3D face reconstruction in a binocular passive stereoscopic system using face properties

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Overview

- Thesis subject
- Introduction to 3D reconstruction in passive stereo system
  - Definition
  - Related works
- Problems and Main Idea
  - Adherence and aperture problem
  - Main idea: Active shape model
- Proposed method
- Experiments and results
  - Bumblebee images
  - 3D texas database
- Conclusion and perspectives
Thesis subject

Face recognition by fusion depth and texture cues

Steps:
- Face depth estimation
- Face recognition
Thesis subject

- Face recognition by fusion depth and texture cues

- Steps:
  - Face depth estimation
  - Face recognition
Given two or more images of the same scene or object, compute the depth information of all the constituent points.

How can we estimate the 3D Information?

- Definition of a stereo matching scheme
Binocular Stereo matching

- Find pixels in both images that correspond to the projection of the same real word point.
- Block-matching (Correlation)
- A disparity map
  - What is disparity?
Related works

- 3D morphable model based method
  - Sparse 3D points:
    - using correlation method [Vuong et al. 2010]
    - Manually [Unsang et al. 2006]
  - Limits
    - high cost of processing time related to the fitting step
    - Manual selection
    - Resulting faces are more similar to the generic model than to their specific model.

- Iterative raffinement
  - differentials constraints [Lengagne et al. 2000]
  - Limits
    - Additional computation cost:
      - calculation of the principle curvatures
      - Iterative process

- Merging Stereo and Structure From Motion processes [Wu et al. 2008], [Chow et al. 2009]
  - Limits:
    - both processes are very sensitive to the lighting conditions.
Problems:

- **Aperture problem**: the context can be too small in certain regions, lack of information.
- **Adherence problem**: intensity discontinuities influence strongly the estimated disparity and if it corresponds with a depth discontinuity, we have a tendency to dilate the front object.

- O : aperture problem
- A : adherence problem
Problem
  ◦ Face → homogenous areas → Aperture problem

Main Idea
  ◦ Incorporating prior information about face in the estimation process while maintaining its real-time suitability.
Proposed method

- Photo-consistency (Correlation) + prior information on face shape by using an Actif Shape Model (ASM) [Milborrow et al. 2008]

Steps:
- Fitting the ASM on the stereo pair and construction of a disparity model
- Model cutting and disparity intervals calculation
- Disparity calculation: Somme of Absolute Difference based Block matching method.
Proposed method

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\[ L = \{(x'_i, y'_i), i \in [1, n]\} \quad R = \{(x_i, y_i), i \in [1, n]\} \]

Euclidean Distance

\[ d = \sqrt{(x_i - x'_i)^2 + (y_i - y'_i)^2} \]

\[ P = \{p_i (x, y, d), i \in [1, n]\} \]
Proposed method

- Steps:
  - Fitting the ASM on the stereo pair and construction of a disparity model
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\[ I(p) = [D_{\text{min}}_p, D_{\text{max}}_p] \]

- \( D_{\text{min}}_p \) is the disparity associated to the plane \( P_n \)
- \( D_{\text{max}}_p \) is the disparity associated to the plane \( P_{n+1} \)
Proposed method

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Given:

- Two images $I_l$ and $I_r$
- $[m \times n]$ correlation window
- Disparity interval $\{l \mid d \in I\}$

\[
SAD(I_l(x, y), I_r(x', y')) = \sum_{u=0}^{m} \sum_{v=0}^{n} |I_l(x + u, y + v) - I_r(x' + u + d, y' + v)|
\]
Experiments and results

- Algorithm’s Parameters
  - Number of cutting plan: 4.
  - Disparity Interval: automatically defined.
  - Aggregation window: 11 x 11.

- Correlation vs. Proposed method
  - Acquisition: Bumblebee stereo camera.
  - Baseline: 12cm.

![SAD result](image1.png) ![Our method result](image2.png)
Experiments and results

- Estimated depth maps vs. Ground
  - Database: Obtained from "Texas 3D database" [Gupta et al. 2010].
  - Baseline: 18cm

Ground truth

Proposed method

Correlation method
Experiments and results

- Similarity matrix
  - Model reconstruction from depth maps and stereo parameters
  - Matrix Values: ICP (Iterative Closest Point)
  - 50 points, 100 iteration

\[ \bar{E} = 0 \text{ mm} \]

\[ \bar{E} = 62.02 \text{ mm} \]

\[ \bar{E} = 220.92 \text{ mm} \]

\( \bar{E} \) is the mean Error of the matrix diagonal
Conclusion and perspectives

- Proposed method
  - Integrating prior information of the face shape in the Intensity-based correlation method
  - Advantages
    - Coherent and efficient estimation of the estimated depth information
    - Less holes and less spikes
    - Speed
  - Limits
    - Sensitive to occlusion and large pose variation
Conclusion and perspectives

- Active Appearance Models
  - Texture
- 3D Active Appearance Models
  - Pose variation

- Comparing time and results of our method to other existing methods
References

- Vuong Le, Hao Tang, Liangliang Cao, and T.S. Huang, “Accurate and efficient reconstruction of 3d faces from stereo images. (ICIP),


