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# Biomechanical Systems Lab Worksheet

Here you will find the instructions to create your own 3D Eye Geometry Model using different materials provided in your kit! Follow all the instructions for this worksheet and fill in the blanks as you go.

**INTRODUCTION:**

There are many medical conditions that can lead to a **loss of motor control or speech**. As a result, many lose the ability to effectively communicate, control their own body, and carry out basic tasks by themselves. This video is an example of a person with an Eye Gaze system mounted on his wheelchair.

**Discuss!**

Where is the screen positioned? What do you notice about the eye tracking camera and technology?

How does eyegaze technology help people who have a loss of motor control and/or speech?

Based on the video, the eye tracking camera is located below the screen. This camera position at the bottom of the screen provides the best view of not just her eyes but the eyeballs themselves, least obstructed by her eyelids. **It's the eyeballs that provide the information needed to tell where she is looking.**

**STEP ONE: LEARN**

Developing a Solution: Eyegaze

**Eyegaze** uses eye tracking technology to allow users to control a device with their eyes.

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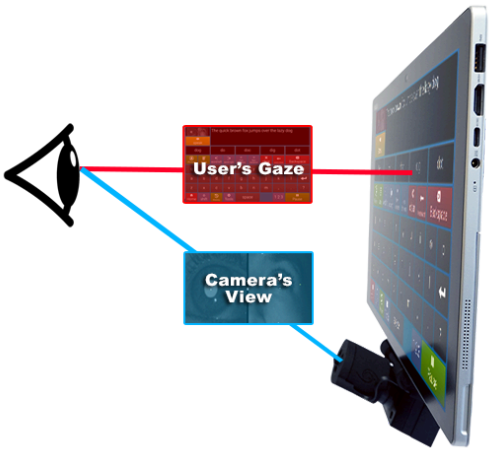
The eye gaze system consists of a **mounted computer, camera and an on-screen keyboard.** Users are supposed to look at the desired key for a specified dwell time until the software sounds an audio click and the character is added. This technology allows users to communicate with others which allows them to regain a sense of independence.

Watch this video and answer the questions below.

**Answer me!**
What are three tasks that Eyegaze allows users to carry out? How does this technology account for users with varying needs and abilities?

Basic terminology of the eye gaze system




**Gaze line:** the imaginary line that emerges from the center of the eye's pupil and points in the direction that the eye is looking

**Gazepoint:** the 3D position in space where the gaze line intersects the screen (where the person is looking on the screen)

**Video camera:** located below the screen and observes the user's eyes as they looks around the screen

**STEP TWO: THINK ABOUT THE PROBLEM**

Imagine you are an engineer and you have to design a system that would grant people the ability to communicate, operate their own wheelchair, and complete tasks using their eyes.

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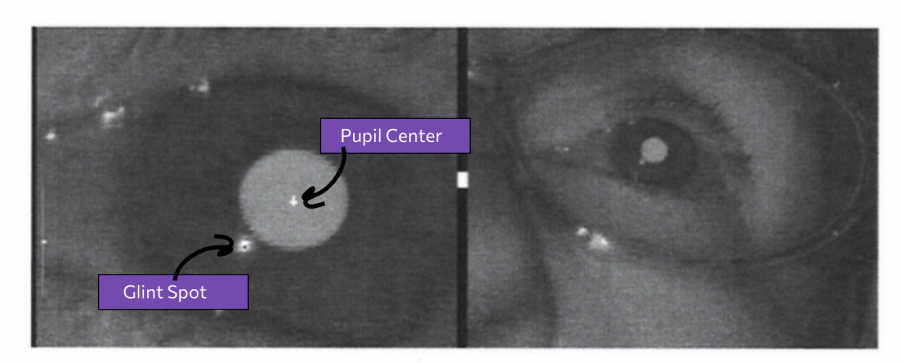
*Activity!*

**Draw a vector** from the glint spot to the pupil center on the left image. This is the **glint pupil vector.** (Hint: make sure the arrow points to the pupil center to indicate direction).




Answer Me!

- What is the direction of the user's gaze? Which combination: Left, Right, Up, Down? (Hint: It is the same as the direction of the vector you drew).

Determining where the eye is looking:

1. Identify the pupil center and the corneal reflection
2. Draw a vector from the center of the corneal reflection to the center of the pupil, known as the glint pupil vector
3. The glint pupil vector tells you where the user is looking with respect to the camera
4. This vector, complex image analysis, and geometry can be used to find the exact gaze point
5. The magnitude of the vector indicates how far away from the camera you are looking

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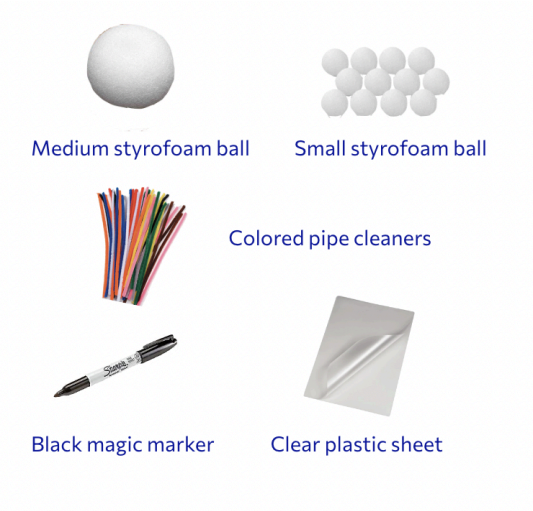
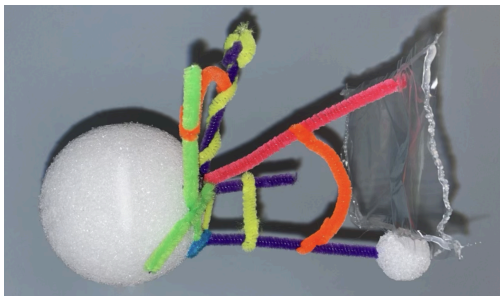
## STEP THREE: DESIGNING YOUR EYE GEOMETRY PROTOTYPE

**What you will need:**




In your kit, you should see the following materials. Use the styrofoam ball to simulate the eye/corneal sphere of the 3D Model of the Eye Geometry. If you are missing any materials, let your teacher know now.

1. Study the Eye Geometry using the 3D Geogebra Model. You are able to move the pupil, glint spot and camera around as you like.
2. Begin building your own Eye Geometry Model: *Make sure to determine the colors of your vectors, horizontal/vertical reference lines, angles, and glint spots. (Click **here** to watch a video of how the 3D Foam Model of the Eye Geometry is built).*



*Insert images of your Eye Geometry Model here:*

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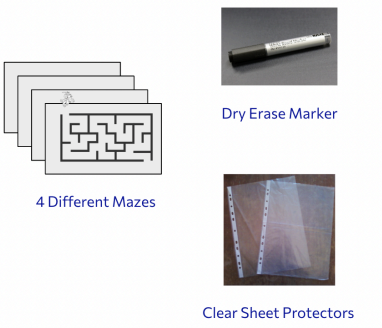
**STEP FOUR: ACTIVITY #2**
**APPLICATION OF THE EYE-GAZE SYSTEM:** The second part of this worksheet will allow you to interpret eye movements to maneuver the wheelchair along a path.

*Translating Eye Gaze into Wheelchair Movements*
**What you will be doing:**

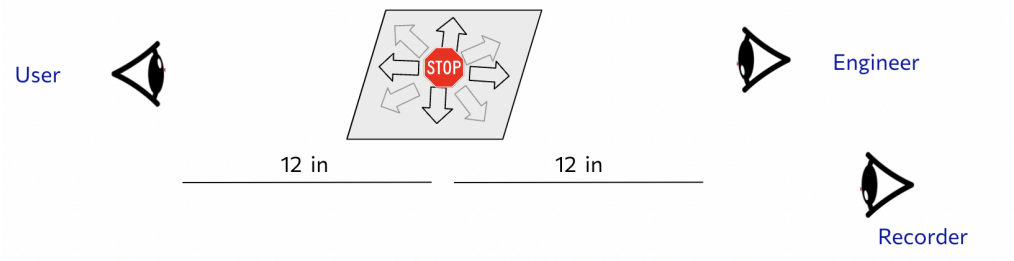
1. Create a controller-template to move a wheelchair a certain distance in any given direction
2. Determine how many different directions will be on the template as well as the optimal spacing to ensure accuracy of identifying the user's intent
3. Consider how to determine the number of units to travel (i.e. This could be based on numbers placed on the template or possibly the duration of a user's eye gaze)




In your kit, you should see the following materials. You can find the mazes linked here. If you are missing any materials, let your teacher know now.

**STEP FIVE: TEST!** Create groups of 3-4 people and define roles: user, engineer, observer(s)

1. **User**: looks at the floor plan (maze) and makes eye movements towards template
2. **Engineer**: interprets the user's eye gaze through the template (follows the eye movements of the user by drawing their path on a blank piece of graph paper)
3. **Observer/Recorder**: sees both the user & maze along with the engineer - records how many correct vs. incorrect movements.



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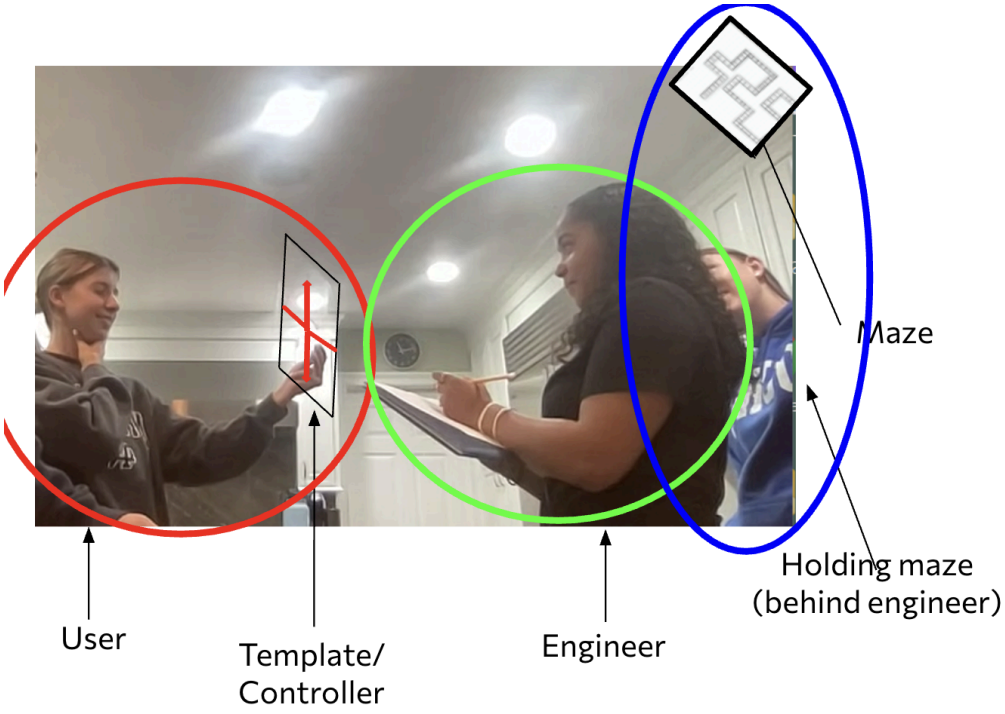


*Insert images of your templates here!*

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| User Distance to the Template | Engineer Distance to the Template | Total Moves | Total Correct Moves | Time through maze | Accuracy (%)<br>(# correct moves)<br>x 100<br># of total steps | Notes<br>- Type of Maze (easy, medium, hard)<br>- Template description, number of buttons<br>- How to know how many steps to move |
|---|---|---|---|---|---|---|
| 12” | 12” | 10 | 9 | 45sec | 9/10 x 100 = 90% | - Easy Maze<br>- Eye Template had up/down/left/right/up-left/up-right/down-left/down-right/stop<br>- Used dwell time to say go to more than 1 step in a given direction |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## SIX : INTERPRETING YOUR RESULT!

*Answer me!*

How did you determine the distance to travel in a given direction?

Did you change anything in your templates (i.e. number of commands, types of commands, size of font, space of commands, etc...)? If so, what worked best?

What would you change to improve your template?

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## STEP SEVEN: REFLECTION

*Discuss!*

- What are some possible limitations of eye tracking technology? How could they be addressed?

- What is something interesting that you learned about the eye-gaze and the eye-tracking technology?

- What did you learn about designing technology for a specific user? What was difficult about it?

## STEP EIGHT: STUDENT EXIT SURVEY

Once you've finished the lab, please complete the student exit survey to share your feedback.

## STEP NINE: CONTINUE TO EXPLORE

If you enjoyed today's lab, you may be interested in the following topics:

- Image Processing
- Algorithms
- Software Development
- Geometric Optics
- Eye Tracking
- Robotics & Embedded Systems
- GazeRecorder- a website that shows you your eye gaze as you look at an article.