Developing Diferent Skin Detection Algorithms and Defining Data Fusion Mechanism for the Integration of the Scores

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Introduction

- There are many of skin detection methods but the ones using color as detection cue have gained strong popularity.
- Color allows fast processing.
- Human skin has a characteristic color which is easily recognized by humans but is hardly recognized by computers (problems which color space to chose, how color distribution schould be modeled etc.)

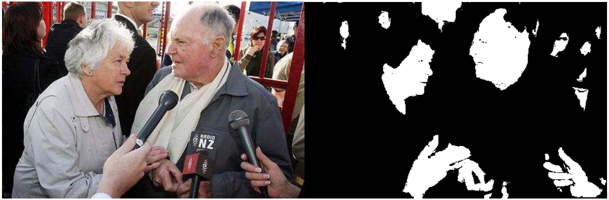
Image selection and preparation 1

- Randomly selected images form web are used in this assignment (different races and ethnic groups)
- Preparation of 'ground truth' images

Image selection and preparation 2

- Trening set

- Test set



- RGB
- HSV (Hue Saturation Value)

$$H = \arccos \frac{\frac{1}{2}((R-G)(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B)}}$$

$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B}$$

$$V = \frac{1}{3}(R+G+B)$$

Skin Modeling

- The final goal of skin color detection is to build decision rule that will discriminate between skin and non-skin pixels.
- Modeling methods
  - Explicitly defined skin region
  - Nonparametric distribution modeling
    - Histogram based Bayes classifier
  - Parametric distribution modeling
    - Single Gaussian

Explicit Skin Modeling

- This metod defines boundaries in some color space by an explicit formula [VSA03]]. (R, G, B) is classified as skin if:

  $R > 95$ and $G > 40$ and $B > 20$ and
  $\max\{R, G, B\} - \min\{R, G, B\} > 15$ and
  $|R - G| > 15$ and $R > G$ and $R > B$

Bayes Classification with Histograms

- The key idea of non parametric skin models is to estimate skin color distribution from the training data without deriving an explicit model of the skin color.
- This method uses an inequality $P(skin|c) > \Theta$ as a skin detection rule, where Θ is a threshold value.
- $P(skin|c)$ is calculated using Bayes rule:

$$P(skin|c) = \frac{P(c|skin)P(skin)}{P(c|skin)P(skin) + P(c|\neg skin)P(\neg skin)}$$

$$\frac{P(c|skin)}{P(c|\neg skin)} > \Theta' \qquad (1)$$

- Both $P(c|skin)$ and $P(c|\neg skin)$ are modeled by histograms.
- RGB and HSV color space variants are used.

Single Gaussian

- Skin color distribution can be modeld by an eliptical Gaussian joint pdf.

$$p(c|skin) = \frac{1}{2\pi|\Sigma_s|^{1/2}} \exp(-\frac{1}{2}(c-\mu_s)^T \Sigma_s^{-1}(c-\mu_s))$$

where

$$\mu_s = \frac{1}{n}\sum_{j=1}^{n} c_j$$

$$\Sigma_s = \frac{1}{n-1}\sum_{j=1}^{n}(c_j-\mu_s)(c_j-\mu_s)^T$$

Data Fusion by Voting

- For every pixel in the input image outputs of each classifier are combined to produce the final result which is the most often predicted label y.

$$C^*(x) = \arg\max_{y=Y} \sum_{i:C_i(x)=y} 1$$

where

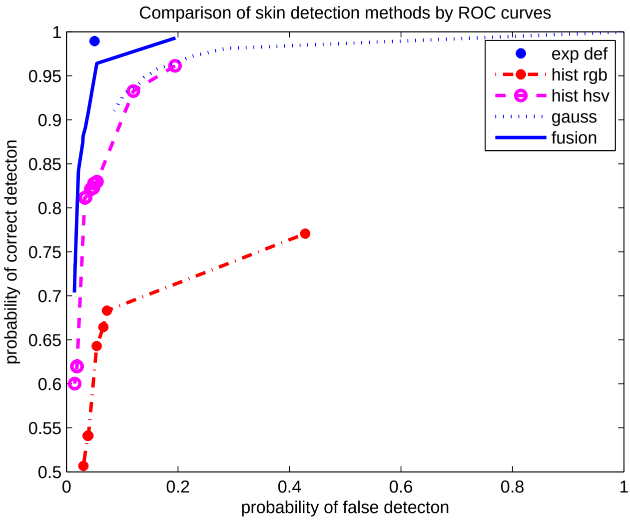
$$C^*(x) - \text{combined output}$$

$$Y - \text{label set - skin and non-skin}$$

$$C_i(x) - \text{output of i-th clasifier}$$

Examples 1

Examples 2


Comparison of skin detection methods by ROC curves
probability of correct detecton
probability of false detecton
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
0.2
0.4
0.6
0.8
1
exp def
hist rgb
hist hsv
gauss
fusion

Future Work

- More comprehensive train and test sets
- Improving existing and adding new classification methods
  - Number of bins in histogram
  - Mixture of Gausians
  - Neural networks
  - SVM
- Other color spaces and dinamic skin distribution models
- Going beyond pixels - regions, fuzzy connectedness, etc.

Conclusion

- Description, comparison and evaluation of results of popular methods.
- Explicitly defined skin color model gives good results as references sugest. [VSA03]
- Histogram based classifier behavious much better in HSV than in RGB color space.
- Parametric skin modeling method is beter suting for constructing classifiers in case of limited trainging and test data set.
- Classification error of individual classifiers can be further reduced by combining the outputs with the other classifiers.

References

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