An Algorithm For Automatic Skin Smoothing in Digital Portraits

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Skin Smoothing Framework

Key to automatic skin smoothing

\[ Y = I(1 - S) + (\alpha I_F + (1 - \alpha)I)S \]

- **Y**: Output image
- **I**: Input image
- **I_F**: Filtered image
- **S**: Skin map
- **\(\alpha\)**: opacity factor (set to 0.5)
Skin Map Generation

1. Portrait
   - Face feature location
   - Skin and non-skin data sampling
   - Gaussian mixture model (GMM) estimation for skin and non-skin data
   - Skin segmentation map generation using Bayesian segmentation
   - Skin segmentation map
   - Neck area expansion
   - Skin map

Face box mask with features unmasked

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Face Feature Location (1): Face Detection

- Multi-view face detector based on the Viola-Jones technique *
- Viola-Jones detector: cascading classifiers
  - Early stage: quickly discards simple non-face region
  - Latter stage: classify more complex cases
- Original Viola-Jones detector detect frontal, upright faces
- Multi-view detector
  - In-plane rotations (0, 90, 180, and 270°)
  - Out-of-plane rotations (left and right profile)

Face Feature Location (2): Face Features

- Seven features of the face are identified: chin, mouth, nose, eyes (2), eyebrows (2)
- Each feature is represented by a polygon defined by a set of points
- Total of 87 points used
- The polygons are aligned using the active shape model (ASM)*

*T. F. Cootes, “Statistical models of appearance for computer vision”, online technical report
Face Feature Location (3): Feature Alignment by ASM

- ASM is a two-stage iterative algorithm
- First stage: optimizes the feature location
  - For each feature point, a new position is searched for in its local neighbors which fits the texture model
  - We use Zhang’s ASM method*: boosted local texture model learned by Real AdaBoost from a large training set based on LUT-type Harr-like features
- Second stage: optimizes the shape parameters based on Bayesian framework
  - Shape parameters are updated to new ones which best fit these new positions

*L. Zhang et al., “Robust face alignment based on local texture classifier,” ICIP 2005
Skin Map Generation (1): Skin and Non-Skin Data Sampling

- **Skin mask creation procedure**
  - Cut lower face -skin area excluding mouth and nostril
  - Unmask eyes and eyebrows
  - Erode the mask by binarization after Gaussian blur

- **Non-skin mask creation procedure**
  - Estimate face ellipse using lower face boundary points
  - Create neck area
  - Unmask face ellipse and neck area (skin region)
  - Re-mask eyes, eyebrows, and lips (non-skin region)

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Skin Map Generation (2): GMM Estimation*

- Each skin and non-skin class is modeled as a GMM
- Input data is a 3-dimensional vector in RGB with length smaller than 1000
- Initial number of clusters $K$ is set to 20, the final $K$ is usually smaller than 10

*C. Bouman, “CLUSTER: an unsupervised algorithm for modeling Gaussian mixture.”
Skin Map Generation (3): Bayesian Segmentation

Using the estimated GMM, we segment the portrait into skin and non-skin regions by Bayesian segmentation.

- Multiscale random field (MSRF) in conjunction with sequential MAP estimator (SMAP) is used.
- Skin regions are identified with high accuracy, especially hair and beard regions.
- Some areas missing; false positives in the features and backgrounds.

* C. Bouman and M. Shapiro, “A multiscale random field model for Bayesian image segmentation” IEEE TIP, 1994
Skin Map Generation (4): Combining Segmentation Map and Face Box, Neck Expansion
Skin Smoothing Result

Original portrait

Enhanced portrait

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Skin Smoothing Result (cont ’d)

Original portrait

Enhanced portrait
Conclusions

- An algorithm for automatic skin smoothing has been successfully implemented.
- The region of interest can be found by combining the face feature information and appropriate segmentation.
- The skin map obtained by the Bayesian segmentation using SMAP and MSRF with skin and non-skin GMM as a prior model produced very accurate skin map.