Karlsruhe Institute of Technology

Ethnicity Classification

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INSTITUTE FOR ANTHROPOMATICS, FACIAL IMAGE PROCESSING AND ANALYSIS

Overview

- Motivation
- Introduction
- Challenges
- Some related work on ethnicity classification
- FIPA Ethnicity Classifier

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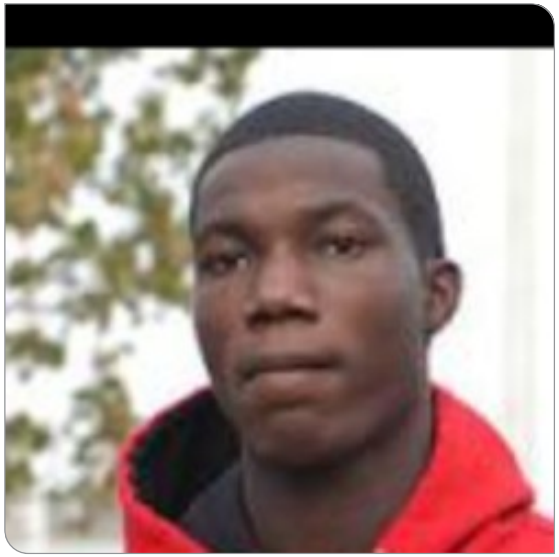
Ethnicity Classification

Motivation



- Why are we able to classify humans in various ethnic groups?

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Institute for Anthropomatics
Facial Image Processing and Analysis

Introduction

Ethnic classes

- Caucasoid
- Mongoloid
- Negroid

Ethnic classes

- Caucasoid

Ethnic classes

- Caucasoid
  - Developed around 1800 by Johann Friedrich Blumenbach
  - Blumenbach named it after the peoples of the Caucasus
  - A geopolitical region at the border of Europe and Asia

Caucasoid Characteristics

- ***Eyes:*** exposed tear trough, large

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- ***Nose:*** prominent, narrow, high bridge

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- ***Lips:*** thin, tight
- ***Face shape:*** center of face juts outward, wedge shaped, long face
- ***Hair:*** wavy or curly, thick body and facial hair(males)

Caucasoid Characteristics

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- ***Hair:*** wavy or curly, thick body and facial hair(males)
- ***Skin:*** white

Ethnic classes

- Caucasoid
- Mongoloid

Ethnic classes

- Caucasoid
- Mongoloid
  - East Asian, South Asian
  - Originated from the Mongol people of East Asia

Mongoloid Characteristics

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- ***Skin:*** yellowish

Ethnic classes

- Caucasoid
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Ethnic classes

- Caucasoid
- Mongoloid
- Negroid
  - Ethnic class of black africans

Negroid Characteristics

- ***Eyes:*** exposed tear trough, large

Negroid Characteristics

- ***Eyes:*** exposed tear trough, large
- ***Nose:*** low, broad

Negroid Characteristics

- ***Eyes:*** exposed tear trough, large
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- ***Skin:*** dark (high melanin quantity)

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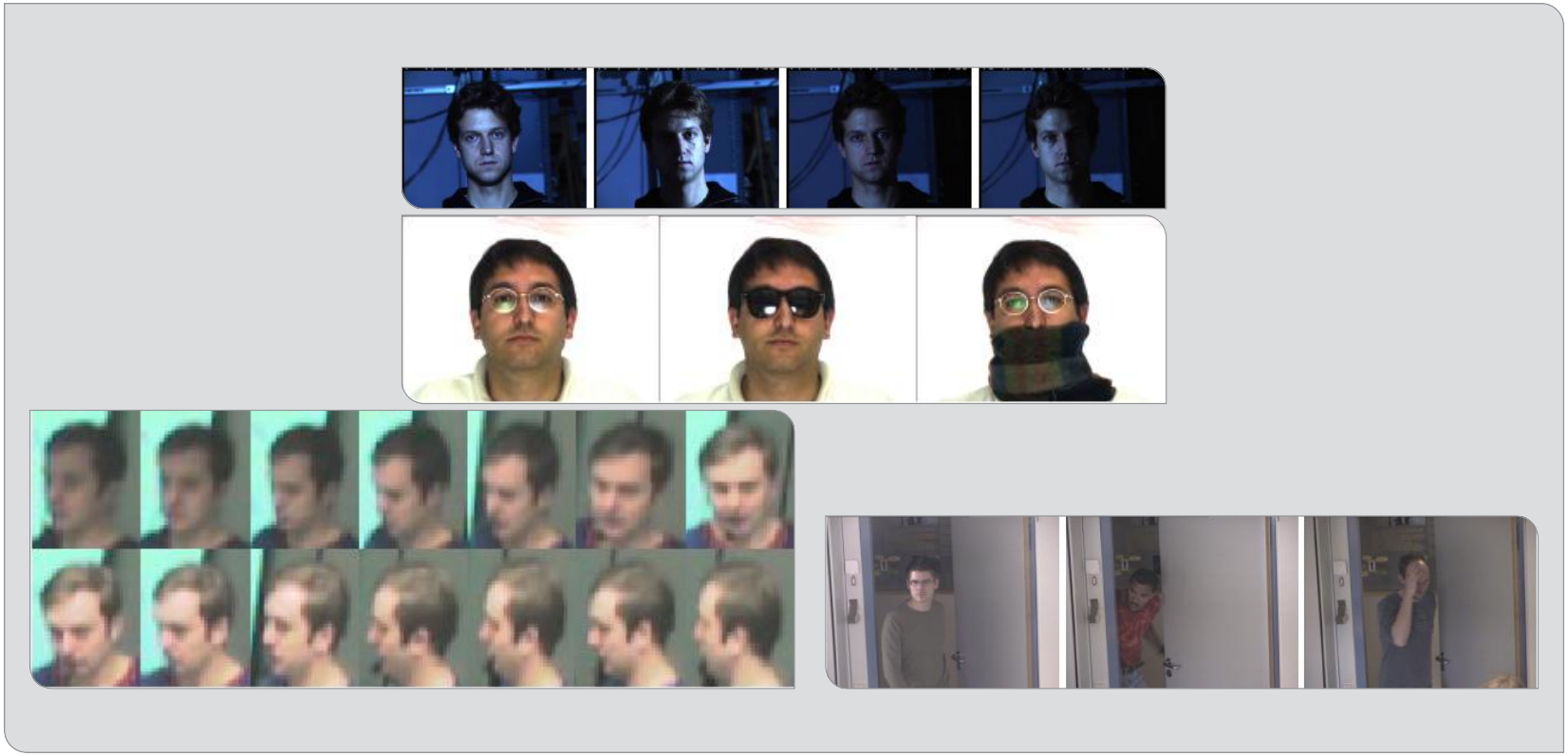
Challenges

- Variations due to illumination, aging, occlusion etc..
- Powerful feature extractor and a generalizable classifier



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Some related Work done on Ethnicity Classification

1. Hybrid Classifier Architecture (Srinivas Gutta et al.)
2. Ensemble of Linear Discriminant Analysis (Xiaoguang Lu and Anil K. Jain)

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Hybrid Classifier Architecture

- Generally based on the concept of reductionism
- Complex problems are solved through stepwise decomposition
- Consist of a connectionist and a symbolic module
- Connectionist module are ensembles of Radial Basis Functions (RBF) Network
- Symbolic module is a Decision Tree(DT)

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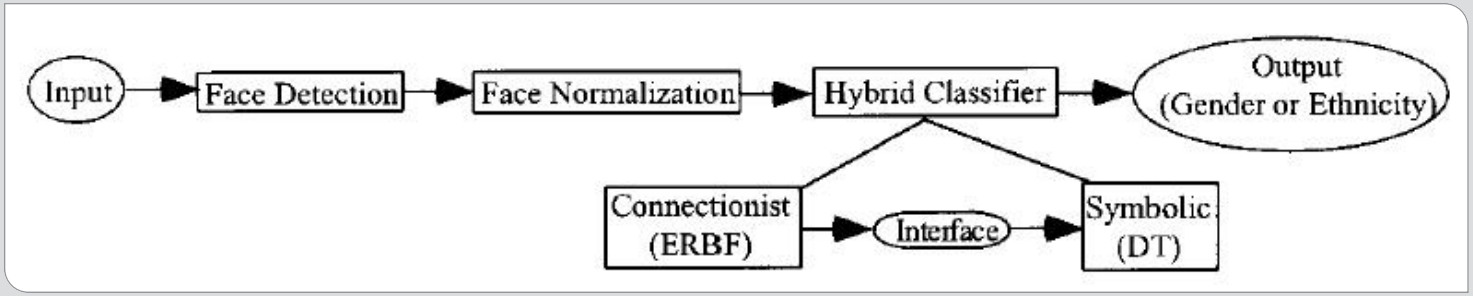
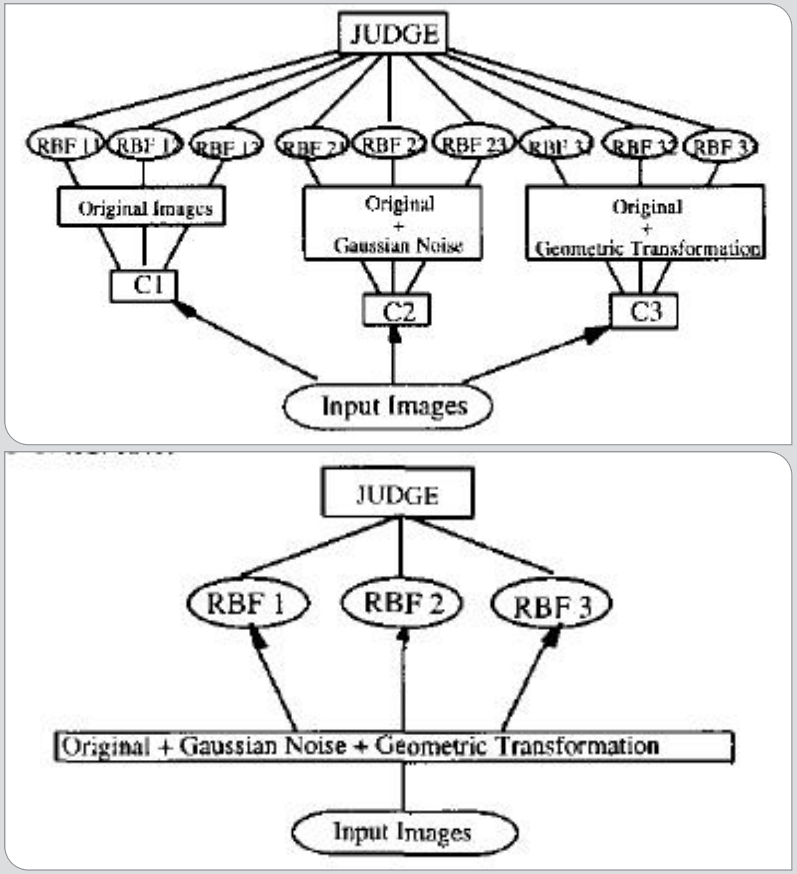


Radial Basis Fuction(RBF) Network

- Ensemble of Radial Basis Fuction 1 (ERBF1)
- Ensemble of Radial Basis Fuction 2 (ERBF2)



Decision Tree (DT)

- These are rules for classifying objects given a training set.
- It implements a top-down divide-and-conquer approach
- The decision tree employed is Quinlan's C4.5

Hybrid Classifier - Experimental Tests (Crossvalidation)

- Experiment was conducted on the FERET data base with 3006 images
- 1009 unique subjects with a resolution of $64x72$ (manually resized)
- 1932 caucasians, 362 mongoloid, 474 oriental, 238 negroid
- 60 (30 caucasians, 10 negroid, 10 mongoloid, 10 oriental) images used to train the DT
- The rest are partitioned into groups of 30 yielding

1. Caucasian (1902/30) = 63 partitions
2. Mongoloid (352/30) = 11 partitions
3. Oriental (464/30) = 15 partitions
4. Negroid (228/30) = 7 partitions

- A 20 fold cross-validation is excecuted by randomly picking 1 partition from each set
- Training with the selected partitions and testing with the rest

Hybrid Classifier - Experimental results

Gender Task	Correct Classification %	Mis-Classification %
RBF	62	38
ERBF1	74	26
ERBF2	82	18
ERBF1 with C4.5	86	14
ERBF2 with C4.5	94	6

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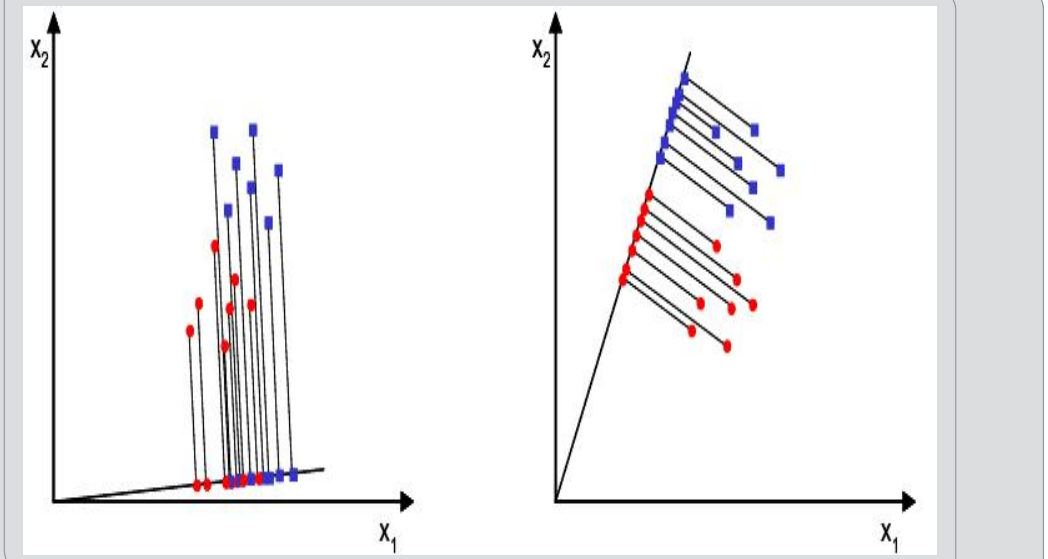
Linear Discriminant Analysis (LDA)

- The objective of LDA is to perform dimensionality reduction
- Preserving much of the class discriminatory information as possible

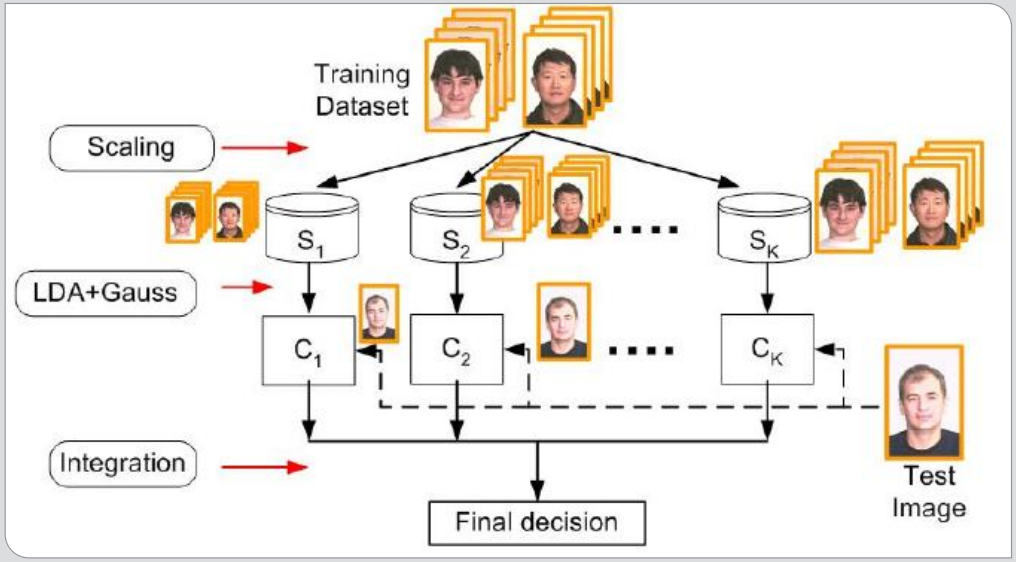


- A single Gaussian is used to model the data distribution

$$p(y|c) = \frac{1}{\sqrt{2\pi\sigma}} exp \frac{-(y-m)^2}{2\sigma^2}$$

Ensembles of LDA at multiple scales

- Images at different scales provide different levels of information
- Each face image is scaled to three different scales.
- A LDA classifier is contructed at each scale.
- Each classifier for every scale



ELDA Experiments

- Each ethnic group is randomly divided into $\frac{2}{3}$ for training and $\frac{1}{3}$ for test
- Data sets are balanced and a 20 fold Cross validation executed
- Data base consisted of 3006 frontal faces (27% asian (east + south)) and the rest non-asian
- Non-asian included are caucasians and negroids
- Average accuracy of 92% achieved

	Asian Accuracy	Non-Asian Accuracy	Total Accuracy
NN at 42×42 scale	97.7% (0.014)	89.3% (0.021)	93.5% (0.011)
NN at 32×32 scale	97.6% (0.015)	90.0% (0.017)	93.8% (0.011)
NN at 24×24 scale	97.2% (0.015)	90.3% (0.021)	93.8% (0.012)
LDA at 42×42 scale	95.8% (0.025)	96.1% (0.019)	96.0% (0.012)
LDA at 32×32 scale	95.6% (0.027)	96.2% (0.017)	95.9% (0.014)
LDA at 24×24 scale	95.7% (0.022)	95.6% (0.017)	95.7% (0.011)
LDA ensemble (product rule)	96.0% (0.025)	96.6% (0.014)	96.3% (0.011)

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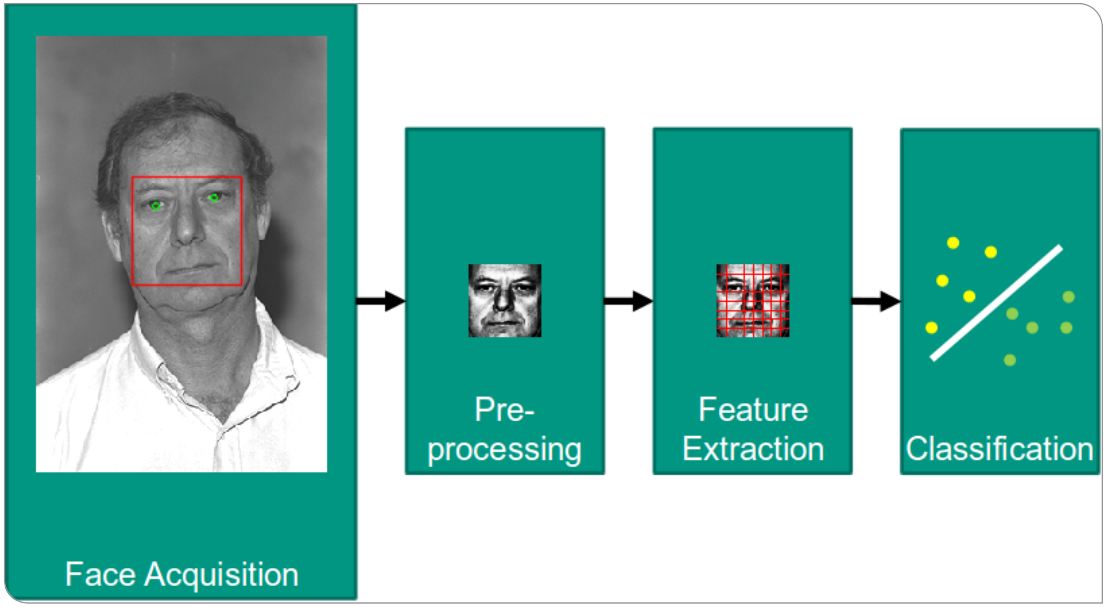


- It uses the Modified Censor Transform (MCT) detector (face and eye)
- Its feature extractor is based on the Discrete Cosine Transform (DCT)
- A cascade of binary Support Vector Machine (SVM) classifiers
- Each is trained to classify a particular ethnic group

2-D Discrete Cosine Transform (DCT)

- DCT expresses a sequence of many finite data points into sums of cosine functions of different frequencies
- It has a strong energy compaction property

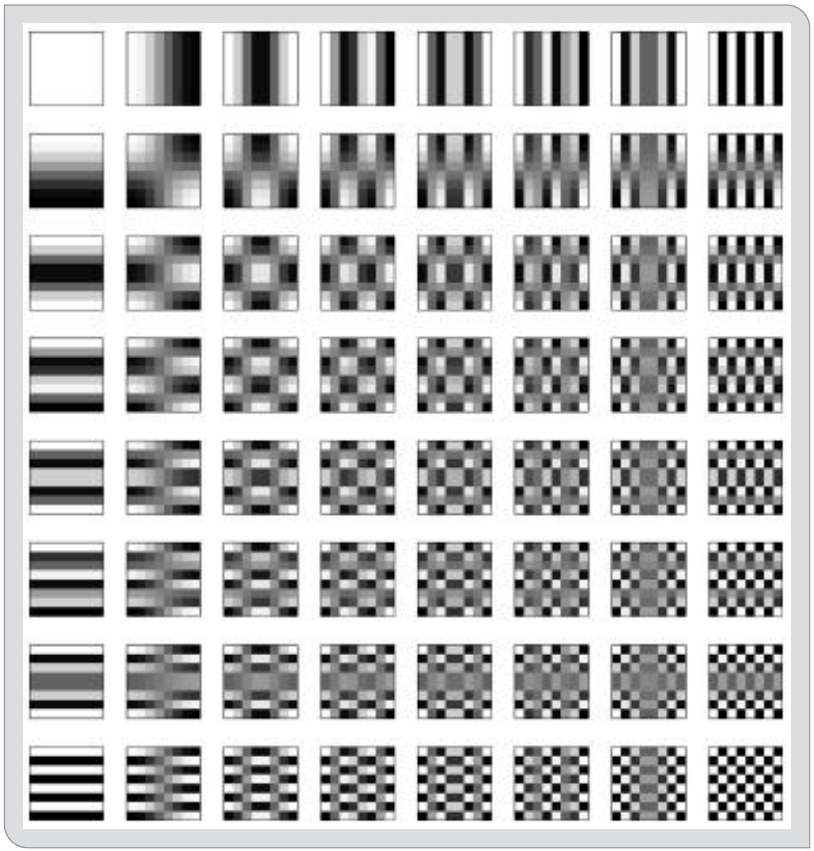
$$C(u,v) = \alpha(u)\alpha(v) \sum_{x=0}^{m-1} \sum_{y=0}^{m-1} \left(f(x,y) \cos\left[\frac{(2x+1)u\pi}{2m}\right] \cos\left[\frac{(2y+1)v\pi}{2m}\right] \right)$$

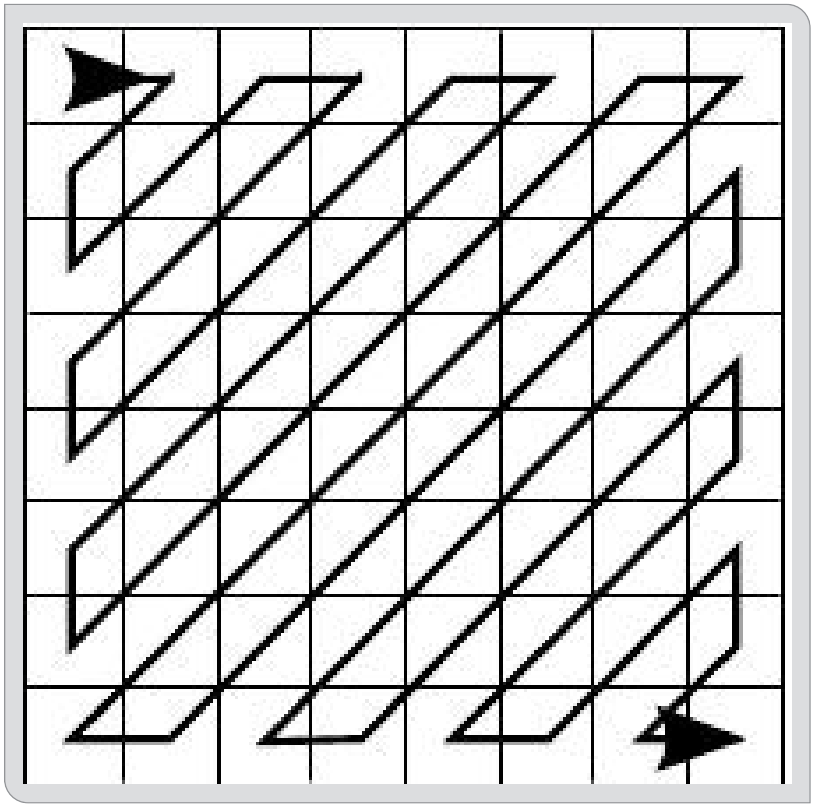
for u, v = 0,1,2,. . . , m-1, where

$$\alpha(u) = \begin{cases} \sqrt{\frac{1}{m}} & \text{for } u = 0 \\ \sqrt{\frac{2}{m}} & \text{for } u = 1,2,\ldots, m-1 \end{cases}$$

2-D Discrete Cosine Transform (DCT)

- Most of the image information tends to concentrate in a few low frequency components





Feature Extractor

- It uses the Local Appearance-based Face Representation (PHD Thesis: Hazim Ekenel)
- Input is a detected face with the greatest bounding box, and eyes' location
- Output is a vector of concantinated coefficients from a DCT

FIPA Ethnic Classifier (EC) - Training

- Experiment was conducted on the LFW data base with 5749 images

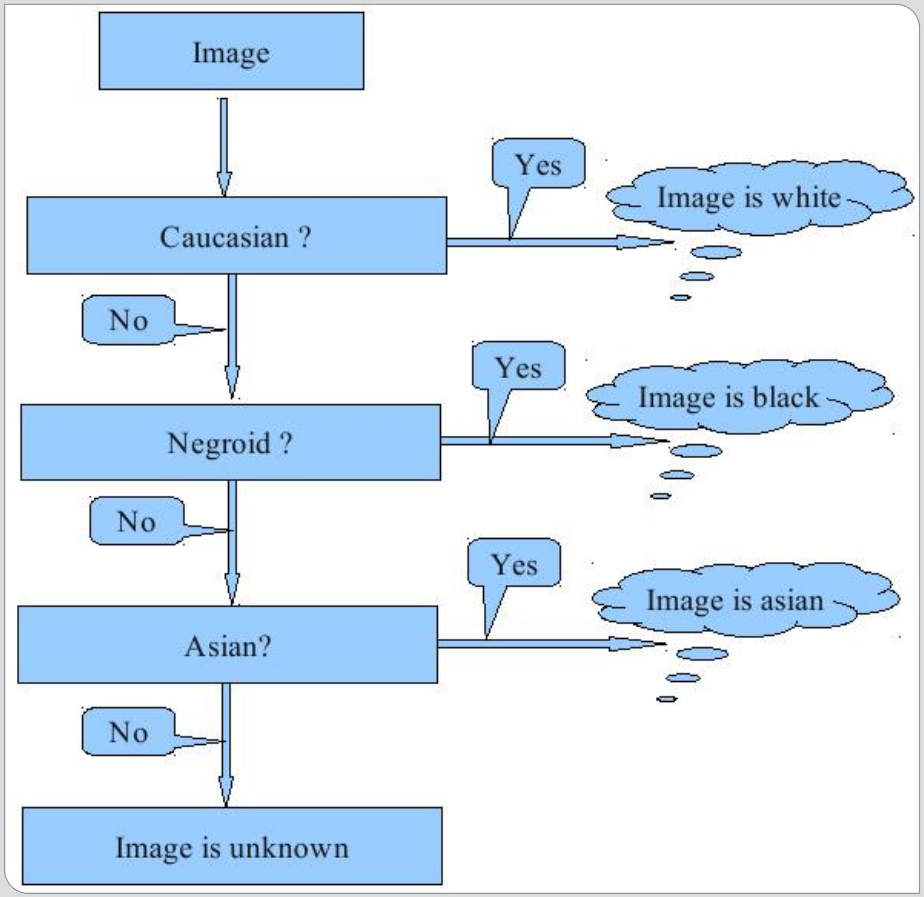


- After labelling I had

1. Caucasian = 4863
2. Mongoloid = 335
3. Negroid = 458
4. Others = 93

FIPA Ethnic Classifier (EC) - Classification

- Classification can be summerized as follows



FIPA Ethnic Classifier (EC) - TODOS

- Refine labelling
- Experiments with different order of classification
- Develope a method to use all the data available for training
- Check for mutual influences (Gender and facial expression)
- Create a cascade of 3 classifiers with 3 different algorithms suitable for each ethnic group

Thanks for your kind attention! Any questions?

References

- H. E. Ekenel, “A robust face recognition algorithm for real world applications”
- Srinivas Gutta et al. ”Gender and Ethnic classification of face images “
- Xiaoguang Lu and Anil K. Jain, ”Ethnicity identification from face images“