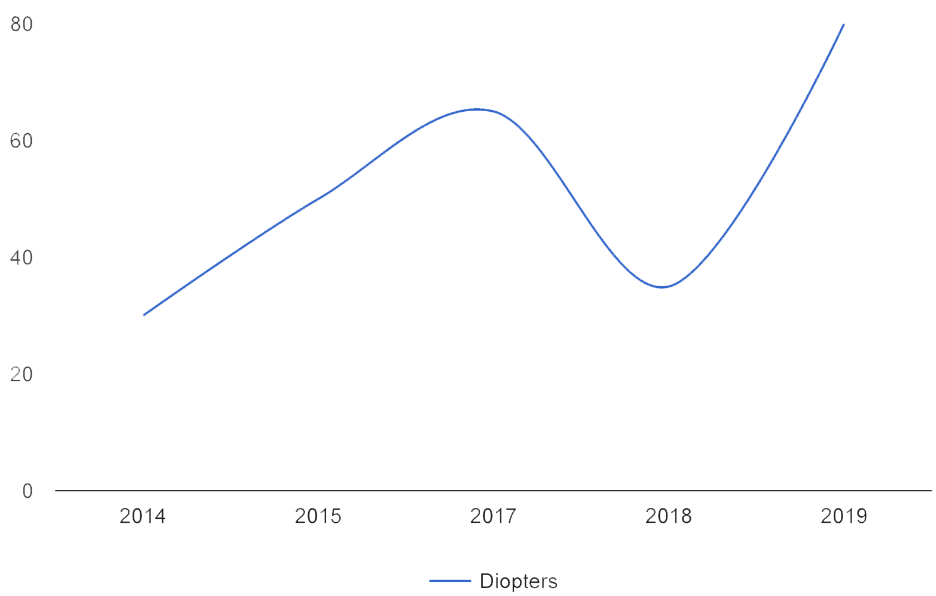

Fig. 1. A visualization through a line-curve chart regarding patient's strabismus evolution in time.

Another example:

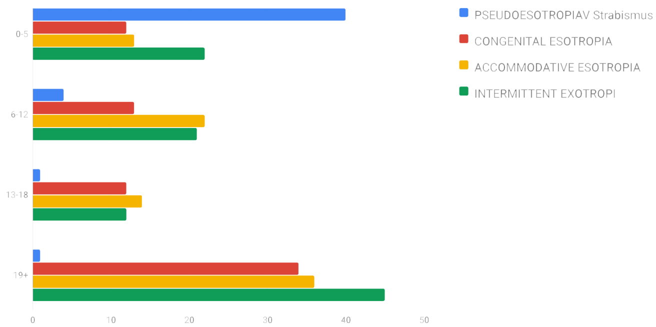

Fig. 2. A visualization of ocurrencies of strabismus types by age

The tool proposed in this study also promotes processing of the faces added in the application. The availa

As soon as the tool user adds a face image to a patient, the tool processes this image and performs some procedures. The first one is facial alignment. Note the following figure:

Fig. 3. Shows how the face aligment works in three steps: Face Detection, Facial Landmarks Recognition and finally: image rotation according by the recognized facial landmarks.

The first step is to detect the face. For this we can use both OpenCV and DLib itself. In this research we use DLib. Then, still using DLib, we recognize facial landmarks, 68 points precisely. Then simply rotate the pixel matrix of the image to achieve two-dimensional alignment.

Once we have an image aligned and recognize facial landmarks, we can provide the tool user with images that highlight the region of interest (the eyes) by 'gaussian' blurring the rest of the image, or even crop just the region of interest (ROI). The following Figure is a sample of these visualizations:

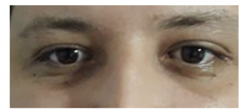

Fig. 4. Two views, on the left a blurred face with only the eye region highlighted. On the right a cropped image of the eyes region only.

3.3 Metrics Extraction

Initially, because we are limited in 'unsupervised' approaches, the measurements of the extracted metrics are in pixels. Using OpenCV, we developed a procedure that for each image, already having the delimited eyes region:

We split the image into two parts, making a vertical section in the center of the eye region to have one eye for each section of the image.

In the left section, we will look for a structure with a high concentration of black pixels, using OpenCv's threshold function. In this function we use the parameter THRESH_BINARY_INV with value for the adjustable threshold. There is a need to adjust the threshold value to avoid shadows or part of the eyebrow.

Given the region captured with the threshold, just look for the contours. The contour with the largest area may be the pupil of the eye. To increase the probability of hit, we can compare this contour found with the results of a Hough transform in the region. However, it should be noted that in certain eye positions where the eye pupil is partially eclipsed, there is a possibility that the Hough transform fails. The center of the larger area contour we can estimate it as the pupil of the eye in this proposed method.

We repeat the same steps for the right eye section.

Finding the pupil region of both eyes, we can calculate the distance and angle between them. Note the markings in the following image.

4 Partial results

We implement all visualization and metric extraction method as presented in the section dedicated to Methodology. We still have to implement the web ap-

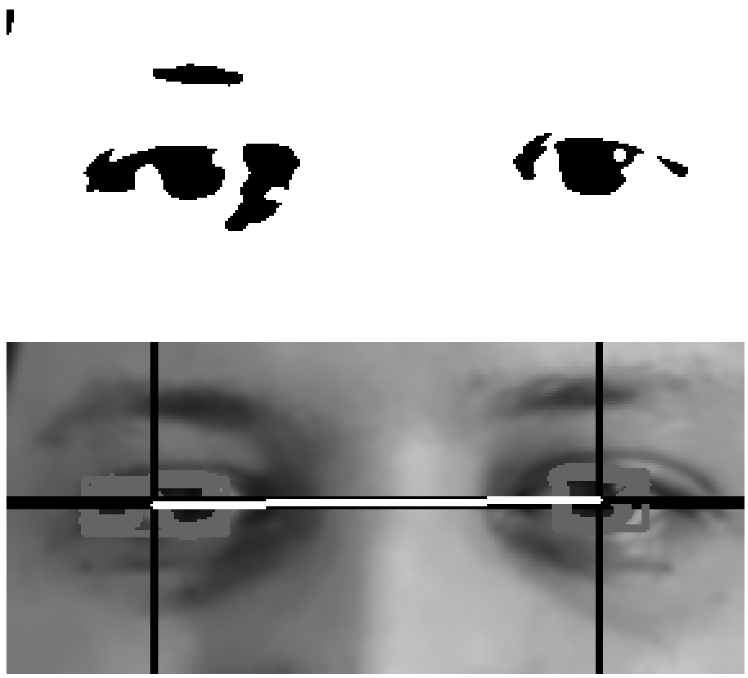

Fig. 5. Two images. The first shows the result of the OpenCV threshold function. The second shows the eye region of interest with the markings for each eye, as well as a line illustrating the distance and angle between them.

plication itself. We have scripts to perform each of the functions described in this article, however they are not provided into an easy to use application. This is the stage we are working on right now.

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6 Conclusion

We believe the finished tool will be a standardized and motivating way for strabismus specialists to collect and organize data from their patients. Organizing and collecting structured data can be an important support for future research, especially those that will depend on supervised data. Therefore, we understand that this study and this proposed tool can pave the way for technological innovations to benefit the health of strabismus patients.

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