Image Processing Capsule Counter

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Definition of the Problem

The main problem for us is counting pills in the tablet. We have thought about the old people they might forget about the pills that they should get they might get the pills lower than needed or more than needed so we have tried to solve the problem by periodically counting pills on the tablet.

Algorithms

In the project image preprocessing(convertion to HSV and thresholding), morphological operations(for removing noise and closing small holes), contour detection(for detecting contours of objects in binary image), and object counting(by calculating number of contours) used for solving the problem.

Overview of the Capsule Counter application.

- Capsule Counter designed to detect and count capsules in images and interact with users via a chatbot.
- Can reply with voice.
- Key components: OpenCV, Tkinter, Google Generative AI.

Libraries

- OpenCV: Preprocesses images, applies filters, detects edges, and identifies contours for capsule detection.
- NumPy: Handles image arrays and supports image processing tasks.
- Tkinter: Graphical user interface.
- Pillow : Converts image for Tkinter.
- pyttsx3: For audible feedback.
- dotenv: Loads API keys and other configuration settings from a .env file.
- Google Generative AI : Generates responses to user queries using the Gemini AI model.

Image Preprocessing

Functions of Image Preprocessing:

- cv2.cvtColor(img, cv2.COLOR_BGR2HSV): This function converts the image from the BGR color space to HSV, facilitating easier segmentation.
- cv2.threshold(saturation, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OTSU): Otsu thresholding method is employed to automatically determine the threshold value from the image histogram. This method calculates the optimal threshold value to separate the foreground from the background.

Morphological Operations

Morphological operations are used to remove noise and small objects from the binary image and to close small holes within the detected objects. This results in a cleaner image where the capsules are better defined, making subsequent contour detection more reliable.

Morphological Operations

Example:

kernel_size = 5

kernel = np.ones((kernel_size, kernel_size), np.uint8)

A kernel (structuring element) of size 5x5 is defined. This kernel will be used for the morphological operations.

morphed = cv2.morphologyEx(mask, cv2.MORPH_OPEN, kernel, iterations=2)

The cv2.morphologyEx function is used with the cv2.MORPH_OPEN operation.

The opening operation is performed to remove small noise from the binary image. It consists of an erosion step followed by a dilation step.

The iterations=2 parameter means this operation is applied twice, further enhancing noise removal.

Contour Detection

The main using of the contour detection is for detecting the pill and draw a rectangle around it.

- Function: find_and_filter_contours
  - Finds contours in the mask.
  - Filters based on area threshold.
- Function: draw_contours
  - Draws bounding rectangles around detected contours.

Contour Detection

Let’s dug deeper to some of our actual code:

- contours, _ = cv2.findContours(mask, cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE): Finds contours in the binary image (mask). cv2.RETR_EXTERNAL retrieves only the external contours, and cv2.CHAIN_APPROX_SIMPLE compresses horizontal, vertical, and diagonal segments, leaving only their endpoints.

Object Counting

- Utilizes the number of contours detected to determine the count of objects in the image.
- Applies a threshold to filter out small objects or noise that may have been detected.
- Displays the count of detected objects prominently to the user, providing valuable feedback on the analysis results.
- Accurate object counting is essential for the reliability and effectiveness of the Capsule Counter application, ensuring precise detection and quantification of capsules in the provided image.

Object Counting

Let’s dug deeper by looking at one of our functions:
area_threshold = 0.01 * img.shape[0] * img.shape[1]: Sets a threshold value based on a percentage (1%) of the total image area to filter out small contours.Contours with an area below this threshold are considered noise and discarded.

User Interface Setup

We used an interface in the project. Tkinter library has been used for GUI. As components labels, buttons, scrollbar etc. has been used. And select image button is for trigggering processing.

Image Processing and Display

We are using all algorithms before in this function.

- Function: process_and_display
  - Preprocesses image.
  - Applies morphological operations.
  - Filters and draws contours.
  - Displays processed image in Tkinter panel.
  - Uses pyttsx3 to speak detection result.

Chatbot Integration

We used gemini for support. In case there is anything needed other than just counting pills. We used 2 functions to call it:

- Function: ask_gemini
  - Sends query to Google Generative AI.
  - Receives and returns response.
- Function: submit_query
  - Gets user input.
  - Updates response text widget.

All Functions

Let’s run it all:

Content:

- root.mainloop(): Runs Tkinter main loop.
- Interactive GUI for selecting images and chatting.
- Real-time capsule detection and AI responses.

Conclusion

We have a capsule counter combines image processing and AI. There is a user-friendly GUI for seamless interaction. There are a demonstration for integration of various Python libraries.

References

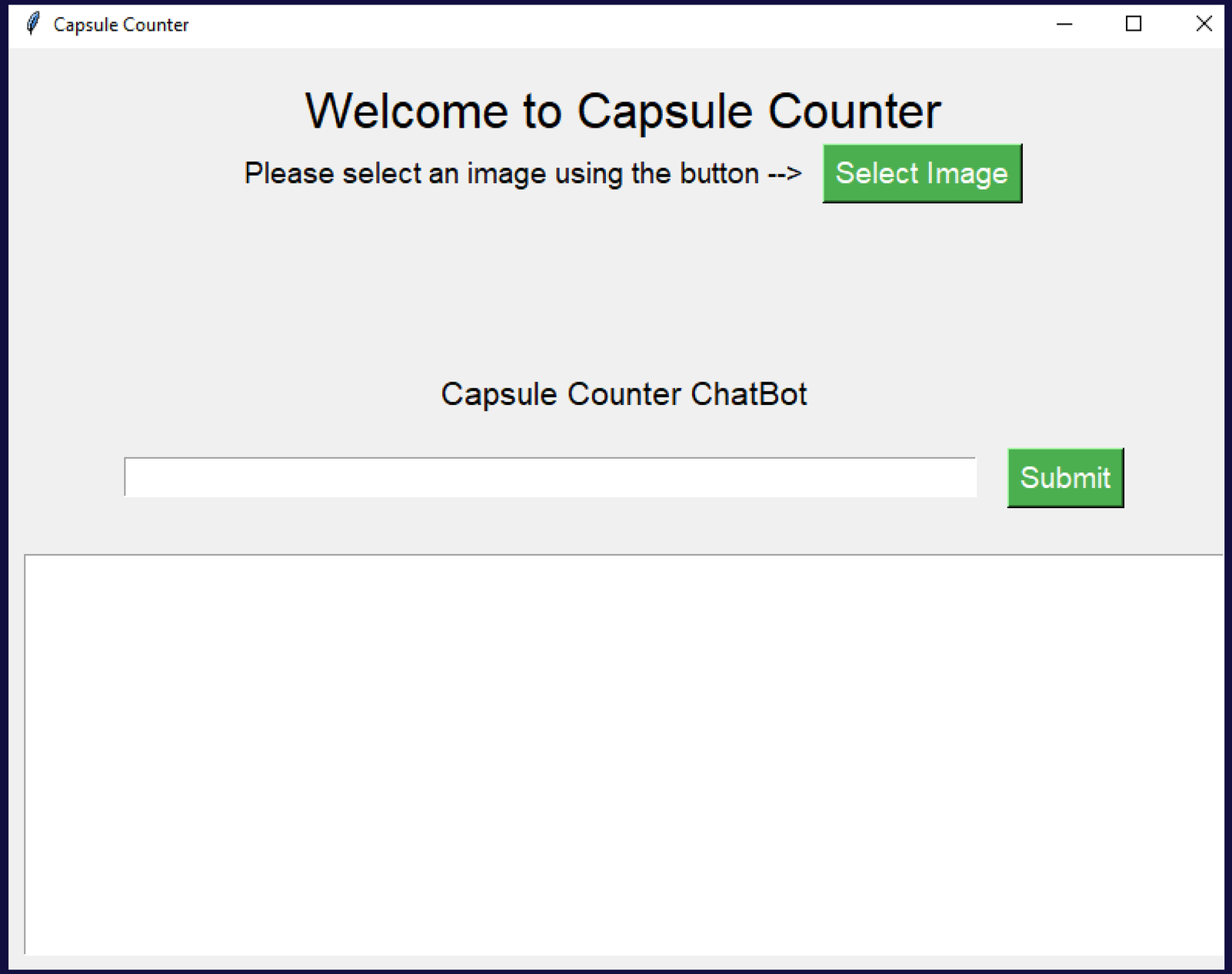
Ali, M. H. (2023). Real-time objects detection, tracking, and counting using image processing techniques. Al-Nahrain Journal for Engineering Sciences, 26(1), 24-30. https://doi.org/10.29194/NJES.26010024

Zhang, Y., Zhou, D., Chen, S., Gao, S., & Ma, Y. (2016). Single-image crowd counting via multi-column convolutional neural network. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 589-597. https://doi.org/10.1109/CVPR.2016.70

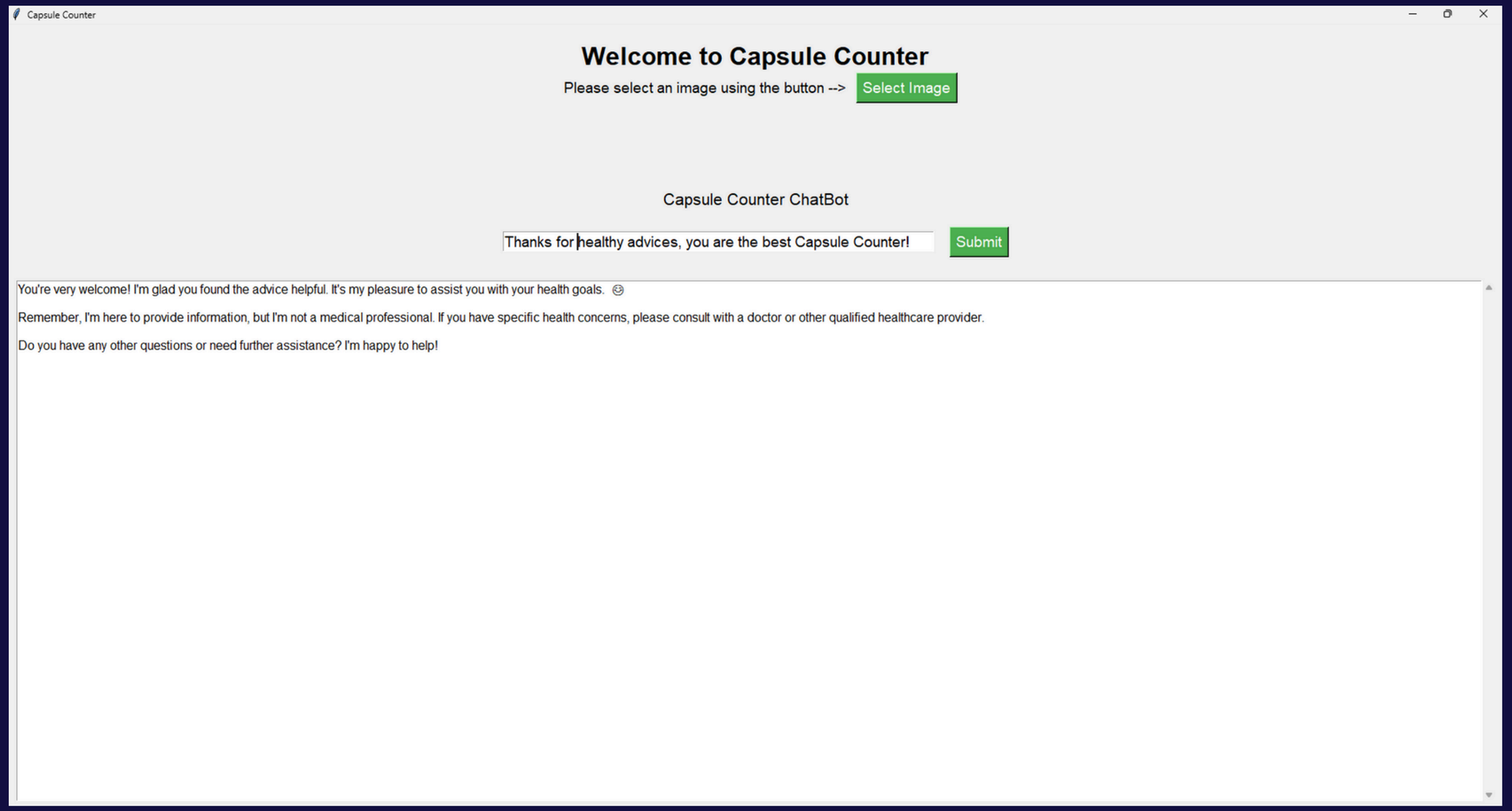
Kumar, A., & Patel, M. (2023). A Novel Approach for Counting Objects in Images Using Convolutional Neural Networks. IEEE Transactions on Image Processing, 32(5), 337-345.

Wang, H., & Zhang, L. (2023). Real-Time Object Detection and Counting Using Image Processing Techniques. Computer Vision and Pattern Recognition, 45(2), 245-252

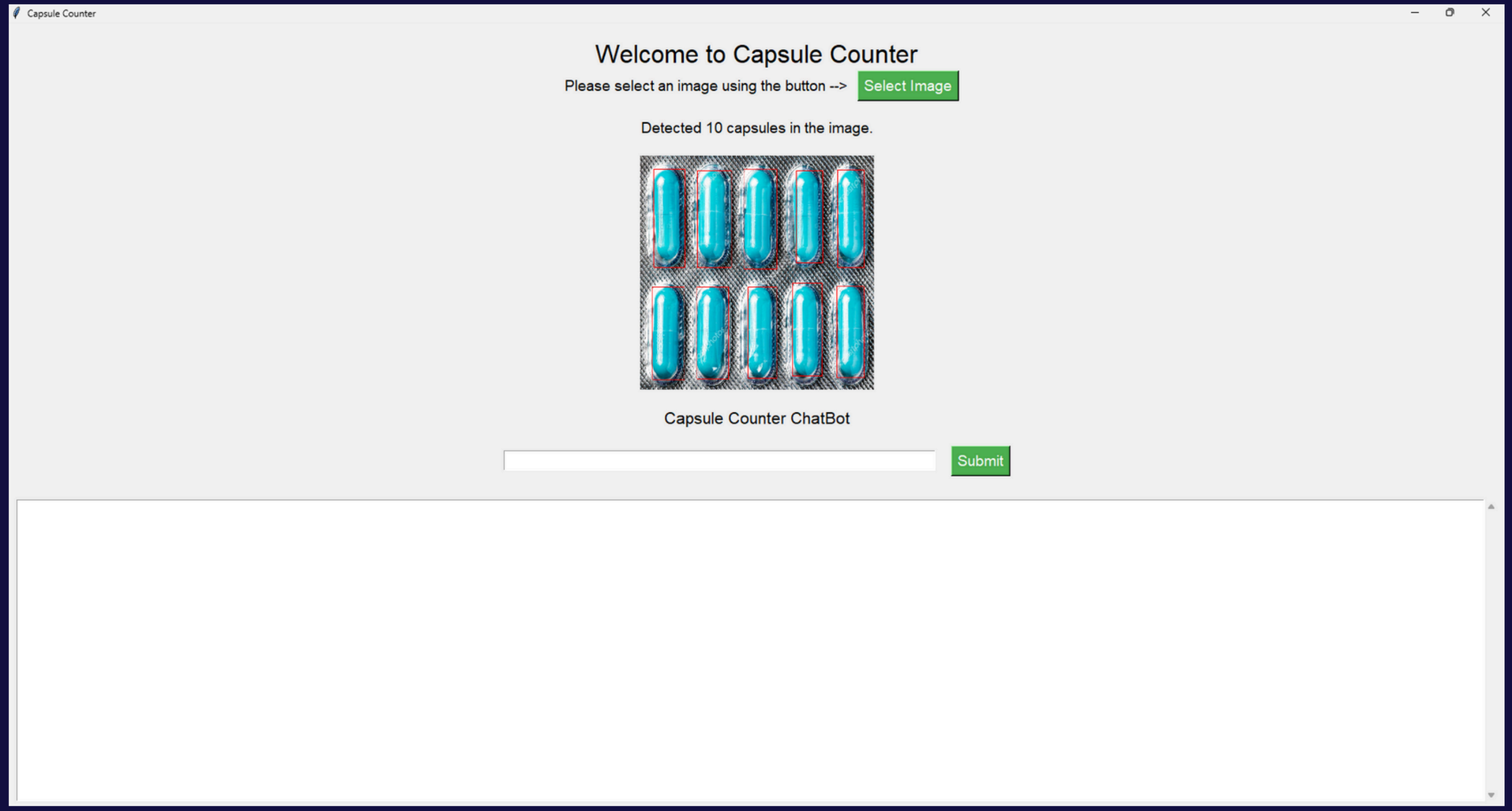
The Program


Capsule Counter
Welcome to Capsule Counter
Please select an image using the button -->
Select Image
Capsule Counter ChatBot
Submit

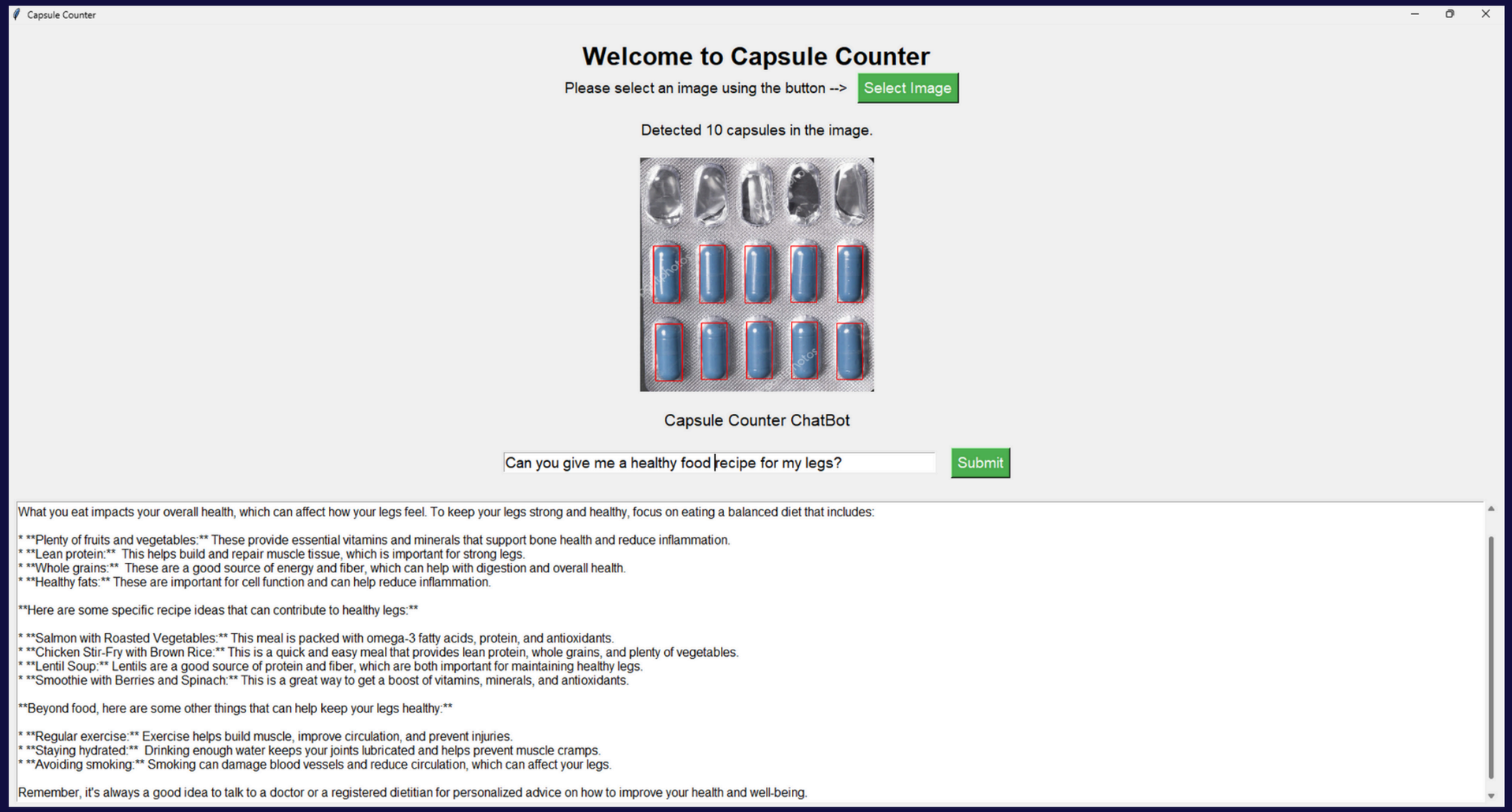
The Program


Capsule Counter
Welcome to Capsule Counter
Please select an image using the button -->
Select Image
Capsule Counter ChatBot
Thanks for healthy advices, you are the best Capsule Counter!
Submit
You're very welcome! I'm glad you found the advice helpful. It's my pleasure to assist you with your health goals.
Remember, I'm here to provide information, but I'm not a medical professional. If you have specific health concerns, please consult with a doctor or other qualified healthcare provider.
Do you have any other questions or need further assistance? I'm happy to help!

The Program


Capsule Counter
Welcome to Capsule Counter
Please select an image using the button -->
Select Image
Detected 10 capsules in the image.
Capsule Counter ChatBot
Submit

The Program


Capsule Counter
Welcome to Capsule Counter
Please select an image using the button -->
Select Image
Detected 10 capsules in the image.
Capsule Counter ChatBot
Can you give me a healthy food recipe for my legs?
Submit
What you eat impacts your overall health, which can affect how your legs feel. To keep your legs strong and healthy, focus on eating a balanced diet that includes:
* **Plenty of fruits and vegetables:** These provide essential vitamins and minerals that support bone health and reduce inflammation.
* **Lean protein:** This helps build and repair muscle tissue, which is important for strong legs.
* **Whole grains:** These are a good source of energy and fiber, which can help with digestion and overall health.
* **Healthy fats:** These are important for cell function and can help reduce inflammation.
Here are some specific recipe ideas that can contribute to healthy legs:
* **Salmon with Roasted Vegetables:** This meal is packed with omega-3 fatty acids, protein, and antioxidants.
* **Chicken Stir-Fry with Brown Rice:** This is a quick and easy meal that provides lean protein, whole grains, and plenty of vegetables.
* **Lentil Soup:** Lentils are a good source of protein and fiber, which are both important for maintaining healthy legs.
* **Smoothie with Berries and Spinach:** This is a great way to get a boost of vitamins, minerals, and antioxidants.
Beyond food, here are some other things that can help keep your legs healthy:
* **Regular exercise:** Exercise helps build muscle, improve circulation, and prevent injuries.
* **Staying hydrated:** Drinking enough water keeps your joints lubricated and helps prevent muscle cramps.
* **Avoiding smoking:** Smoking can damage blood vessels and reduce circulation, which can affect your legs.
Remember, it's always a good idea to talk to a doctor or a registered dietitian for personalized advice on how to improve your health and well-being.