**Application Wiki for Beam Property Analyzer**

**Overview**

Beam Property Analyzer is a software application designed to process images of beams and calculate their properties, such as diameter, area, and Full Width at Half Maximum (FWHM). The application utilizes computer vision techniques to detect and analyze beam contours and edges, providing detailed measurements and visualizations.

**Features**

1. **Image Upload and Processing**:
   * Load and process grayscale images using OpenCV.
   * Convert images to binary format for contour detection.
   * Apply edge detection and Hough Line Transform to identify beam rays.
   * Filter out small and irrelevant contours.
2. **Contour and Line Analysis**:
   * Detect contours and draw them on the original image.
   * Calculate beam properties, including diameter, area, and FWHM.
   * Detect lines in the image using edge detection and Hough Line Transform.
3. **Results Display**:
   * Display original, contour, and line-detected images.
   * Present detailed measurements in a table format.
   * Allow users to export results as a CSV file.
4. **User Interface**:
   * Built using Tkinter for a graphical interface.
   * Interactive elements including file dialogs, buttons, and entry fields for scale input.
   * Dynamically update and display results.

**Dependencies**

* **Python Libraries**:
  + OpenCV
  + NumPy
  + Tkinter
  + PIL (Python Imaging Library)

**Usage**

**Running the Application**

1. **Install Dependencies**: Ensure you have the required libraries installed. Use pip to install them if necessary:

bash

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pip install opencv-python-headless numpy pillow

1. **Execute the Script**: Run the main script to start the application:

bash

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python main.py

**User Interface**

1. **Open Image**:
   * Click the "Open Image" button to select and upload an image for processing.
2. **Set Scale**:
   * Enter the scale in pixels per micron in the provided entry field.
3. **Calculate Properties**:
   * Click the "Calculate" button to process the image and display the results.
4. **Export Results**:
   * Click the "Export Table as CSV" button to save the results in a CSV file.

**Image Processing Details**

* **Thresholding**: Converts the grayscale image to binary using a threshold value of 50.
* **Contour Detection**: Identifies external contours and filters out those with an area smaller than 50 pixels.
* **Edge Detection**: Uses Canny edge detection to identify edges in the image.
* **Line Detection**: Utilizes the Hough Line Transform to detect lines, with parameters set for line length and gap.
* **Property Calculation**: Computes the diameter, area, and FWHM based on the detected contours and edges.

**Result Display**

* **Images**: Displays the original image, the image with contours, and the image with detected lines.
* **Measurements**: Shows the calculated distances, average distances, and properties like diameter, area, and FWHM in a table format.

**Code Structure**

* **Imports**: Imports necessary libraries such as OpenCV, Tkinter, and PIL.
* **Global Variables**: Defines variables like uploaded\_filename and scale\_pixels\_per\_micron.
* **Functions**:
  + process\_image: Main function to process the image and calculate properties.
  + calculate\_beam\_properties: Helper function to calculate diameter, area, and FWHM.
  + open\_file\_dialog: Opens a file dialog to select an image.
  + save\_table\_as\_csv: Exports the results table as a CSV file.
  + update\_image\_display: Updates the displayed images.
  + update\_results\_display: Updates the results table with new measurements.
  + load\_last\_results: Loads the last processed results if available.
* **User Interface Setup**:
  + Creates the main Tkinter window and its elements like buttons, labels, and entry fields.
  + Configures the results table for displaying measurements.
* **Main Loop**: Starts the Tkinter main loop to run the application.

**Conclusion**

Beam Property Analyzer is a powerful tool for analyzing beam properties in images, providing precise measurements and visual feedback. Its user-friendly interface and comprehensive functionality make it suitable for various applications in research and industry.