DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE18

Viola-Jones Face Detection

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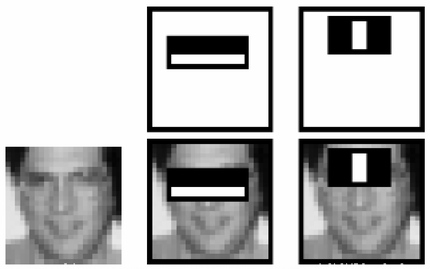
Problem Definition

Face detection is a fundamental task in computer vision with applications in security, human-computer interaction, and image processing.

The goal of this project:

- Develop a face detection system that identifies images containing human faces
- Implement using the Viola-Jones algorithm, which uses Haar-like features to detect facial patterns
- Optimize the design for detection accuracy, processing speed, and real-time performance



[face]

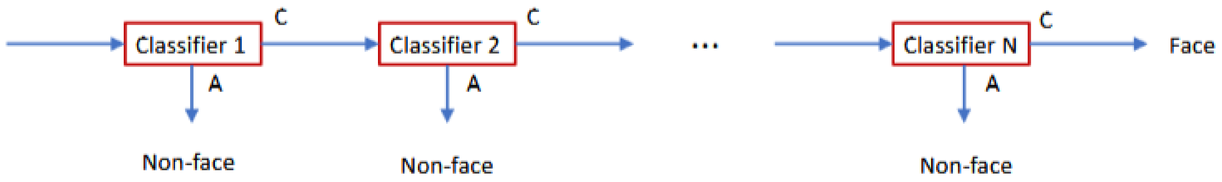
[non-face]

Final Design

Our system is split into a training module and an execution module.

The training module implements AdaBoost training on a large set of features, and outputs a collection of classifiers that is the most accurate at properly determining if an image is a face.

This set of classifiers are connected in a cascade within the execution module, and input images must pass through each classifier to be identified as a face.



Design Calculations & Analysis

1. Haar-like Features

- Rectangular features compute differences in pixel intensities
- Efficiently evaluated using integral images

2. Integral Image

- Allows rapid computation of feature sums
- Reduces complexity from $O(n^2)$ to $O(1)$ per feature

3. AdaBoost Training

- Selects the most relevant weak classifiers
- Combines them into a strong classifier
- Assigns higher weights to misclassified samples

4. Cascade Classifier

- Series of stages that quickly reject non-face regions
- Early stages are simple; later stages are more complex
- Improves speed by minimizing unnecessary computations

Preliminary Results

Training Output

AdaBoost training generates configuration files defining each classifier's feature, threshold, polarity, and weight.

```
classifier 0
feature type 1
(x, y, w, h) = (4, 4, 20, 8)
threshold = -1570.50
polarity = 1
weight = 0.973671
```

Early Results

- Correct classification on sample inputs
- Cascade structure supports scalable depth (N)

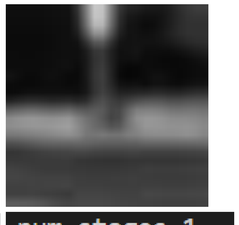
Ongoing Evaluation

- Detection rate vs false positives
- Latency vs different cascade sizes

Live Demo

- Finished running system available at expo

```
num_stages 1
prediction 1
label FACE
```



```
num_stages 1
prediction 0
label NON_FACE
```

Face → Passed all classifiers (True Positive)
Non-face → Rejected at Stage 1 (True Negative)