Panoramic Image Generation using Image Stitching

A Computer Vision Project using OpenCV & Geometric Cropping

Understanding Image Stitching

What is Image Stitching?

Image stitching is the process of combining multiple overlapping photographs to create a seamless, wide-field panoramic view. This technique aligns and blends images by detecting common features and applying geometric transformations.

Real-World Applications

- **Photography**: Creating stunning wide-angle landscapes
- **Drone mapping**: Surveying large geographical areas
- **Medical imaging**: Comprehensive scan reconstruction
- **AR/VR**: Immersive 360° environments

Project Motivation

Efficiency Challenge

Manual stitching is time-consuming, labour-intensive, and prone to human error in alignment and blending.

Warping Artefacts

Traditional warping produces irregular output shapes with unsightly black borders and curved edges.

Solution Required

A robust method to generate smooth, rectangular panoramas with automated intelligent cropping.

This project addresses both challenges: implementing reliable stitching whilst solving the automated smart cropping problem for professional-quality output.

System Workflow Overview

Input Loading

Load and display multiple overlapping source images for processing

Image Stitching

Apply OpenCV's stitching module with feature detection and homography estimation

Mask Generation

Detect and isolate valid regions, identifying black and invalid areas

Morphological Processing

Apply opening and closing operations to clean and refine the binary mask

Rectangle Computation

Calculate the largest possible rectangular crop area within valid regions

Final Output

Extract and output the clean, border-free panoramic image

OpenCV Stitching Module

Core Stitching Process

The OpenCV stitching pipeline implements a sophisticated multi-stage approach:

1. **Keypoint detection**: Identifies distinctive features using ORB algorithms
2. **Feature matching**: Establishes correspondences between overlapping regions using Brute-Force Hamming matcher
3. **Homography estimation**: Calculates geometric transformations using RANSAC
4. **Warping & blending**: Transforms images and seamlessly merges them

Key Limitation

Whilst stitching successfully combines images, it produces panoramas with **irregular black curved edges** that require additional processing.

Mask Creation & Morphological Operations

Greyscale Conversion

Transform the stitched panorama to single-channel greyscale representation

Binary Thresholding

Apply threshold to separate valid pixels from black border regions

Morphological Opening

Remove noise and small artefacts using erosion followed by dilation

Morphological Closing

Fill interior holes and gaps to create smooth, continuous regions

Result: A refined binary mask that accurately represents the usable panoramic regions whilst eliminating noise and discontinuities.

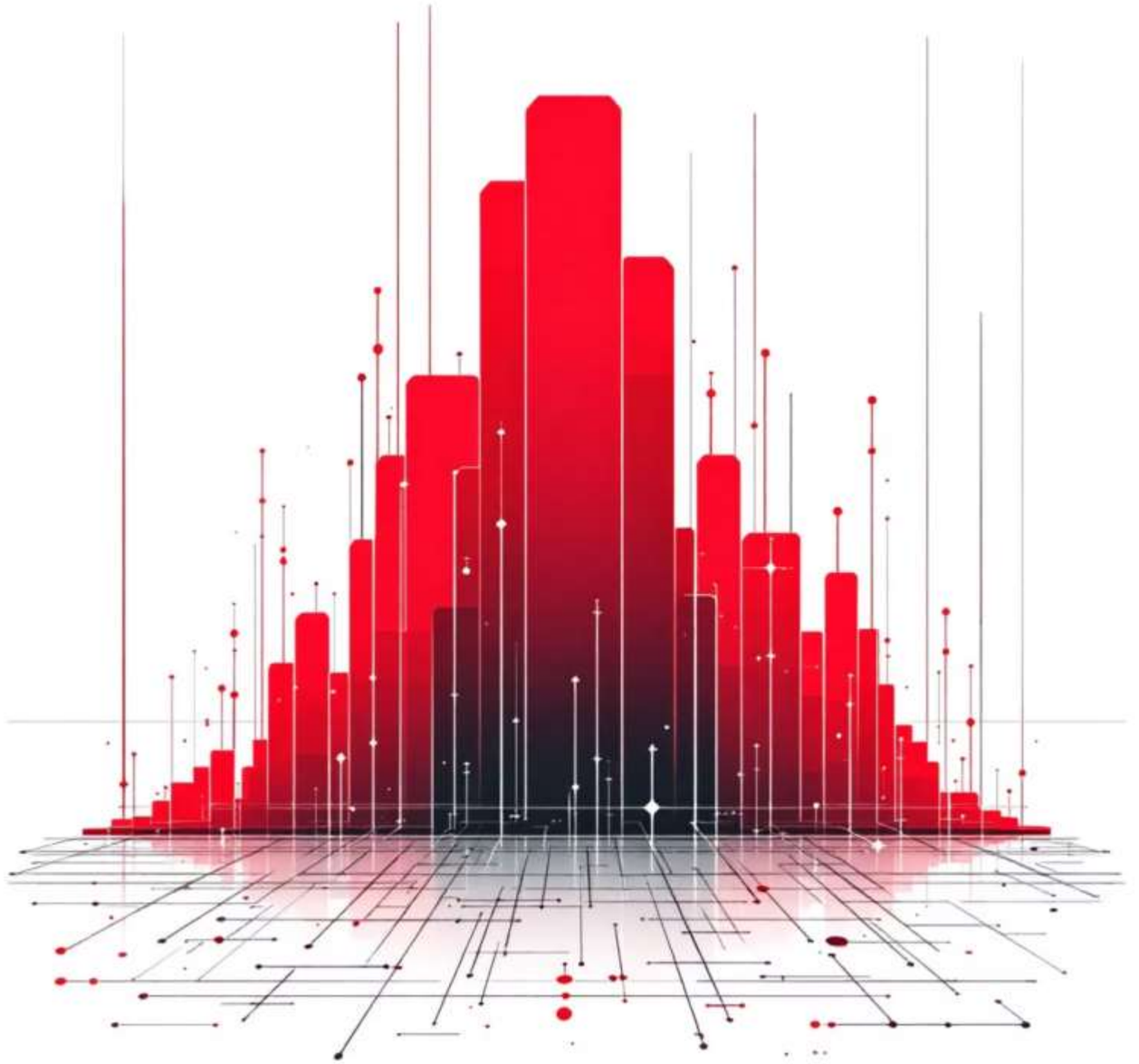
Largest Rectangle Algorithm

Histogram-Based Approach

The algorithm leverages the classic **Largest Rectangle in Histogram** technique to find the optimal crop:

- Each row of the binary mask generates a column-height histogram
- For every row, compute the maximum axis-aligned rectangle
- Track and retain the rectangle with maximum total area

Objective: Identify the largest possible clean rectangular region that contains no invalid or black border pixels.



Automated Cropping Pipeline

1

Mask Construction

Generate refined binary mask through morphological operations identifying valid panoramic regions

2

Rectangle Detection

Execute histogram-based algorithm to locate maximum-area rectangular crop region

3

Visual Overlays

Create diagnostic visualizations including contours, mask representations, and rectangle outlines

4

Final Extraction

Crop and extract the optimal rectangular panorama from the stitched output

Key Advantages

✓ Fully automated processing

✓ Maximum-area crop extraction

✓ Complete removal of invalid regions

Dataset Description

Our image stitching project was developed and tested using a meticulously curated dataset designed to reflect real-world challenges and diverse photographic conditions.

Diverse Image Sources

The dataset comprises images either manually captured or sourced from various external providers, ensuring a wide range of photographic styles and content.

Overlapping Fields of View

Each set of images within the dataset features crucial overlapping fields of view, which are fundamental for successful feature detection and subsequent stitching.

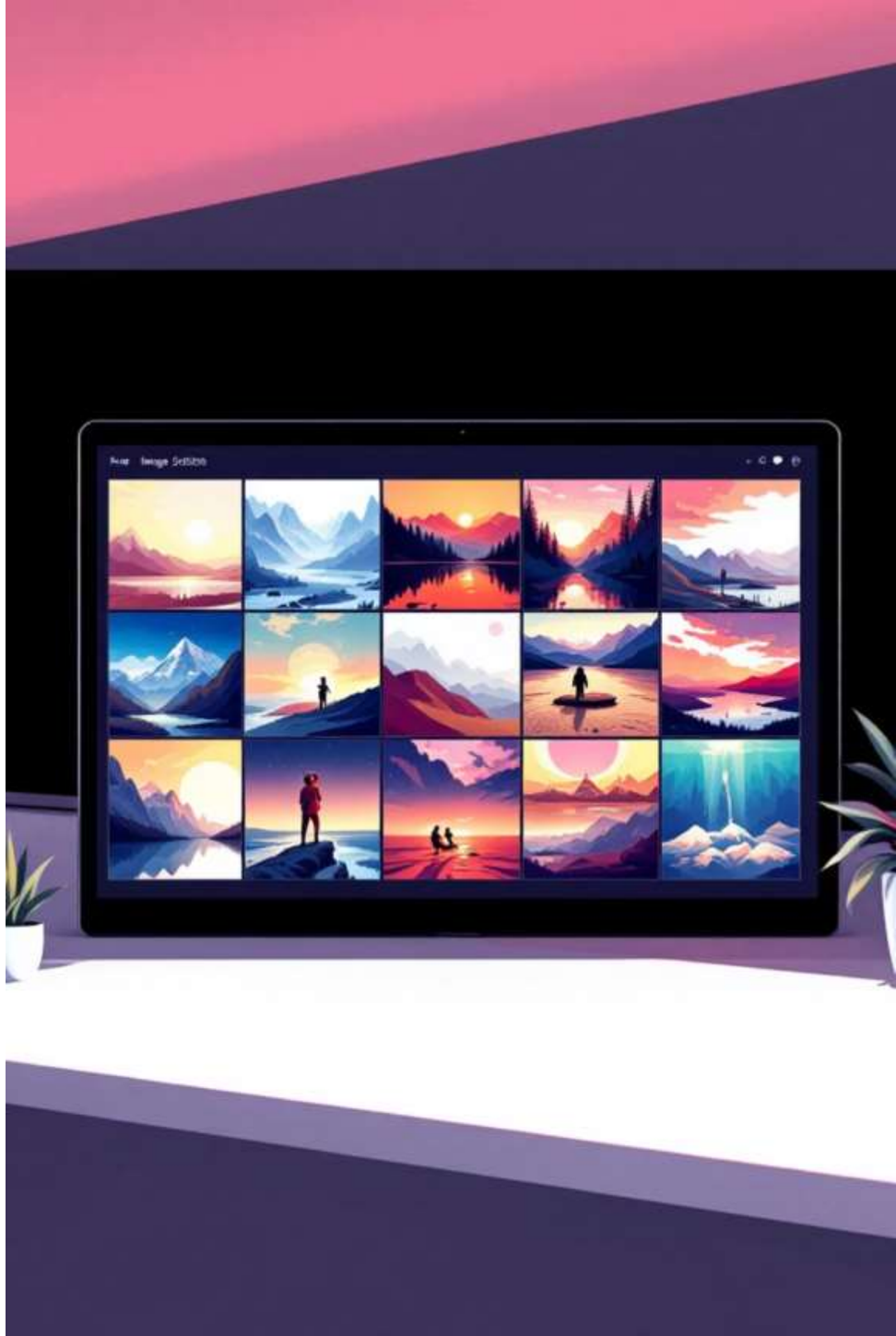
Varied Conditions

We specifically included images with variations in lighting, exposure, and camera angles to rigorously test the robustness of the stitching algorithm under challenging scenarios.

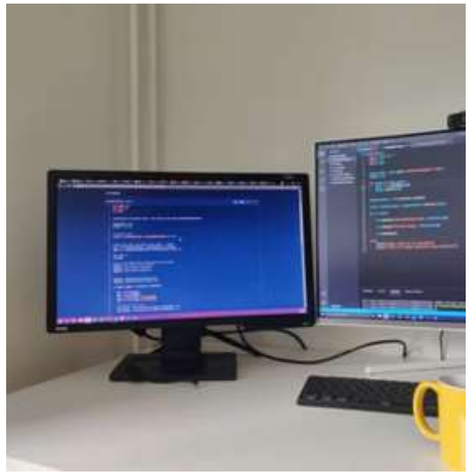
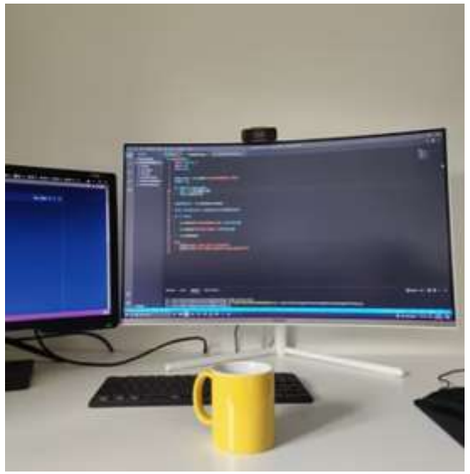
Realistic Stitching Scenarios

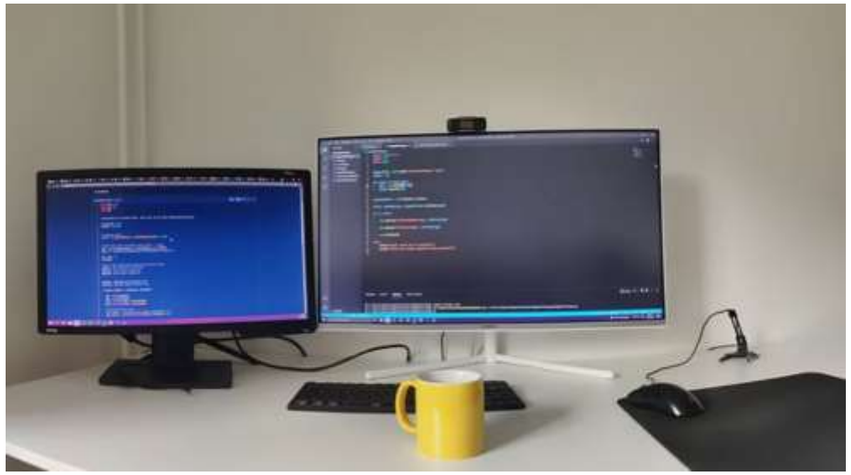
The collection represents realistic use cases for panoramic photography, providing authentic challenges to validate the system's ability to produce high-quality results.

This comprehensive approach allowed us to generate compelling sample results that showcase the effectiveness of our automated cropping pipeline.



Results & Visualisation



Before Processing

Raw stitched output exhibits irregular black borders and curved edges from warping transformations

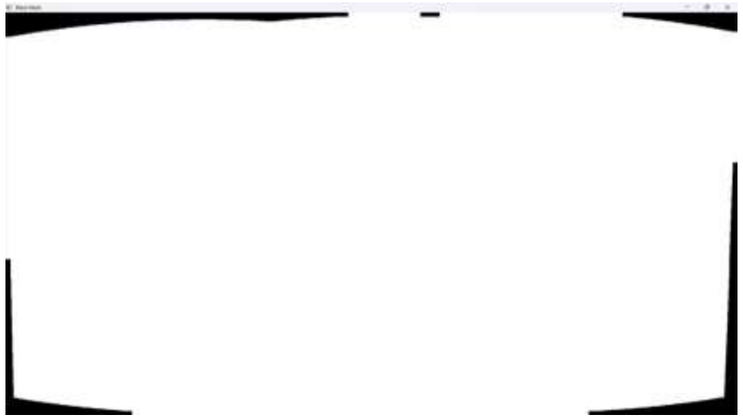
Mask Analysis

Binary mask clearly delineates valid regions from invalid areas requiring removal

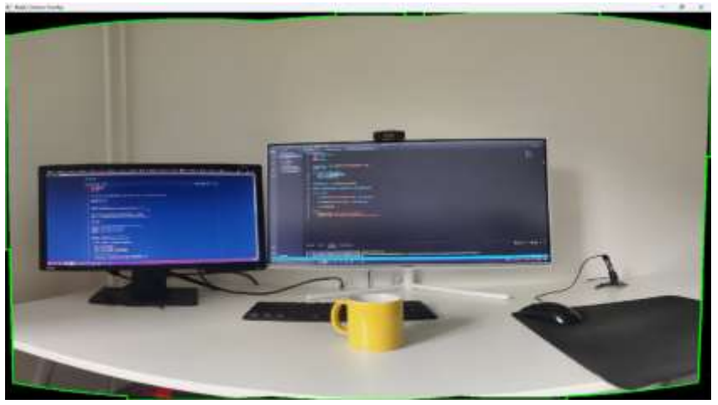
After Cropping

Final panorama is perfectly rectangular with no black borders and maximum usable area preserved

Raw Stitched Image

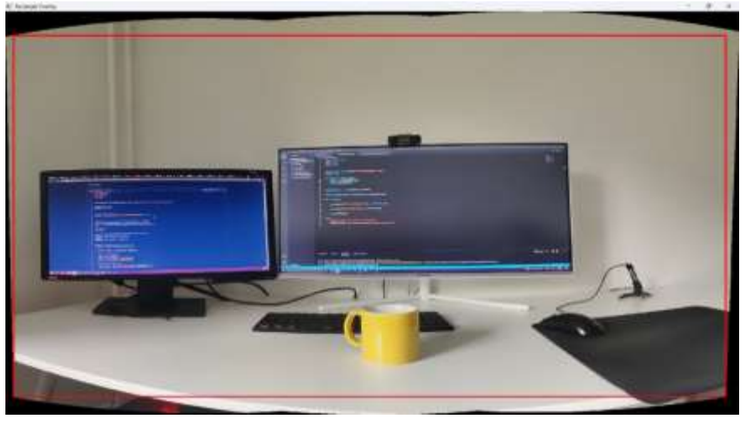


Warp Mask

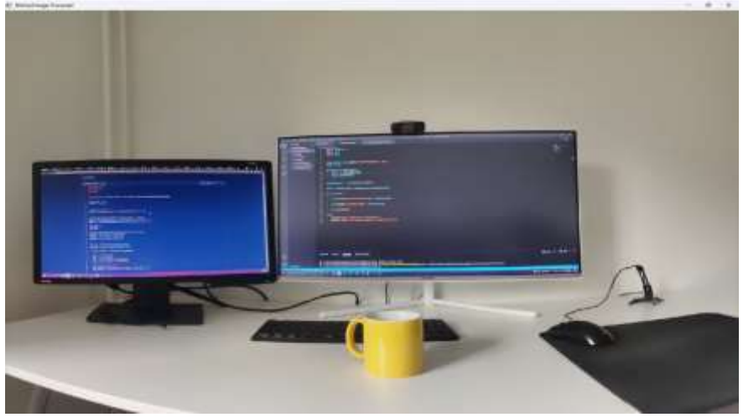


Mask Contour Overlay

minRectangle Image



Rectangle Overlay



Processed Stitched Image

Conclusion & Future Work

Project Achievements

- Successfully implemented automated panoramic stitching pipeline
- Solved the critical problem of irregular black border artefacts
- Applied histogram-based geometric algorithm for optimal cropping
- Delivered clean, rectangular, visually consistent output

Future Enhancements

- **Cylindrical/spherical projection** for 360° panoramas
- **GPU acceleration** for real-time processing
- **Advanced blending** using multi-band techniques
- **Automatic exposure** correction and colour balancing

Application Development – Web & Mobile Interface

We developed a full-stack web application enabling users to upload multiple overlapping photos and instantly generate seamless panoramic images. The front-end is built with React and Vite, styled with TailwindCSS, while the back-end uses Flask and OpenCV to handle image processing. Users can preview results in real-time and download the final stitched image with one click. The app is hosted on Vercel (front-end) and Render (back-end), providing a responsive, cloud-ready deployment accessible from any device.

Key Features

- Drag-and-drop image upload (2+ images)
- Fast panorama stitching powered by OpenCV
- One-click download of stitched output
- Responsive UI for desktop and mobile
- Live demo link: https://panorama-stitcher.vercel.app

Technology Stack

Frontend

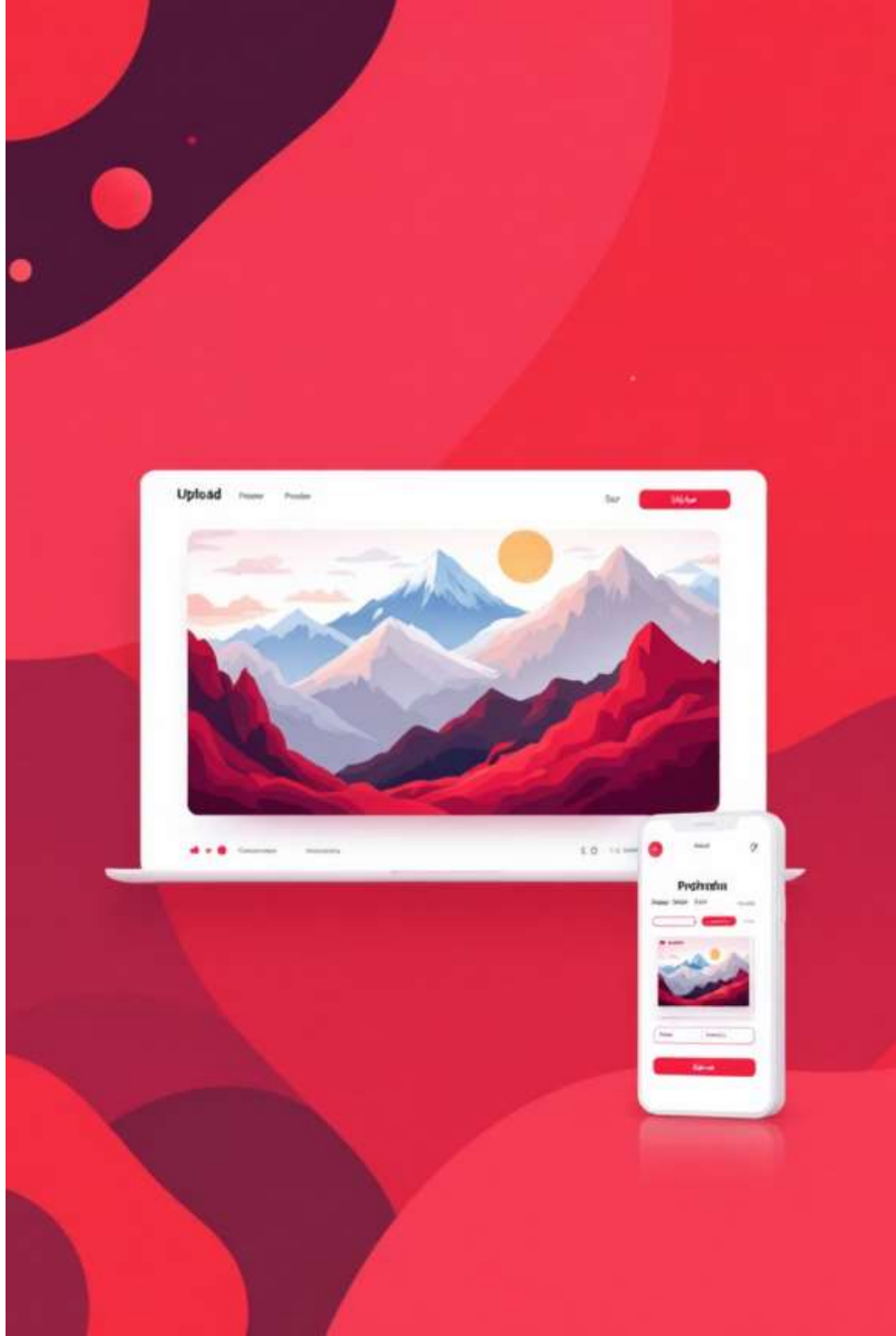
React + Vite + TailwindCSS

Backend

Flask + OpenCV + Gunicorn

Hosting

Vercel (Frontend) + Render (Backend)



Thank You

Presented by

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