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CS 589-04: Image Processing
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FACE RECOGNITION USING HYPERSPECTRAL IMAGES

Outline

- Hyperspectral Imaging
- Eigen Faces
- Face Recognition
- Face Tracking
- Other Methods
- Implementation
- Results
- Future Work
- Conclusion

Project Goals

- Original: Build a real time face detection system for hyperspectral instrument
- Desired: Fast Matlab facial recognition of hyperspectral images
- Objective: Use specific wavelengths from hyperspectral cube to narrow down a face

HYPERSPECTRAL IMAGING

Hypersprectral Imaging [1]

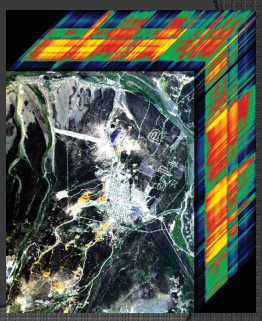
- Hyperspectral images also called “image cubes”
- Have large spectral dimensions
  - Finer granularity
- Have two spatial dimensions
- Combine spectral and spatial information

Hypersprectral Imaging Contd.

- Generally contain dozens to hundreds of bands
- Can sense electromagnetic radiation between 400nm and 2500 nm depending on the sensor
- Can provide unique spectral signatures of objects and materials

Hyperspectral example

- Spectral dimension: Top and right
- True color composite: Front
  - Secondary minerals
    - Red/Orange/Yellow: Acid mine drainage



Ref: http://www.asprs.org/publications/pers/2004journal/april/highlight.pdf

Hyperspectral Applications

- Surveillance
  - Human face detection
  - Human face recognition
- Non-intrusive medical applications
- Target detection
- Material mapping
- Material identification
- Mapping details of surface properties
- ……more

FACE RECOGNITION

Facial Recognition

- Different from face detection
- Applications
  - Identity verification
  - Surveillance
  - Smart environments [3]
    - Human Actions
    - Intention
    - Behavior

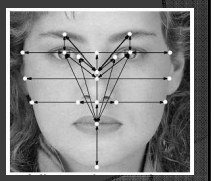
Facial Recognition

Different Methods

- Geometric facial features
- Light fields model
- Thermal infrared
- 3D morphable face model

Facial Recognition [4]

- Different from face detection
- Historical way: Geometry based
  - Point based approach
  - *A priori* feature selection
- Problems
  - Automatic point location
  - Image quality
  - Degradation in rotated images
  - Poor performance on images taken over time



Facial Recognition [4]

- Elastic face matching
  - Warp images
  - Compensates for facial expressions and pose
  - Better than Geometry based
- Problems
  - Rank based system
  - Needs maneuvering of warping parameters

Facial Recognition [4]

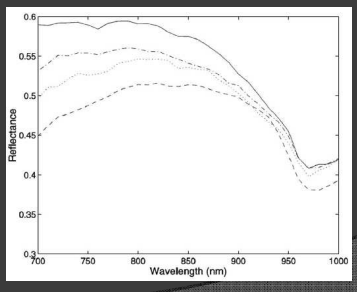
- Neural networks
  - Input unit, gray scale images
  - Training unit
  - Output unit, one per person
  - Uses thresholding and Euclidian distance
  - Better than previous techniques
- Problems
  - Need to have training set
  - Need to train the system

Hyperspectral Facial Recognition [5]

- Hyperspectral cameras provide useful discriminants for human face recognition [5]
- Near Infra Red (NIR) images
  - Larger penetration depth
- Spectral measurements over NIR sense subsurface tissue structure
  - Stable over time
  - Significantly different from person to person

Hyperspectral Facial Recognition [5]

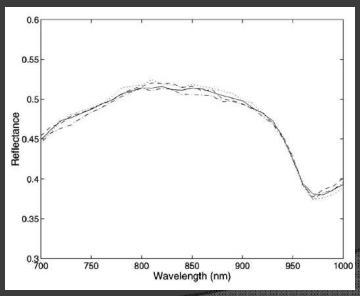
Near-Infra Red skin characteristics



Skin spectra for four subjects

Hyperspectral Facial Recognition [5]

Near-Infra Red skin characteristics



Four skin spectra for one subjects

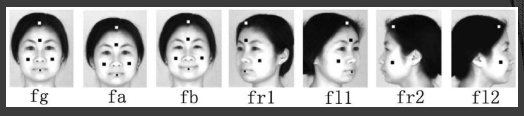
Hyperspectral Facial Recognition [5]

Data set

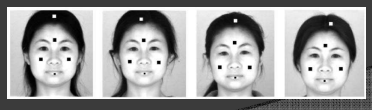
Thirty-one bands for hyperspectral image of one subject

Hyperspectral Facial Recognition [5]

Data set



Examples of images with different expressions and rotations



Examples of images taken at different times

Hyperspectral Facial Recognition [5]

- 200 human subjects
- Spectral reflectance vectors
- Covariance matrices
- Images taken at different time
- System accommodates changes in facial pose

FACE TRACKING

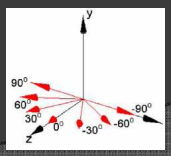
Facial Tracking

- Pose Tracking
- Position Tracking

- Our original aim was to do Position tracking

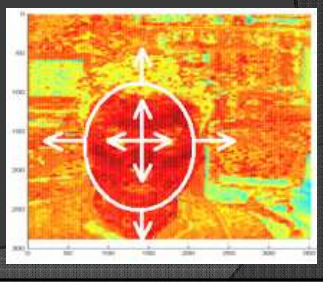
Pose [8]

- Where is the nose pointing
- How is the face tilting
- Why
  - Feature Extraction
- Guideline
  - Mouth
  - Eyes



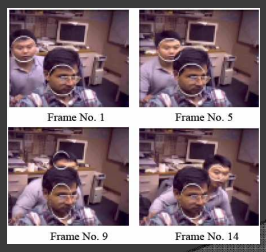
Position – Method [10]

- Statistical pixel grouping
- Deformable template
- Energy function



Position - Difficulties

- Occlusion
  - Percentage
  - Time Period
  - Similarity
- Methods to account for
  - Kalman filtering
  - Constraints



EIGEN FACES

What is an Eigenface? [9]

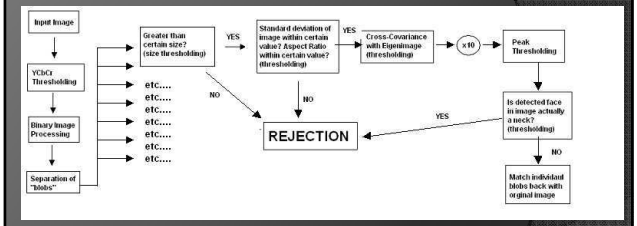
- Not features
  - Not eyes, ears and noses
  - No three dimensional geometry
- Eigen vectors and values
  - Cross covariance matricies
  - Linear combination of Eigenfaces

Process

- Initialization
- New image
  - Calculate weights of new image and eigenfaces
  - Is a face?
- Classify whether the face is known or unknown

GUIDE LINE

Suggested Algorithm [6]



Suggested Algorithm [6]

- Used color RGB images
- Converted RGB to YCbCr
- Cross-covariance with Eigenface to detect a face

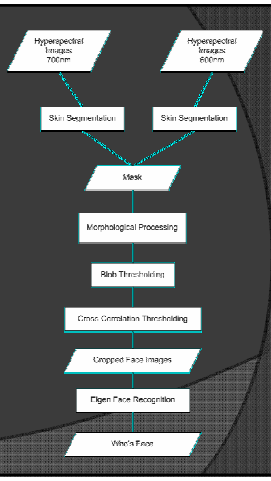
Suggested Algorithm [6]

Eigen Faces

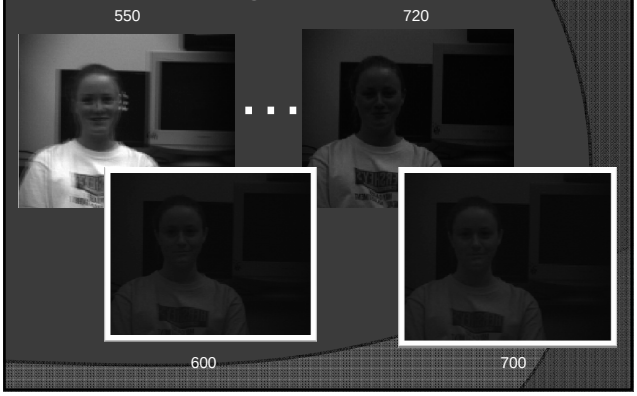
IMPLEMENTATION

Algorithm

- High level view
- Linear process
  - Top->Down
- Time consuming
  - Morphological
  - Blob



Source Images



Segmentation

- Normalized images
- Threshold values
- Combined mask

Intersection

700

600

Morphological Processing

- Stuctural Elements
  - Face Kernel
  - Disk
- Erosions
- Dilations
- Hole Filling

Final Mask

Hole Filling

Erosion

Dilation

Blob Thresholding

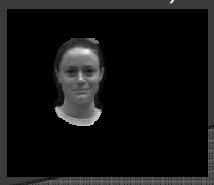
- Link connected components
- Aspect ratio
- Min(size)
- Centroid enclosed

Start

Finish

Cross-Correlation Thresholding

- Select a box centered at blob
- Run cross-correlation with an average face
- Threshold on max(correlation value)



Eigen Face Recognition

- Nearest Neighbor

New Image

Associate Training Image

Implementation

- Disclaimer
  - Our system does not handle faces on the edges of images
  - Did not test for faces of African or Asian descent
  - System test used interior lighting only

Detection Accuracy

Accuracy	Value
Over all Percentage	83.33% -Found the face
Faces/Total Items	11/22 – 50%
Non Faces/Total Items	11/22 – 50%
False Positives (Detection)	2/22 – 9.09%
False Negatives (Detection)	1/22* - 4.55% (Due to problem constaints)

Timing

Timing	Value (seconds)
Overall	156.8420/12 (13.0702) * Included displaying to screen
Segmentation	1.0770/12 (0.2078)
Morphological	11.8750/12 (0.9881)
Blob	136.2240/57(2.3499)
Detection	2.6410/22 (.1200)

Recognition Accuracy

Attribute	Value
Good/ Total	50%
Bad/Total	50%

Results

- Problems
  - Vince
  - Facial Hair
  - Lighting
- Whose image doesn't work and why?

Future Work

- Multi-level skin thresholding
  - Good for Caucasian/Asian/African decent
- Different sized faces
- Fast blob linking
- Better aspect ratio
  - Diagonal orientation
- Better test environment, more robust
  - More people
  - Better lighting
  - Trying NIR

Conclusions

- Our system works with an accuracy of
  - Detection: 83.333%
  - Recognition: 50%
- Hyperspectral images are useful
  - Potential fine tuning for skin based analysis

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