NUE Face Detection

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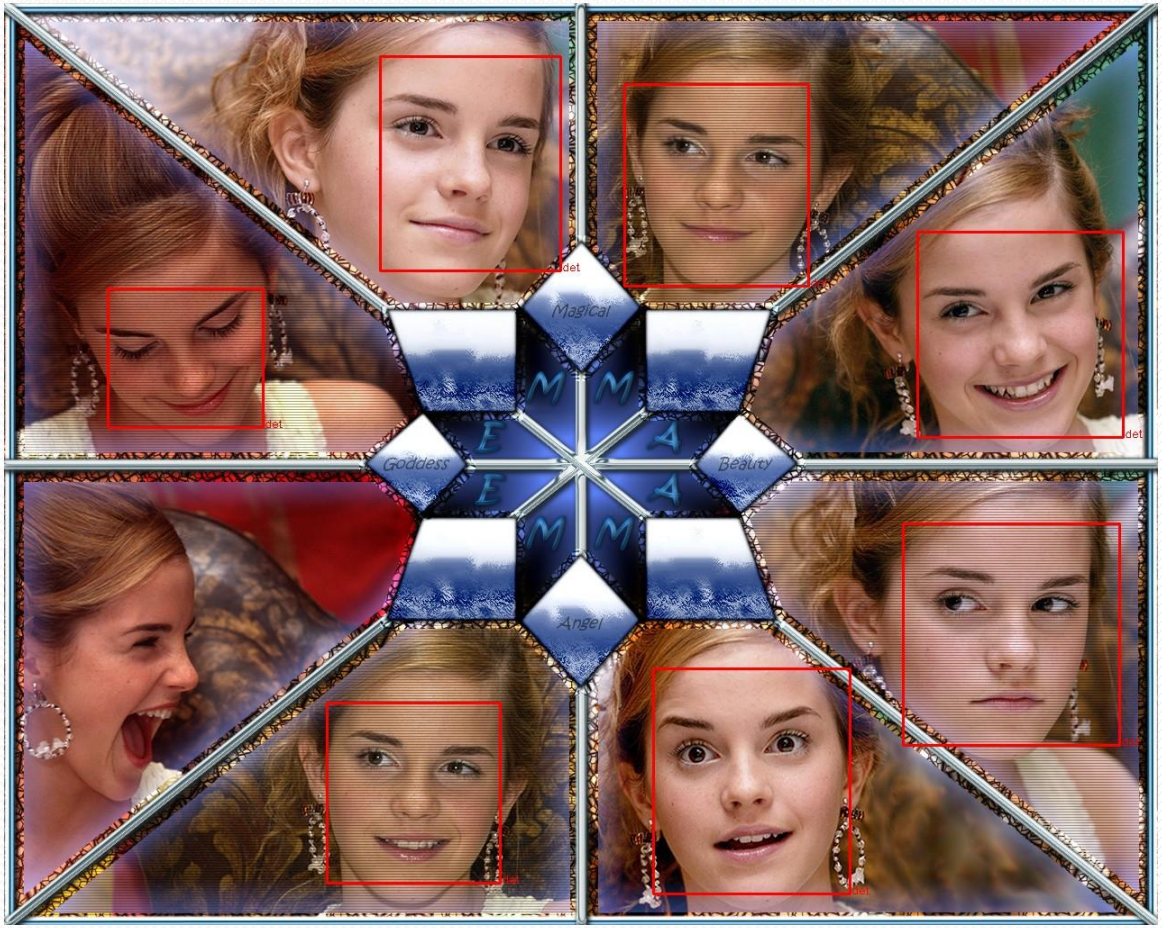
Introduction

- Face detection algorithm developed by Lutz Goldmann and Ullrich Monich
- It was developed at Nuremberg (NUE) Communication Systems Group in collaboration with Technische Universitat, Berlin
- Detection of frontal and upright faces
- Min width 80 pixels. Ignoring this leads to unsatisfactory results

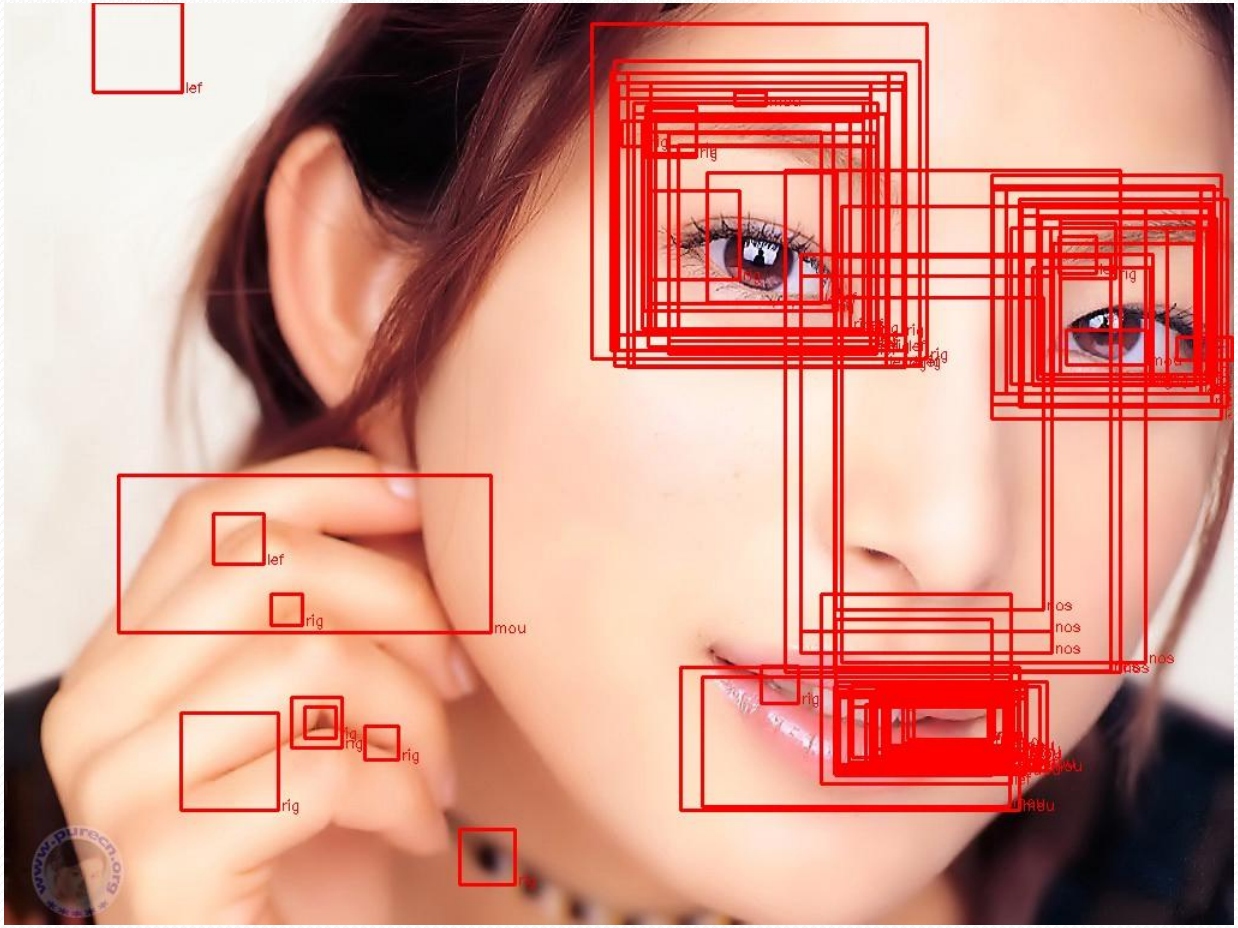
Sample Image File



Algorithm

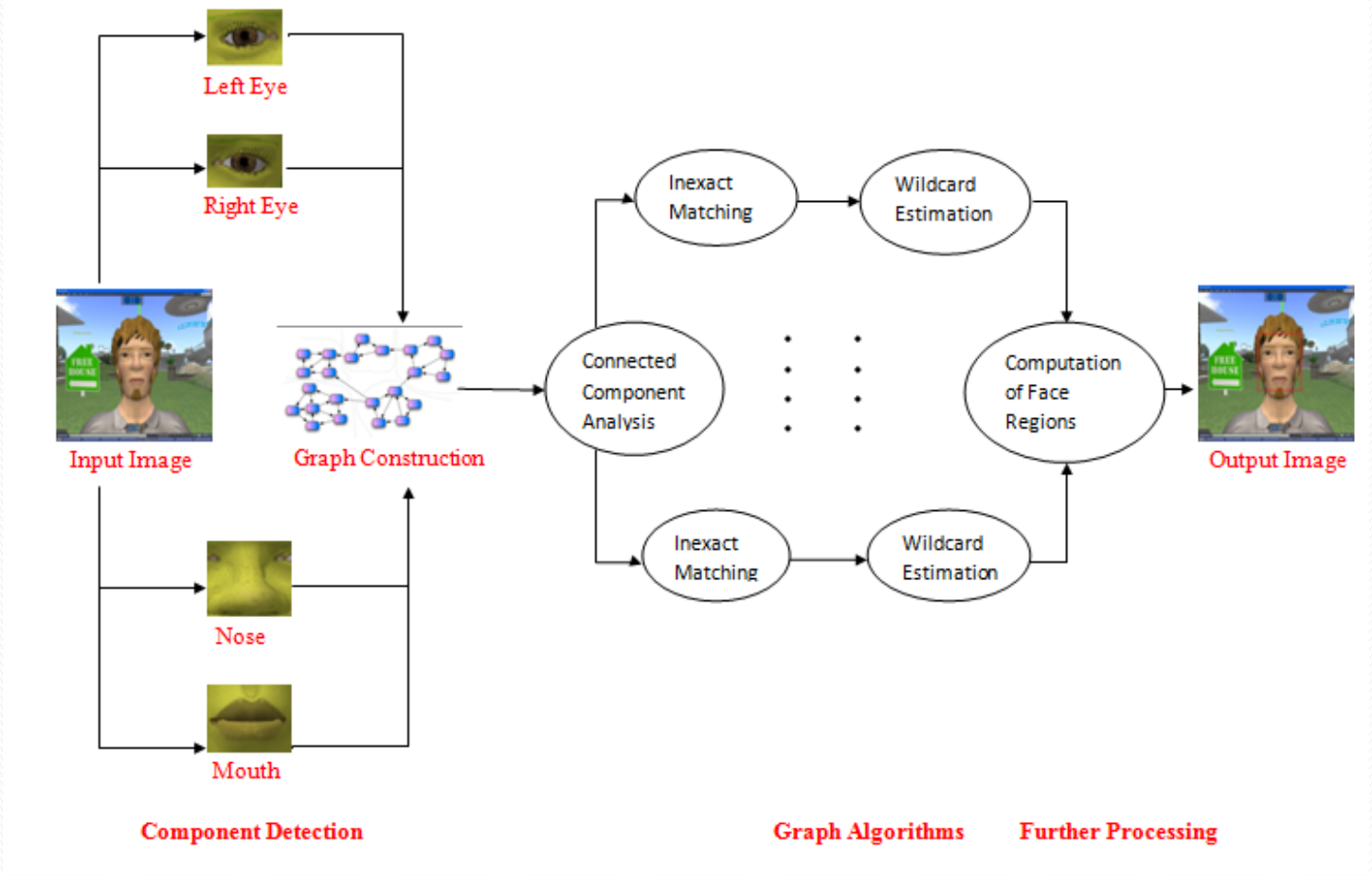
- Component based face detector
- First detects components i.e. nose, mouth and eyes, then uses graph algorithms to detect faces based on the component detections
- Advantage: High robustness towards partial face occlusions

Example (Face Components)



Example (Occluded face)

Flowchart


Left Eye
Right Eye
Input Image
Graph Construction
Nose
Mouth
Component Detection
Inexact Matching
Wildcard Estimation
Connected Component Analysis
Inexact Matching
Wildcard Estimation
Graph Algorithms
Computation of Face Regions
Output Image
Further Processing

Component Detection

- Modified version of OpenCV Haar detection algorithm, based on the paper by Viola and Jones and extended by Lienhardt
- Facial components detected using cascade of boosted classifiers which work with Haar-like features

Viola Jones

- Integral Image, an intermediate representation of an image

  Using the following pair of recurrences:
  $s(x,y) = s(x,y-1) + i(x,y)$
  $ii(x,y) = ii(x-1,y) + s(x,y)$

  {where s(x,y) is the cumulative row sum, s(x,-1)=0 and ii(-1,y)=0} the integral image can be computed in one pass over the original image.

- Rectangle features detected with horizontal, vertical and diagonal orientations available

Viola Jones contd …

- Boosting used as a basic classifier to select rectangle features that separate the positive and negative examples For each feature, the learner determines optimal threshold classification function to reduce misclassification
- A cascade of classifiers is trained to detect almost all objects of interest in frontal faces while rejecting a fraction of the non-object patterns
- Each stage is trained by adding features until the target detection and false positive rates are met
- Stages are added until the overall target for false positives and detection rates are met

Graph Algorithms

- A graph is built where each component detected is a vertex
- Presence of at least two face components helps estimate missing ones
- Pair of vertices belonging to one face are connected
- Connected component analysis segregates possible faces obtained

Graph Algorithms contd …

- Error-tolerant graph matching algorithm checks if components belong to a face or not
- This with estimation of missing components is only applied on connected components, thus helping in significant improvement in speed
- Coordinates of the detected and estimated face components help draw a bounding box around the face

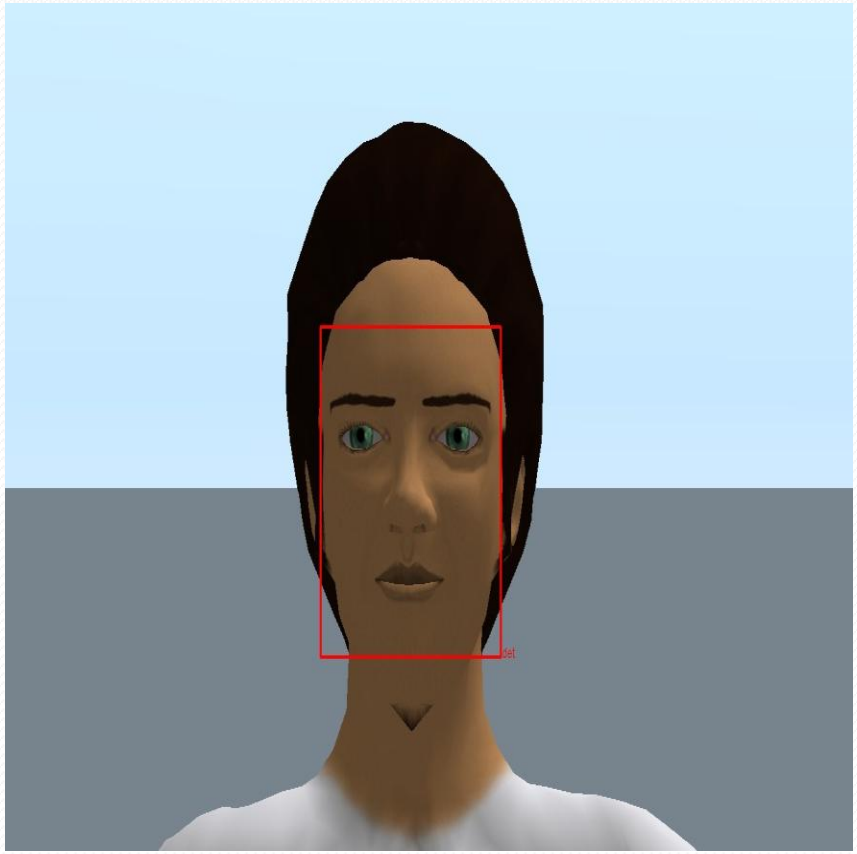
Experiment Datasets

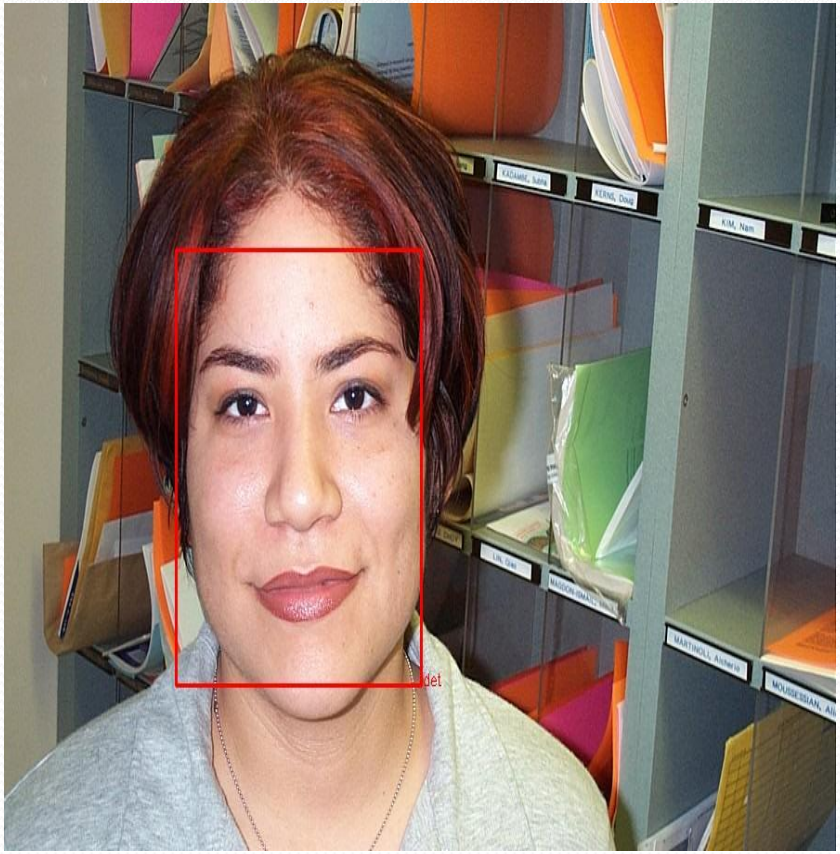
- Avatars from different online virtual worlds

  SecondLife (Manual and Automated)
  Entropia (Male and Female)

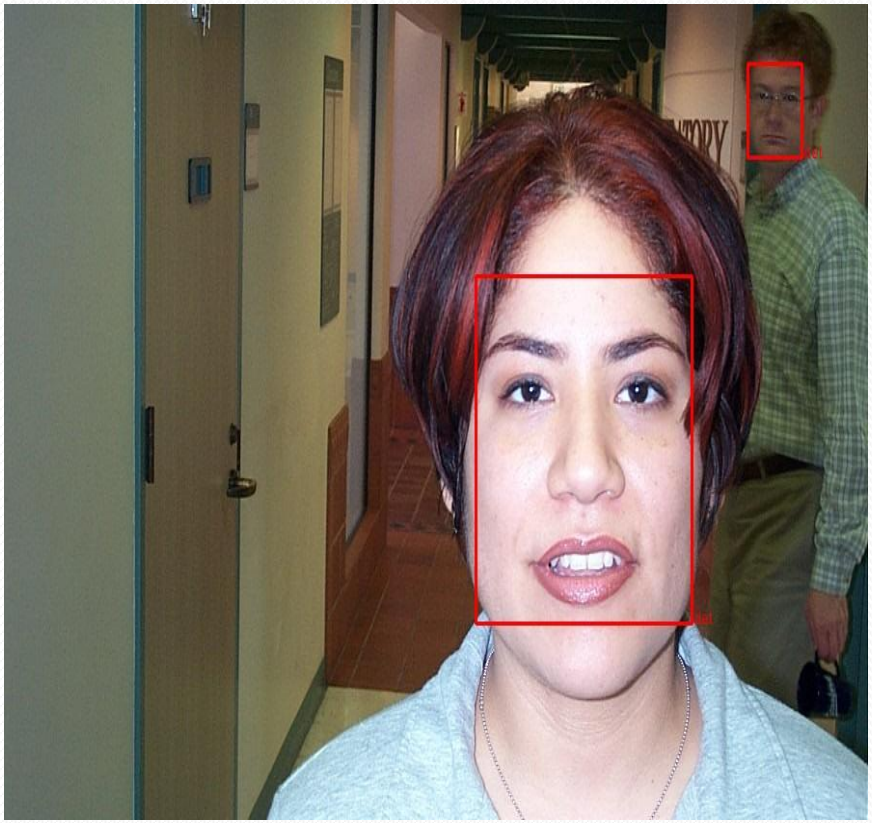
- Humans
  Obtained by Markus Weber, California Institute of Technology
  http://www.vision.caltech.edu/Image_Datasets/faces/README

Results (Accurate Detection)





Results (False positives)



Results (Zero detection)

Questions ???