RESNA 2017 Student Design Competition

Eye-Tracking in Challenging Populations with Intel RealSense

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Problem Statement

Eye-tracking systems have improved greatly over the past decade for multiple applications. One of the important applications is helping the disabled population, those who do not have movement in their arms or legs, interface with computers.

Currently high-end eye tracking cameras are the only means of helping the disabled population interact with computers. Our goal for this project was to create a low cost solution for people with high spinal cord injuries and have lost movement below their neck. Intel has been working on improving their eye-tracking system, and recently announced a low-cost 3D camera. This new camera has better precision, but the preciseness is not great enough to compete with high-end eye gaze tracking cameras.

In order for people with disabilities to control the computer more intuitively and accurately, our approach combines both eye tracking and head tracking. By utilizing multimodal access methods for the computer we hope that the cursor positioning will be more precise and accurate. We hope to create a proof of concept that shows the potential of combining head and eye tracking systems and provide a possible low cost solution to people with disabilities who cannot afford expensive cameras.

Methods/Solutions considered

To make our system as intuitive as possible we decided to implement a switching mechanism for the tracking methods. The software initially starts in eye tracking mode so the user can easily navigate to the area of interest. Keeping the gaze fixed for a threshold amount of time, the software will switch into head tracking mode for the user to make fine adjustments using their head as a “joy stick”. Once the cursor is at the desired position, the user can then left blink and the software will left click.

The RealSense SDK exposes information on the eye’s angles with respect to the normal vector of the person’s face when looking at the monitor. Using this information, along with the pixel dimensions of the monitor we can map this values from the angle range to the pixel dimension range. This way we can obtain an (X,Y) coordinate to move the mouse based off of the user’s eye angle as seen in Figure 1. To further refine this approach, we will utilize information such as how far the person is from the screen and the number of pixels per inch to better calculate the coordinate of the mouse.

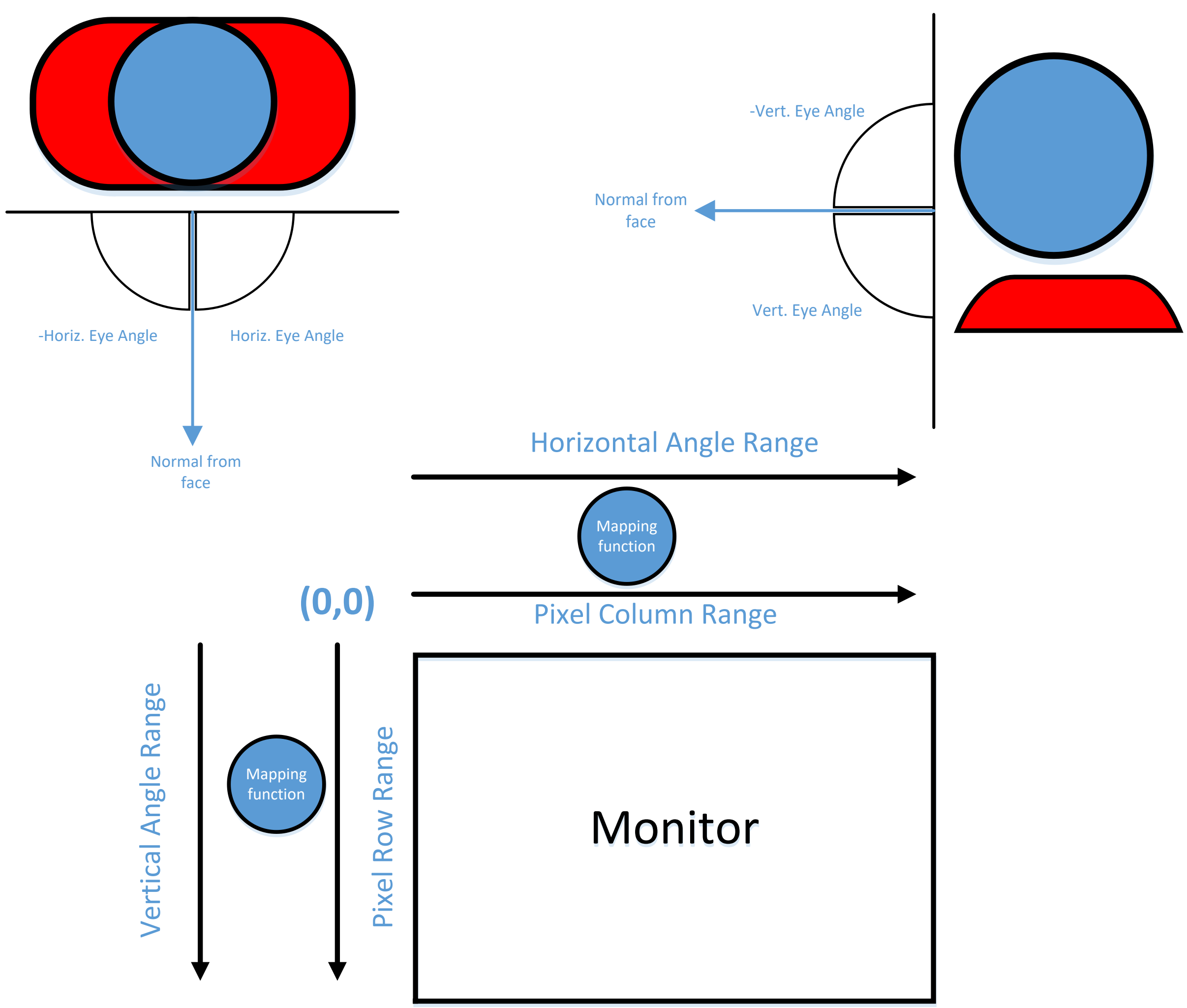

Figure 1

The purpose of the head tracking system is to take over after the program detects that a user has a steady gaze - thus indicating that the user is looking at the desired item on the screen. Then the goal of the head tracking portion is to allow the user to fine tune the cursor position until it's over the desired item on the screen. We will make use of the joy sticking approach for head tracking, so that the user will be encouraged to return their head back to a neutral position before shifting their eyes to a new position on the screen.

As was noted during experimentation, the eye tracking capabilities of the Intel real sense camera are average at best. In order to increase the accuracy a secondary goal of ours was to implement The Random Forest algorithm, which is a machine learning algorithm to further enhance the accuracy of the eye tracking. The algorithm operates by constructing a multitude of decision trees. The training algorithm for random forest uses a technique known as bagging. Assume we have two training sets X containing (x1,x2…...xn) and Y containing (y1, y2…… yn), bagging selects a random sample with replacement for the training sets in a constrained time.

Description of Final Approach and Design

The final design resulted in a combined head and eye cursor movement system. For eye tracking, the camera is able to identify pupil and gaze of the eyes more clearly, thus the cursor movement by using eye tracking has also improved significantly. This details are depicted in Figure 2. Unfortunately due to technical and compatibility issue we were unable to implement the random forest algorithm to improve the accuracy and had to rely on our default eye tracking mechanism.

For head tracking, the camera is able to identify facial markers, and maneuver the cursor across the screen by head tracking as shown in Figure 3. Lastly, after combining head tracking and eye tracking systems, the users will be able to use eye tracking and head tracking systems intuitively by switching back and forth through certain facial gestures, including eye blinking or mouth opening.

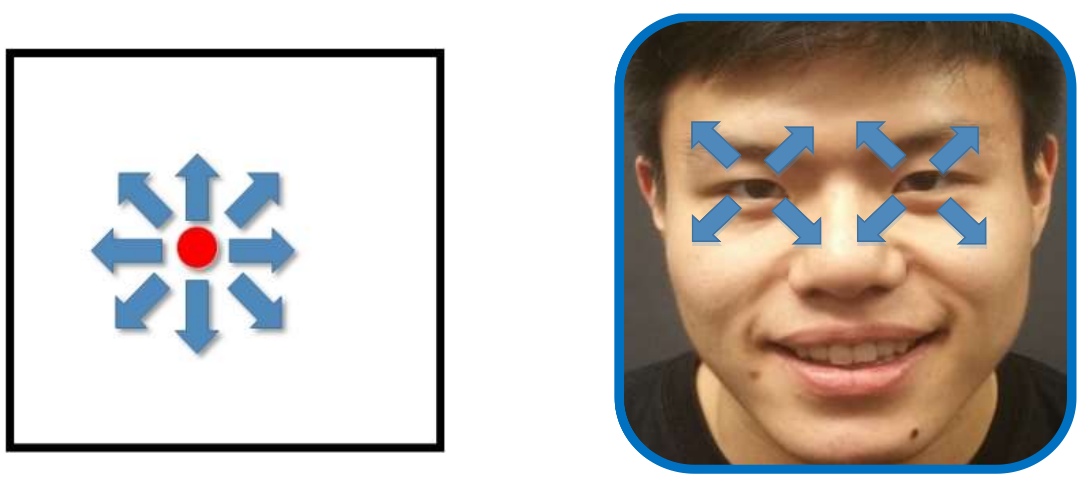

Figure 2

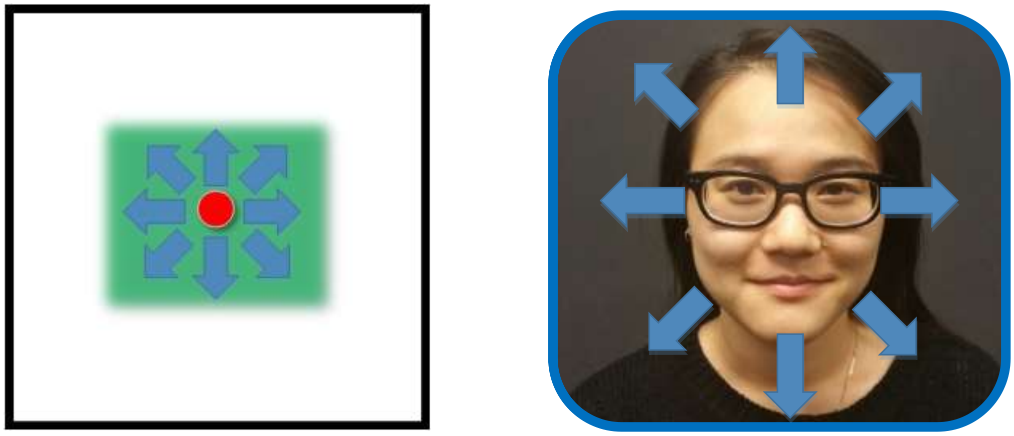

Figure 3

Outcome

As a result of this project we can successfully switch from eye tracking to head tracking when a user's gaze is fixed for a long enough time. A design issue we originally faced was switch back and forth between eye tracking and head tracking. The was issue is present due to when the user moves their head, the eye gaze estimation jumps around significantly and thus cannot be used to determine if the user's eye gaze changes. To solve this issue we implemented a system to switch back to eye tracking using a timeout if there is no head movement, or some user action such as sticking out your tongue if an item is clicked. It is worthy to note that we were not able to attain an ideal eye tracking accuracy. However do not believe that this is a direct result of any in capabilities of the camera we used, rather not enough time to fully exploit the system as needed.

Budget

The cost for a standard Intel Real Sense $167. This can be equipped with any computer which has a support for a USB 3.0 port and a touch screen keyboard. The price for such computers start around $300. For better performance of the solution, higher end machines can be purchased at a higher price.

Significance

Our project goal was to create a low cost solution that improves upon these current technologies by combining each into one program. Disabled people are most likely already financially encumbered by medical bills, so most won't even consider buying an expensive camera just to check their emails. Our solution's cost could save patients hundreds or thousands of dollars and increase the amount of people who have access to a computer. With most of us in the computer industry ourselves, we find it hard to believe that some people do not have access to the internet let alone a computer, so we hope to bring the joy of these beautifully complex systems to the disabled.

References

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