

□ Project Report: Face Detection using Viola-Jones (VJ) Algorithm

1. Introduction

This project aims to implement and evaluate a real-time face detection system using the Viola-Jones (VJ) algorithm. The project is developed as part of the **Digital Image Processing Design** course at **Inha University**. Our objective is to create an efficient face detector using OpenCV and Haar features.

2. Project Details

- **University:** Inha University
- **Department:** SGCS
- **Major:** Integrated System Engineering (ISE)
- **Course:** Digital Image Processing Design [202402-ISE4131-001]
- **Professor:** Kakani Vijay
- **Project Title:** Face Detection using Viola-Jones (VJ) Algorithm
- **Team:** KBM

Team Members

- **Team Lead:** Shukrullo Meliboev
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3. Objectives

- To practice programming the VJ algorithm using OpenCV.
- To utilize Haar features to accurately detect faces.

- To evaluate the performance of the face detector by analyzing maximum and minimum detectable face sizes, as well as detection speed.
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4. Methodology

4.1 Training

- **Cascade Classifier:** The face detection model is trained using a combination of public datasets and a self-made dataset that includes images of team members under various orientations, scales, and lighting conditions.
- **Data and Resources:**
 - Training Data Link (<https://drive.google.com/drive/folders/1eKAg2KUzV6aSoDvpSEWK06y1WKEOHQIC?usp=sharing>) - Contains datasets used for training and testing.

4.2 Testing and Evaluation

- **Image Size:** 1024 x 768 pixels.
 - **Evaluation Metrics:**
 - Minimum detectable face size.
 - Maximum detectable face size.
 - Average detection time per image and per face.
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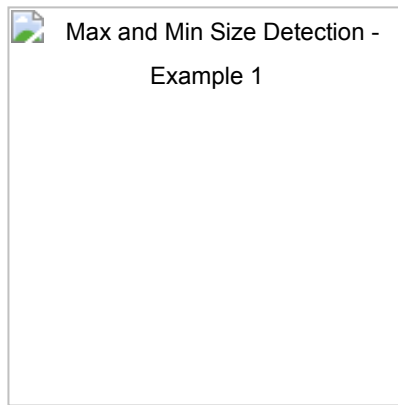
5. Results

Minimum and Maximum Detectable Face Sizes

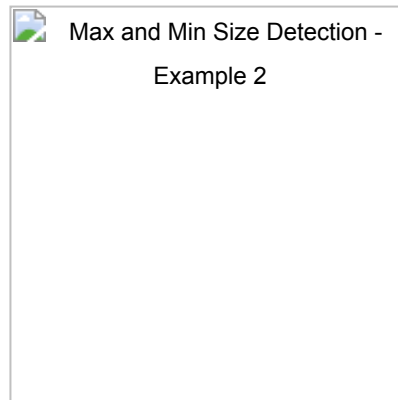
The face detection script (`source.py`) was run, and the results for minimum and maximum detectable face sizes were captured in real-time. The detected sizes are as follows:

- **Minimum Detectable Size:** 30 x 30 pixels
- **Maximum Detected Size:**
 - Example 1: 283 x 353 pixels
 - Example 2: 344 x 429 pixels

Captured Images



Max Detected Size: 283x353 pixels



Min Detected Size: 344x429 pixels

Average Detection Time

- **Per Image:** 0.0213 seconds
 - **Per Image Per Face:** 0.01 seconds
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6. Discussion

Observations

- **Performance Analysis:**
 - The VJ algorithm is capable of detecting faces in real-time with a reasonable level of accuracy for different face sizes.
 - The results indicate that the face detector can successfully detect faces within a range of sizes, with the smallest detectable size being 30 x 30 pixels.

Challenges and Limitations

- The accuracy of detection may vary depending on the presence of factors like:
 - Viewpoint variation
 - Deformation
 - Occlusion
 - Illumination changes

- Cluttered or textured backgrounds
- Intra-class variation

Further analysis will be conducted to evaluate the detector's performance under these conditions.

7. Future Work

- **Performance Optimization:** Test the model under different lighting and orientation conditions to optimize its accuracy.
 - **Additional Evaluations:** Determine the average detection time per image and per face to assess real-time efficiency.
 - **Complete Documentation:** Update this report with a thorough analysis of detection challenges.
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8. Project Demonstration

- **Demo Video:** A demonstration video showcasing the face detection process and results is available here:
 - Video Link (https://drive.google.com/file/d/1uPG95sclV3zaYdYxJ_S2bBMrVD29NFVn/view?usp=drive_link).
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9. References

- OpenCV Documentation
- Viola, P., & Jones, M. (2001). Rapid Object Detection using a Boosted Cascade of Simple Features. Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition.