Identifying Dementia From Normal Aging for Early Treatment

PDE Major Project - Junyao Wang

HOW CAN YOU IDENTIFY NORMAL AGING FROM DEMENTIA

Normal Aging	Alzheimer's Disease
Making a bad decision once in a while	Making poor judgments and decisions a lot of the time
Missing a monthly payment	Problems taking care of monthly bills
Forgetting which day it is and remembering it later	Losing track of the date or time of year
Sometimes forgetting which word to use	Trouble having a conversation
Losing things from time to time	Misplacing things often and being unable to find them

Other Symptoms

Insomnia
Going out more often without purpose
Irritability develops
...

→ Ordinary people cannot identify the difference between the two **since it is so subtle**.

What is the problem?

01.

Delayed diagnosis and treatment

Consequence-

Treatment becomes **difficult and ineffective**

Living for 3-4 years
with severe symptoms

A **great challenge** to the family's patience

Why is this worth doing?

02.

What if diagnosis in early stage?

Benefits-

Reducing the difficulty of treatment

Living as normal for 7-10 years with medicine
Even Reversing dementia

Less impact on family relationships

What the product might deliver?

03.

A product for self-assessing cognitive health

02 User & Interview

Age: Over 60 years old   **Gender: Male & Female**   **Work: Not limited**

Hobbies and interests:

- Performances of music or dance
- Flower arranging, reading
- Vacationing, partying

Views of dementia:

- Be ashamed of this
- Strongly believe that they are just aging normally
- Hiding their symptoms from the family

Interviews

Neurologist & Nurse

Memory Loss: **Medication errors**
Forgetting places and names
Inability to recall strangers' names
Dyslexia
Disorganisation
Losing the way home

Not being able to locate your bedroom at home
Odd mental behaviour
Forgetting things and failing to recall them even when reminded

Reaction time is slow

Monitoring of mental status after diagnosis can help doctors administer medication

Families

Taking medicine: **Unable to recall dosage**
Relies on box packaging, pill shape, and colour to **distinguish medication**

Money: **Being held in a certain location.**

Electronics: **Forgetting to turn off gas**

Cooking: **Inconsistency in cooking skills** (too salty or spicy)
Inability to identify between seasonings
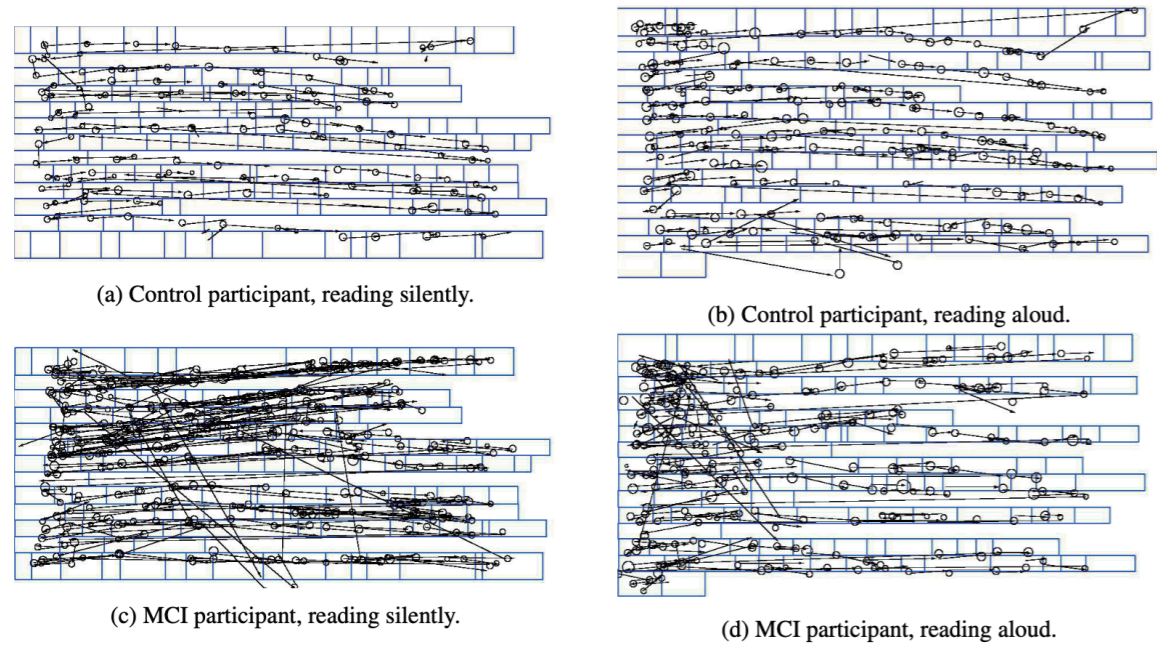
Opportinities

Medication Errors   **Financial Problems**   **Dyslexia**

✗   ✗   ✓

03 FURTHER RESEARCH

(a) Control participant, reading silently.

(b) Control participant, reading aloud.

(c) MCI participant, reading silently.

(d) MCI participant, reading aloud.

Experiment: An analysis of eye-movements during reading

Aim: For the detection of mild cognitive impairment

Participants: 27 MCI patients / Age: 68

30 Healthy people / Age: 70

Results: MCI: Tends to **skip over** words and then **return to them later**

💡 **IDEA**

Eye tracking technology

Detect

Whether too much sweeps

Identify

Risk of cognitive impairment

Reading Postures & Habits

		Habit	Opportunity		Habit	Opportunity		Habits
		Too far from the book	Magnifying fonts Distance caution			Marking and storing		Drinking coffee
		Too close to the book			Occasional marking with pen			Spending time with a cat
		Face the book parallel or at 45 degrees	Distance caution			Searching information		Talking to others

04 Initial Concept - Smart Bookmark

Plan A - One piece in total, can be wrapped on the book
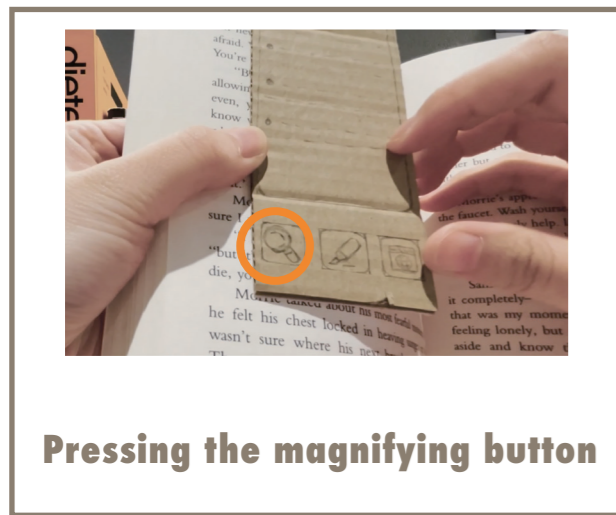

Turning on the touch switch
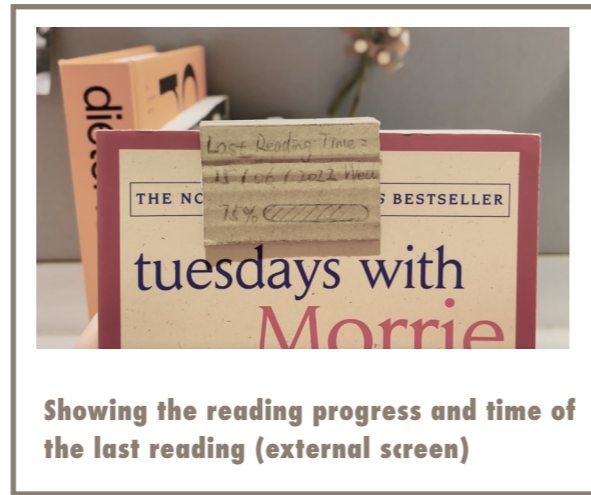
Showing the reading progress and time of the last reading (external screen)
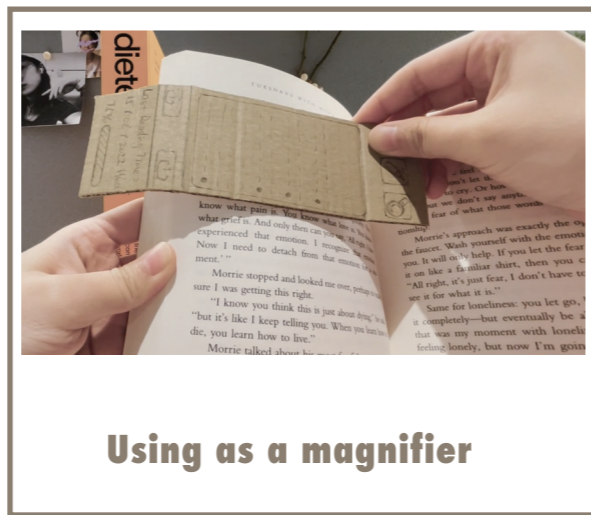

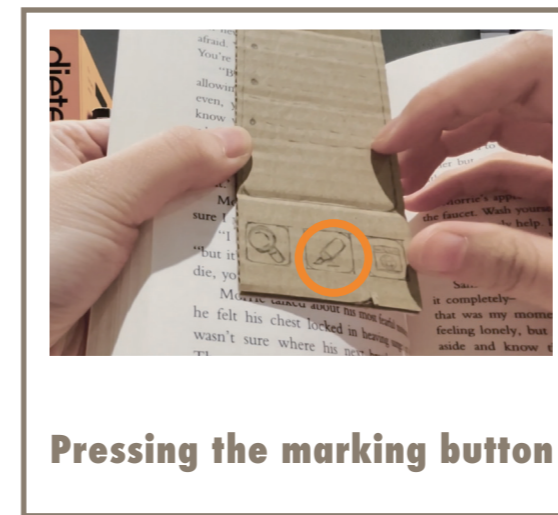**Showing interesting expressions stored from the last reading (internal screen)**
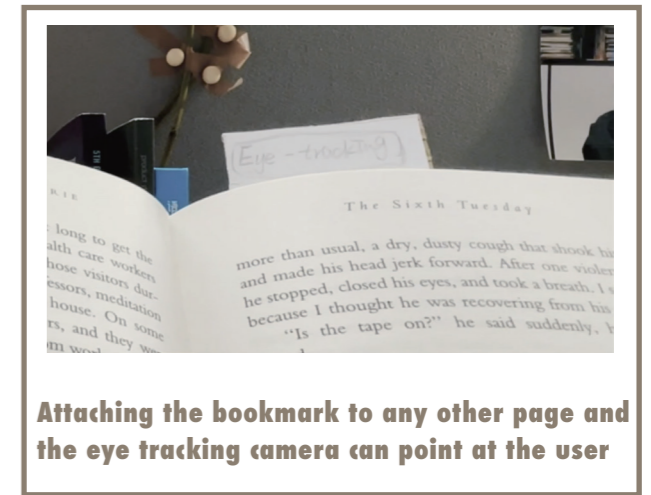
Attaching the bookmark to any other page and the eye tracking camera can point at the user

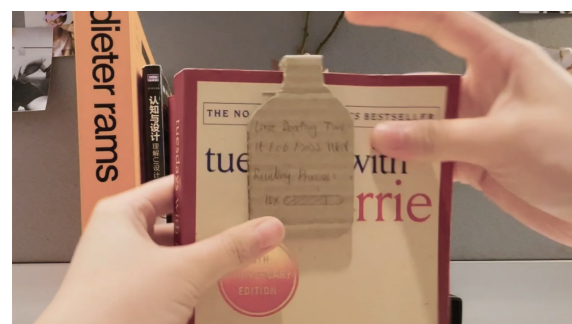**Pressing the magnifying button**

Using as a magnifier

Pressing the marking button

Scaning contents and storing in the bookmark

Other Version - Same Functions, Different Shape

Benefits compared to the previous one:

- This shape is easier to hold
- Can be folded and easy to carry
- Similar to the real magnifier
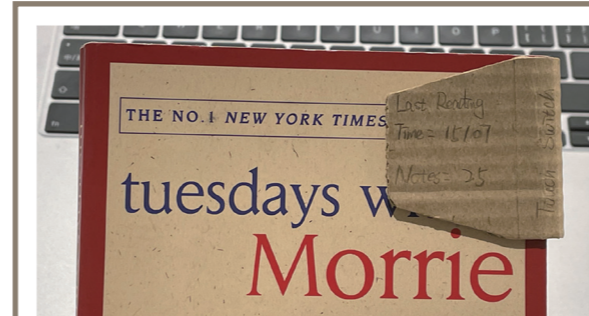
05 Further Concepts & Feedback

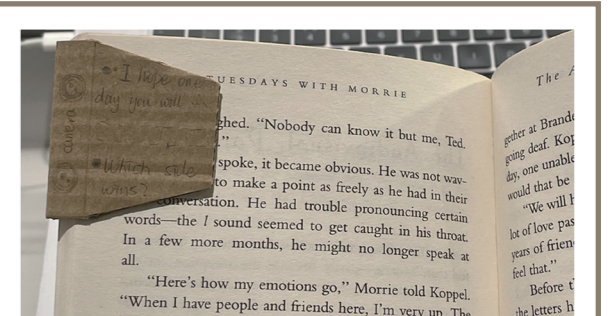## Plan B - Two pieces in total, joined together by magnets
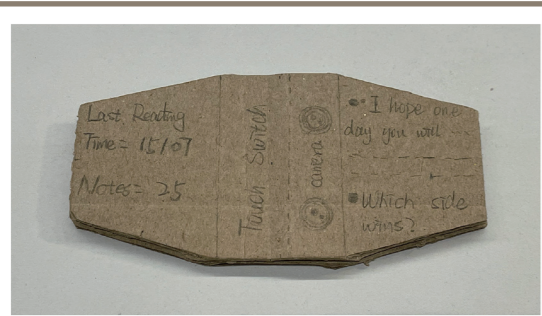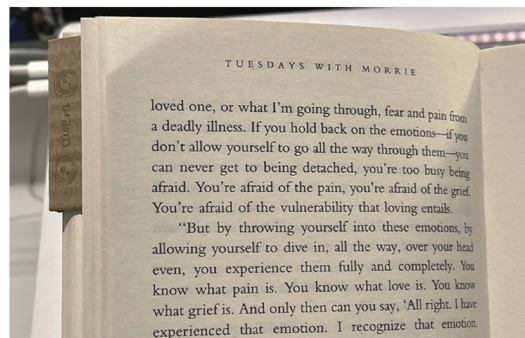

A bookmark on one side

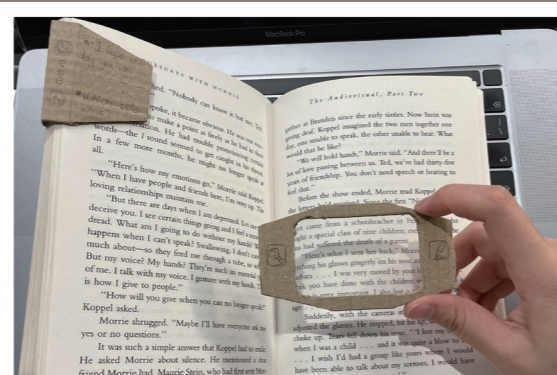**Zoom and marker function on the other**

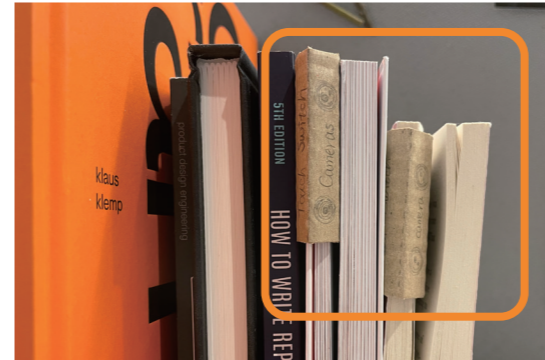**Showing the reading progress and time of the last reading (external screen)**

Showing interesting expressions stored from the last reading (internal screen)

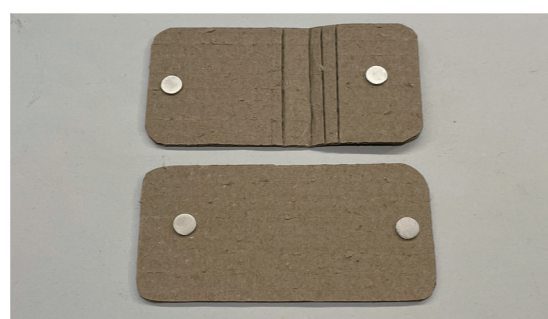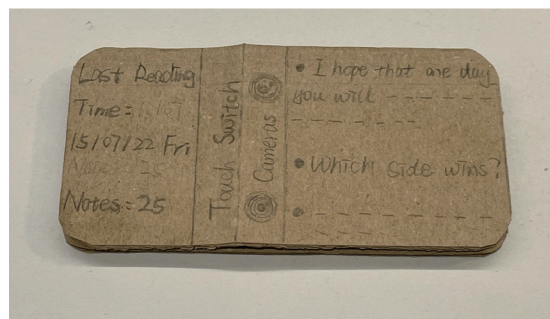**Attaching the bookmark to the side, and built-in cameras are naturally exposed**

Using another piece to enlarge the font, scan and store the content

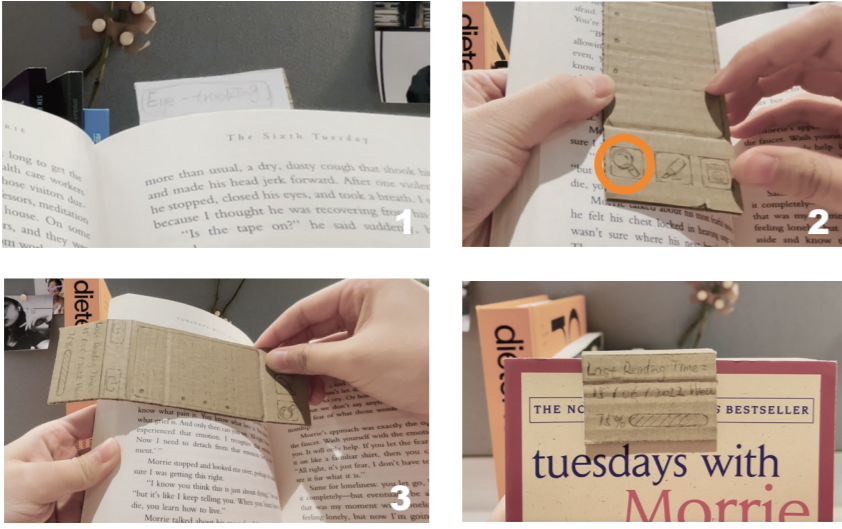
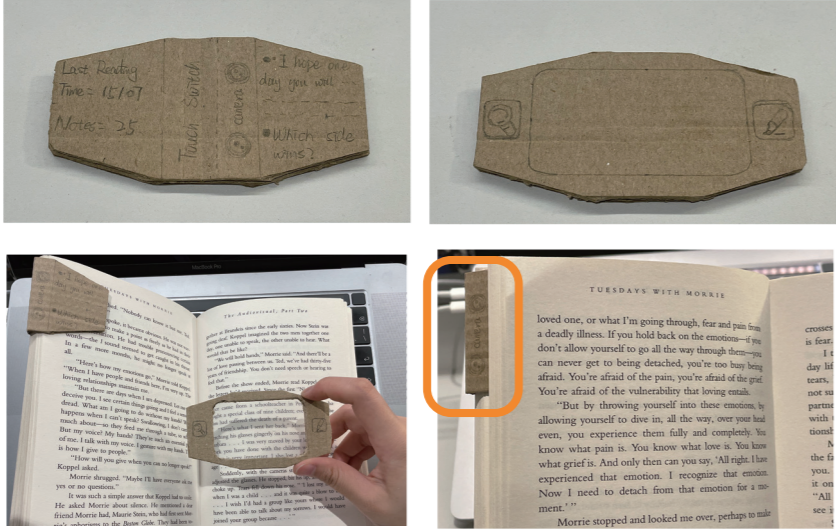**Users can also buy multiple bookmarks to go with different books**

Other Version - Same Functions, Different Shape

Benefits compared to the previous one:

- **Bigger screens to show more information**

- **Easier to hold**

06 Summarize of Feedback & Technology

		Benefits	Problems
Plan A		• The screen is **large enough** • There is **no need to move the product back and forth** when using the zoom function	• 1 — 2 — 3 — 1 After using these functions, the user need put the bookmark back to the book — **Complicated** operation / **Not logical** for reading progress • The eye tracking **camera is easily obscured** • **Easy to lost** when people reading or after using the magnifying and marking functions
Plan B		• Bookmarks are fully attached to the book and are **not easily lost** • The **camera** is not covered and **is naturally exposed** • When employing the zoom and marker functions, the **process is simple** • **Reading progress can be calculated** by distance due to the two-piece construction	• The **camera may struggle** with eye tracking from the side • The **camera's accuracy is influenced** by page turning • Screens are too small, and the **display is unclear**

Conclusion

Choose Plan B as the Final Plan

Change the bookmark part to be attached to the top of the book ——— **Minimise the impact of page turns on the camera**

Add distance measuring function

Detect the distance between the user and the book to indicate ——— **Detects the distance between two pieces and calculates reading progress**

Caution:

Too close to the book

Distance < 20cm

Distance Detection

If the user's distance from the book is less than 20 cm and more than 10 mins.

The notification will appear on the internal screen.

Magnifying Fonts

Triple the font size

Marking and Storing

Scan for and record words.

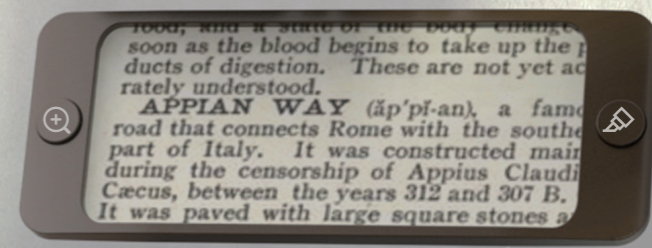When searching, the matching page number can be displayed.

External Screen

Shows reading progress and time

Camera

Detects head position orientation. Determines whether there are too many sweeps when reading. To assess the risk of cognitive impairment.

Ink Screen

Displays the enlarged font and the information stored by the user in the background.

Last Reading Time:

20/07/2022 Wed

1 hour

Caution:

Too close to the book

Distance < 20cm

08 Storyboard

I received a present that both aids in reading and tracks cognitive wellness.

After the separate the two components. One part is used as a clip-on bookmark, while the other can be used to scan the contents of a book.
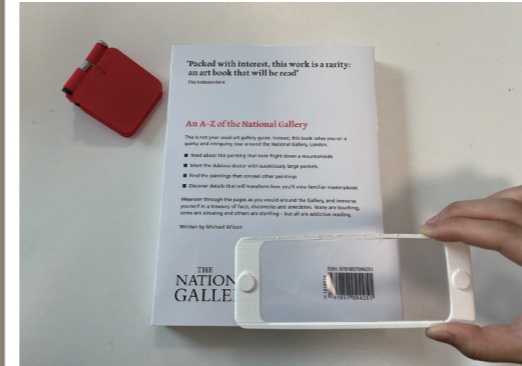
The QR code is scanned by the back camera using the white portion to gather information about the book.

Attach the bookmark to the top edge of the book. The camera at the top is naturally exposed after turning the page and detects the user's head posture and distance from the book.


If the distance is too close, a warning will appear on the internal screen.

When the book's content is hard to read, the user can use the zoom button on the left. The image will be captured by the product's rear camera and magnified three times.

The user can capture items from the book by pressing the record button on the right. The text is recognized, recorded, and saved. When the user scrolls through the history, they can identify the page number that matches to the content.
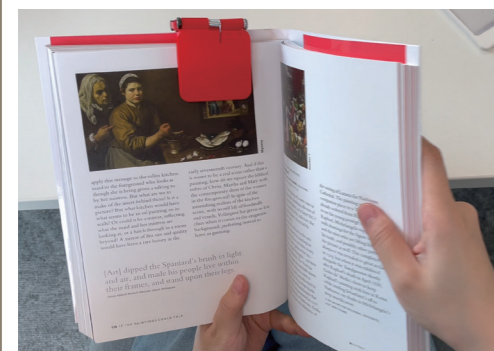

When the user is finished reading, the red bookmark section can be re-attached to the book's edge. The reading position is marked.

When the user uses the device again, he needs to touch the top screen to activate the switch, and the external ink screen will display the last reading time and reading progress.

09 Structure Development(Different Structures and Size)

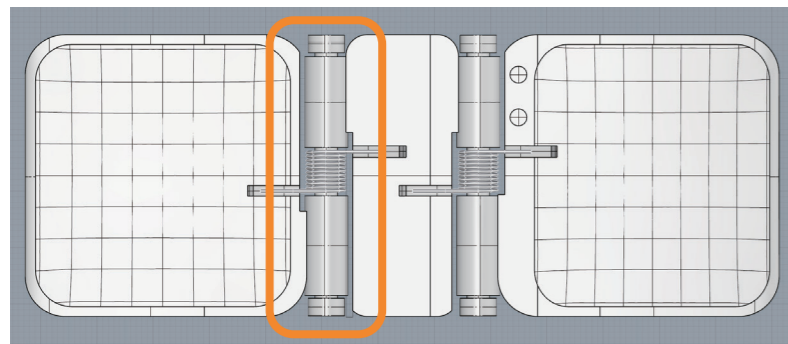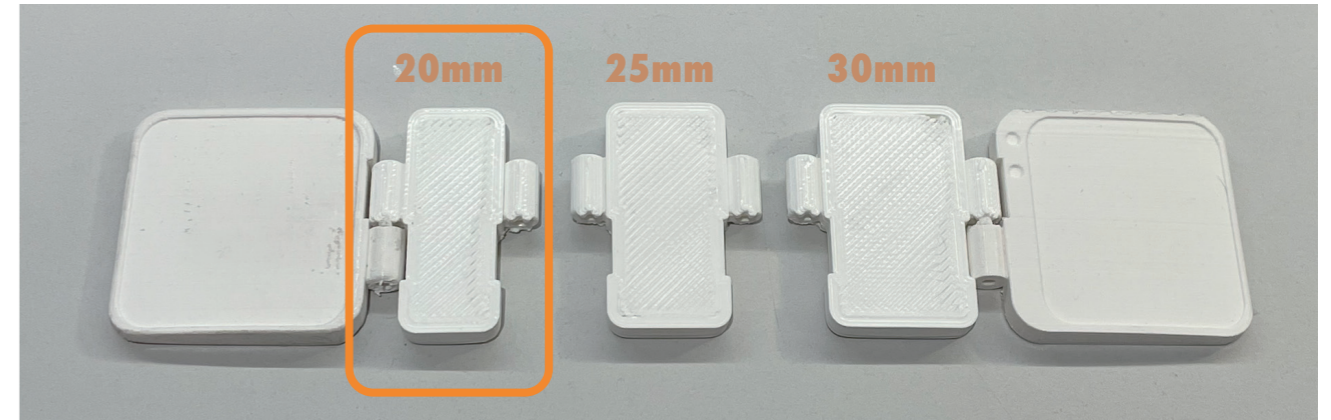## Different Structure and Results
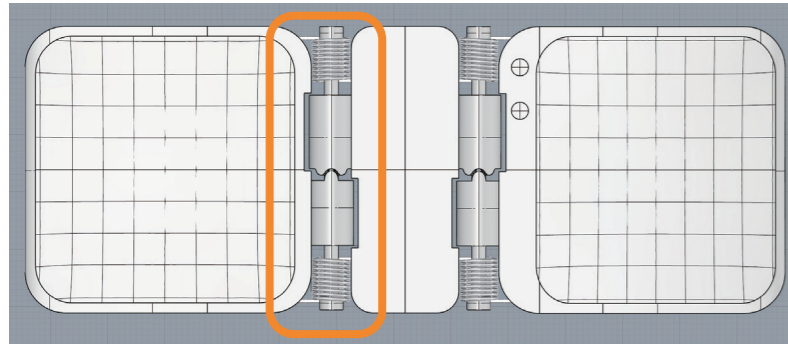
Structure 1

2 torsion springs - need more force

To stretch the torsion spring to 180 degrees, a lot of force must be applied to the shaft and its clips at either end.

**Shafts are more prone to distortion and reduced durability.**

20mm   25mm   30mm

Structure 2

1 torsion spring in the middle - more stable

Placing the torsion spring in the middle, adding gaps, and employing the shafts on either side. This stops the torsion spring from swinging and affecting the stability of the entire structure.
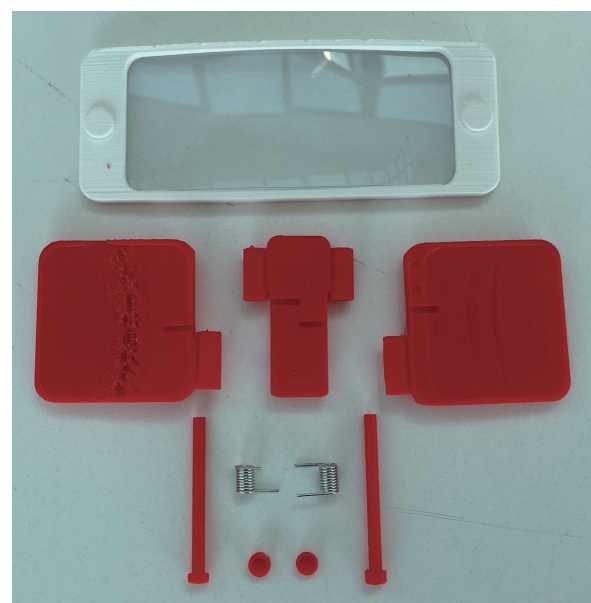
The force on the shaft is decreased together with the amount of torsion springs. Increasing the shaft's diameter to 4mm.
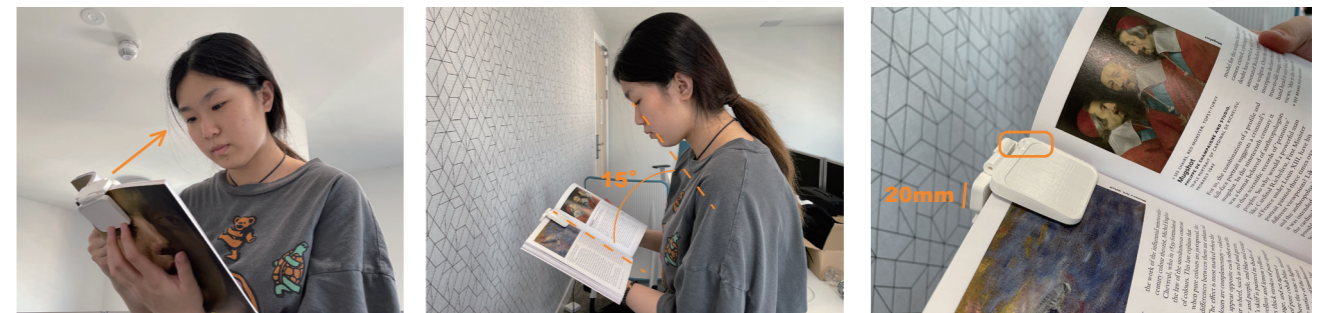
Relative position of camera and head

- The distance sensor's detection range includes the head's range of motion.
- The head-to-camera angle is within the camera's functional range at about 15 degrees. During reading, the face is visible.

Final model
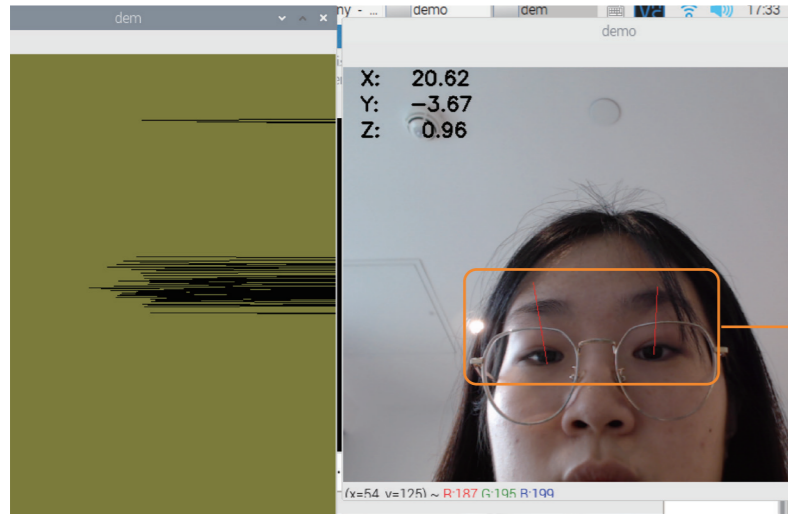

Two pieces can be joined together by magnets

The bookmark can be a clip when the two components are separated

The other component can be used to scan the book's contents
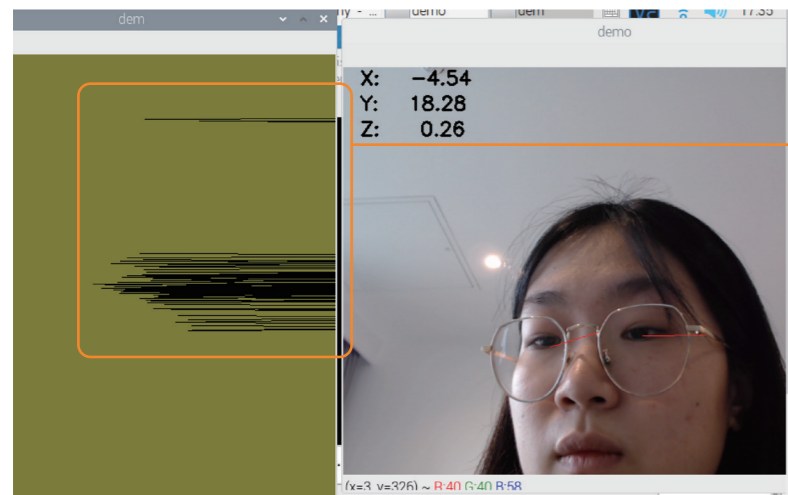
10 Technical Development

Head Position Estimation

Head Position =
Direction of Eye Contact

The head's facing is shown by the direction of the red line in the image.

The precise head position, according to theory, should indicate where the eyes are focused.

Movement Track Canvas

The head movement of the user while reading is indicated by the trajectory on the left canvas.

As demonstrated by experiments, increased sweeping can be detected using the head posture.

By employing this technology, it is made sure that the camera's precision is not adversely affected when the book's pages are flipped.

Distance Detecting and Caution
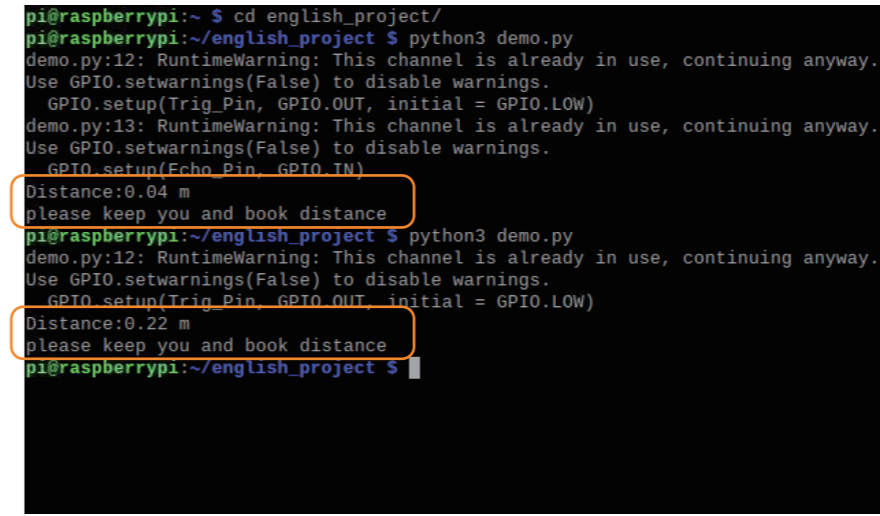
Distance Detecting -
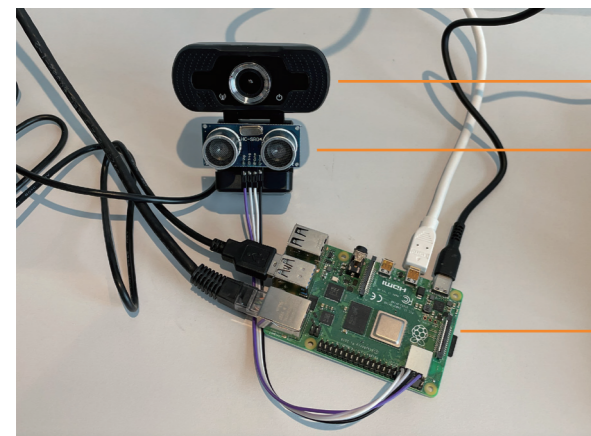### Before Opening the Camera

If the distance is too close, a message is displayed on the screen
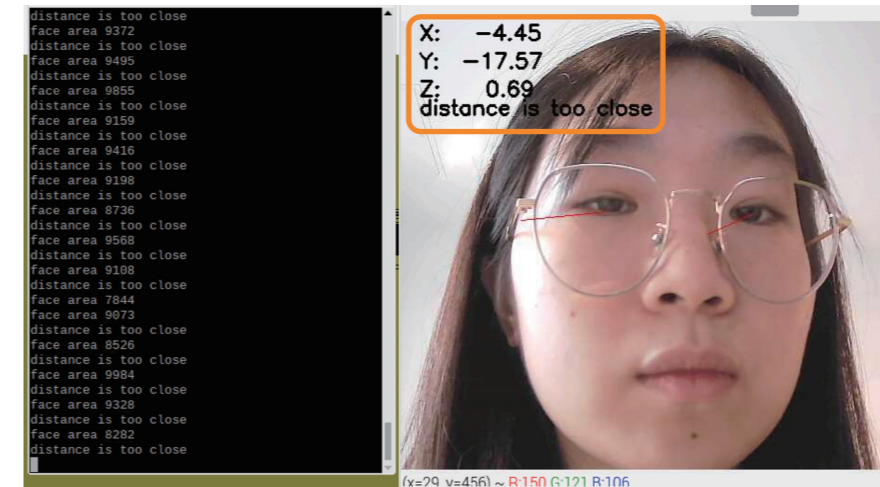
Distance Detecting -
After Opening the Camera

Determine if the user is too close by calculating the area occupied by the face in the video
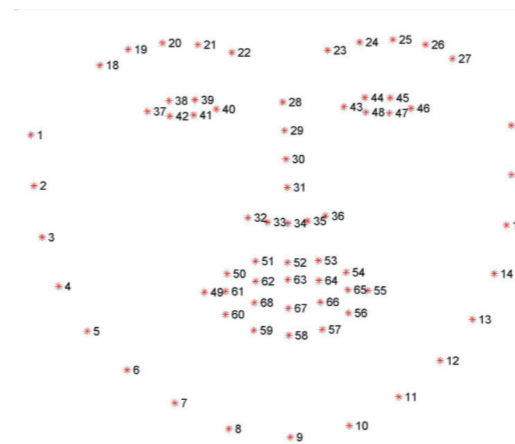
Raspberry Pi Model
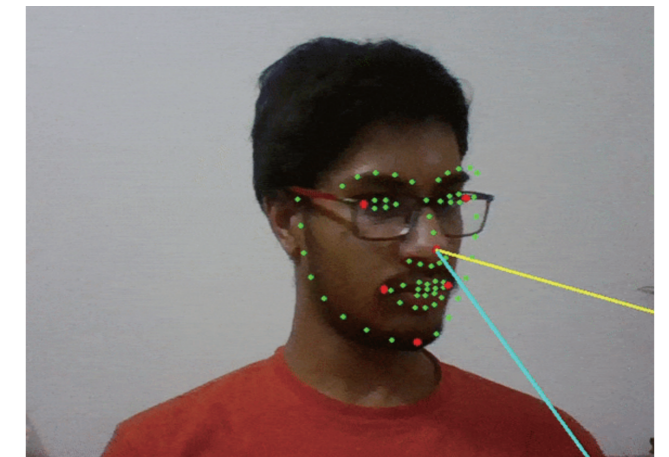

High Definition Camera

Ultrasonic Distance Sensor

Raspberry Pi 4 Board

Dlib Face Recognize(2D)

OpenCV Face Recognize(3D)

11 Conclusion & Further Work

Conclusion

The design concepts and the execution of my finished project have me beyond pleased. Finding the reading habits that most individuals will have, starting with the initial perspective of the daily life of elderly people. It lowers the likelihood that a user will reject a product by incorporating a cognitive health monitoring feature with a reading device. In the same way that blood pressure and blood sugar levels can be checked, it enables users to keep an eye on their cognitive health. This aids in reducing user anxiety about dementia and improving their understanding of mental disease. The proportions for the finished physical model still have some thickness.

To ensure structural stability, the cylinders on either side of the torsion spring have a wide diameter. Overall, the product appears to be a little thicker. In later developments, I'd like to experiment with smaller connections and torsion springs. The product should be as thin as it can be.

Further Work

The experiments' usage of a head pose estimate technique has a relatively low accuracy level in order to maintain the integrity of the design process. Dlib was able to identify the left and right eye feature points on the face, but not all of the face's feature points. The accuracy of the head position estimate technique needs to be increased in the following step, in addition to the product's thickness being decreased as specified in the conclusion. In order to guarantee the detection of a more precise number and range of sweeps.