NATIONAL UNIVERSITY OF SINGAPORE
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A Minimalist Approach To Facial Reconstruction

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Presentation Outline

1. Introduction
2. Overview of the Solution
3. Feature Extraction
4. Reconstruction
5. Results/Demo
6. Conclusion

1. Introduction

•Introduction
Motivation
Background
Our Solution
Caricature
Advantage
Differential
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Considerations
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- Motivation - Potential Applications
  - Games and Movies
  - Virtual Environments
  - Next Generation Interfaces
  - Low-Bandwidth Video-Conferencing

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- Background (more than 25 years)
  - A Morphable Model for the Synthesis of 3D Faces
    - Blanz and Vetter, SIGGRAPH 99
  - Synthesizing Realistic Facial Expressions from Photographs
    - Pighin et al., and Guenter et al. SIGGRAPH 98
  - Model Based Face Reconstruction
    - Lee et al., MMM 97
  - ……
  - Rendez-vous a Montreal
    - Magnenat-Thalmann and Thalmann, IEEE CGA, 87
  - ……
  - Animation of Faces
    - Parke, ACM Annual Conference, 72

1. Introduction

- Our Solution
  - Minimalist approach - Perceptive Realistic 3D Face
    - Minimal number of input images
      - Easily available equipment
      - Low quality input
    - Minimize manual intervention
      - No camera calibration
  - Ideas
    - Make better use of facial characteristics
    - Maximize cognitive experience

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1. Introduction

- Work of cognitive psychologists inspires our solution
- Cognitive Considerations
  - Stevenage 95, Johnston and Ellis 95, in Cognitive and Computational Aspects of Face Recognition: Explorations in Face Space
  - Caricature Advantage
  - Differential Inversion
- Anatomical Considerations
  - Similarities
  - Differences

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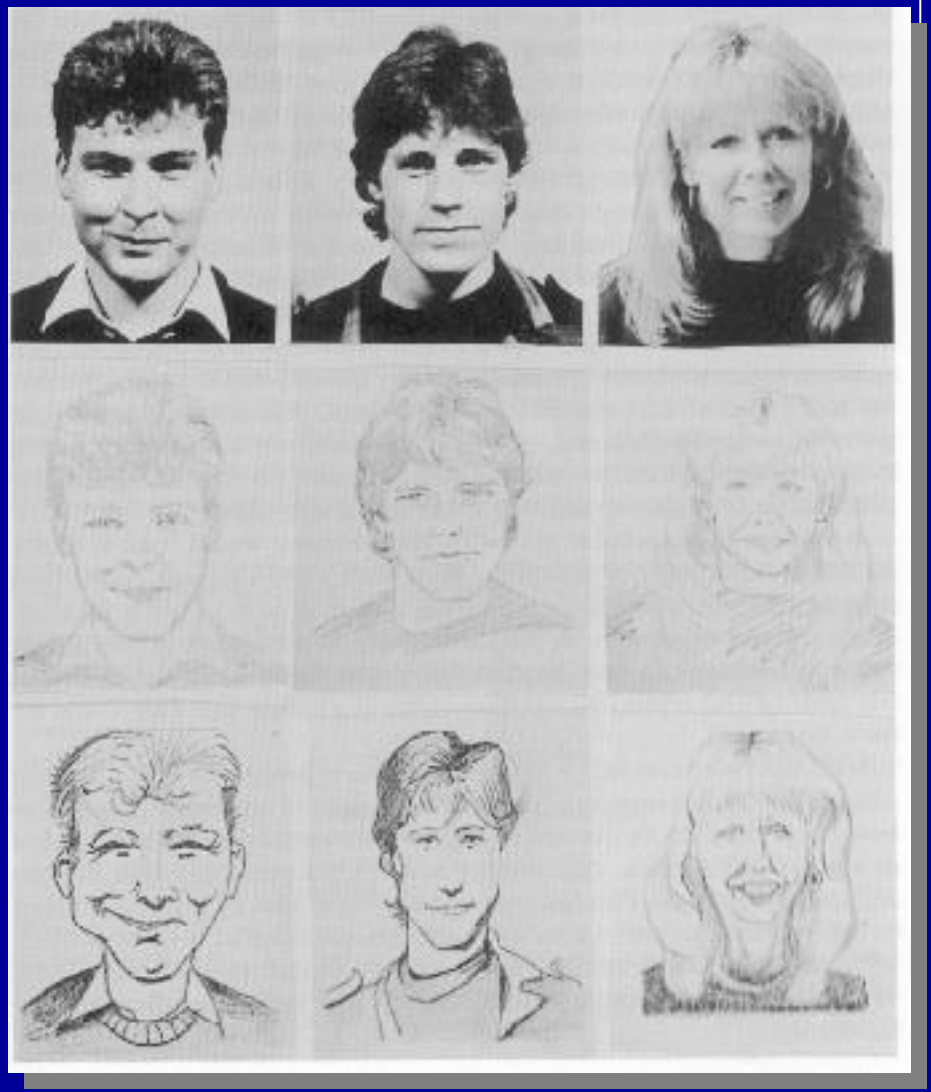
1. Introduction

- Caricature Advantage



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- Differential Inversion

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- Differential Inversion

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- Anatomical Considerations (Parke and Waters 96)
  - The skull and the jaw fit into an egg-like shape
  - The eyes are located halfway between the top of the head and the bottom of the chin
  - The eyes are about one eye's width apart
  - ……

2. Overview of the Solution

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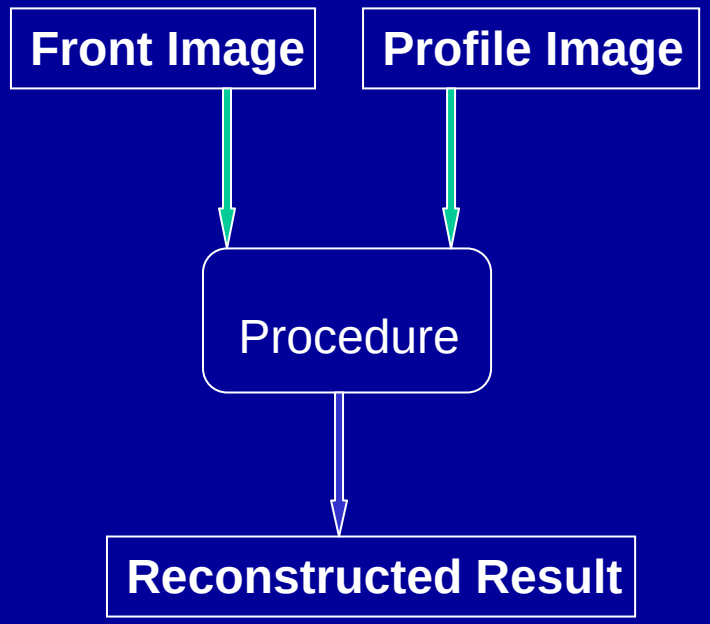
- Procedural Overview



2. Overview of the Solution

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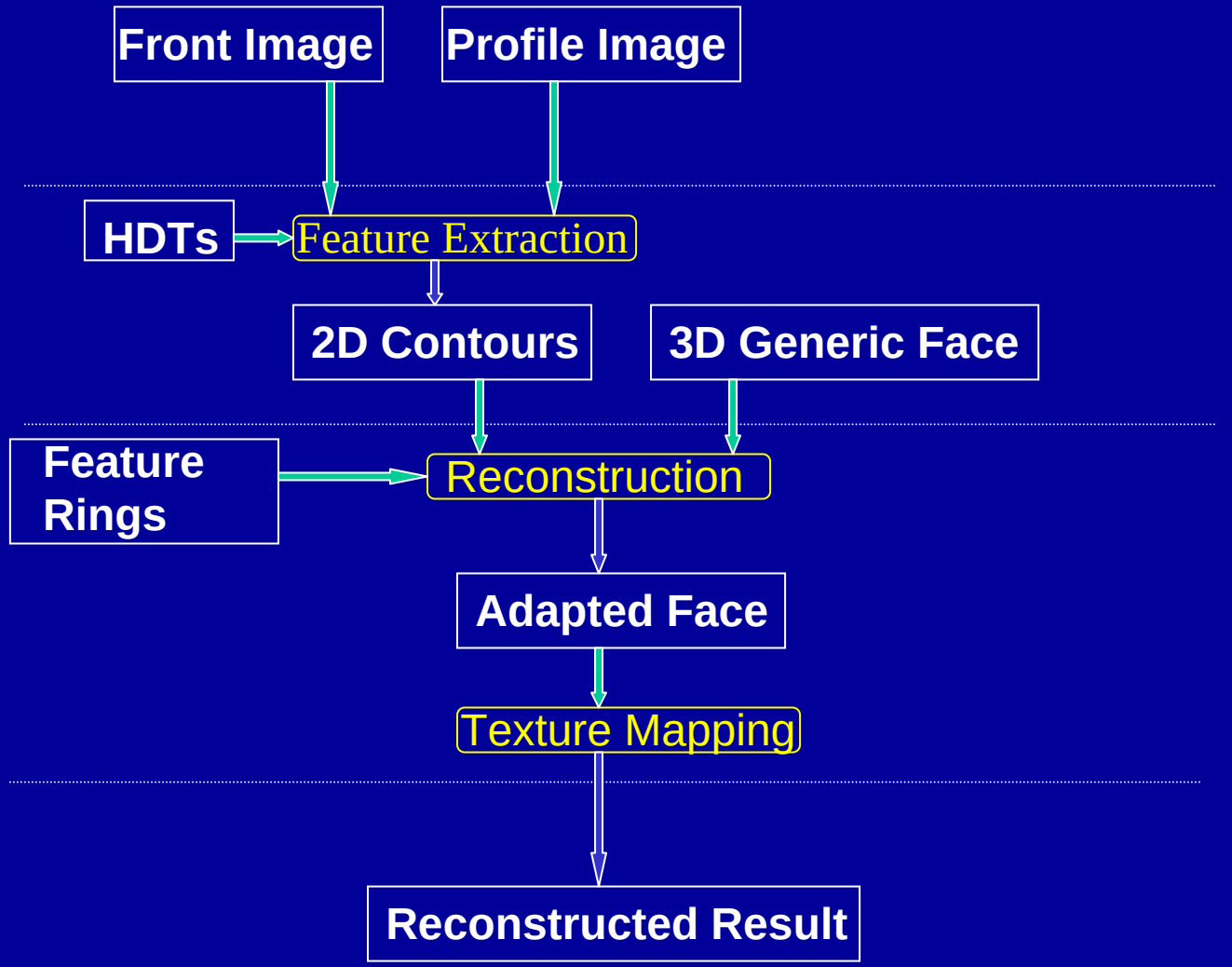

3. Feature Extraction

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- Overview of Extraction Component
- Snake
- Physics-Based Snake Formulation
- Hierarchical Deformable Templates (HDTs)

3. Feature Extraction

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- Overview of Extraction Component
  - Input:
    - One or two images
    - Hierarchical Deformable Templates (HDTs)
  - Output:
    - 2D Contours

3. Feature Extraction

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- Snakes (Kass, Witkin, and Terzopoulos, ICCV 87)
  - Novel way to solve contour tracing
  - Energy Minimizing Spline guided by
    - Internal Force (Hooke's Law)
      - Elasticity
      - Stiffness
    - External Forces
      - Image Gradients, etc.
    - Additional Constraining forces
      - Application dependent

3. Feature Extraction

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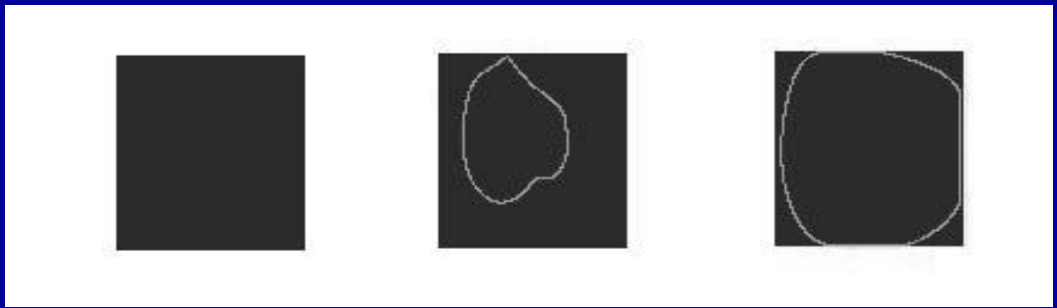
- Formulation of the Snakes

$$E^{*}_{Snake} = \int_{0}^{1} E_{Snake}(v(s))ds$$

$$= \int_{0}^{1} E_{Internal}(v(s)) + E_{\mathrm{Im}age}(v(s)) + E_{Con}(v(s))ds$$

SAMPLE SNAKE BEHAVIOUR



3. Feature Extraction

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- Hierarchical Deformable Templates (HDTs)
  - Motivation
    - Encode Anatomical Expertise
    - Disciplining Snakes

3. Feature Extraction

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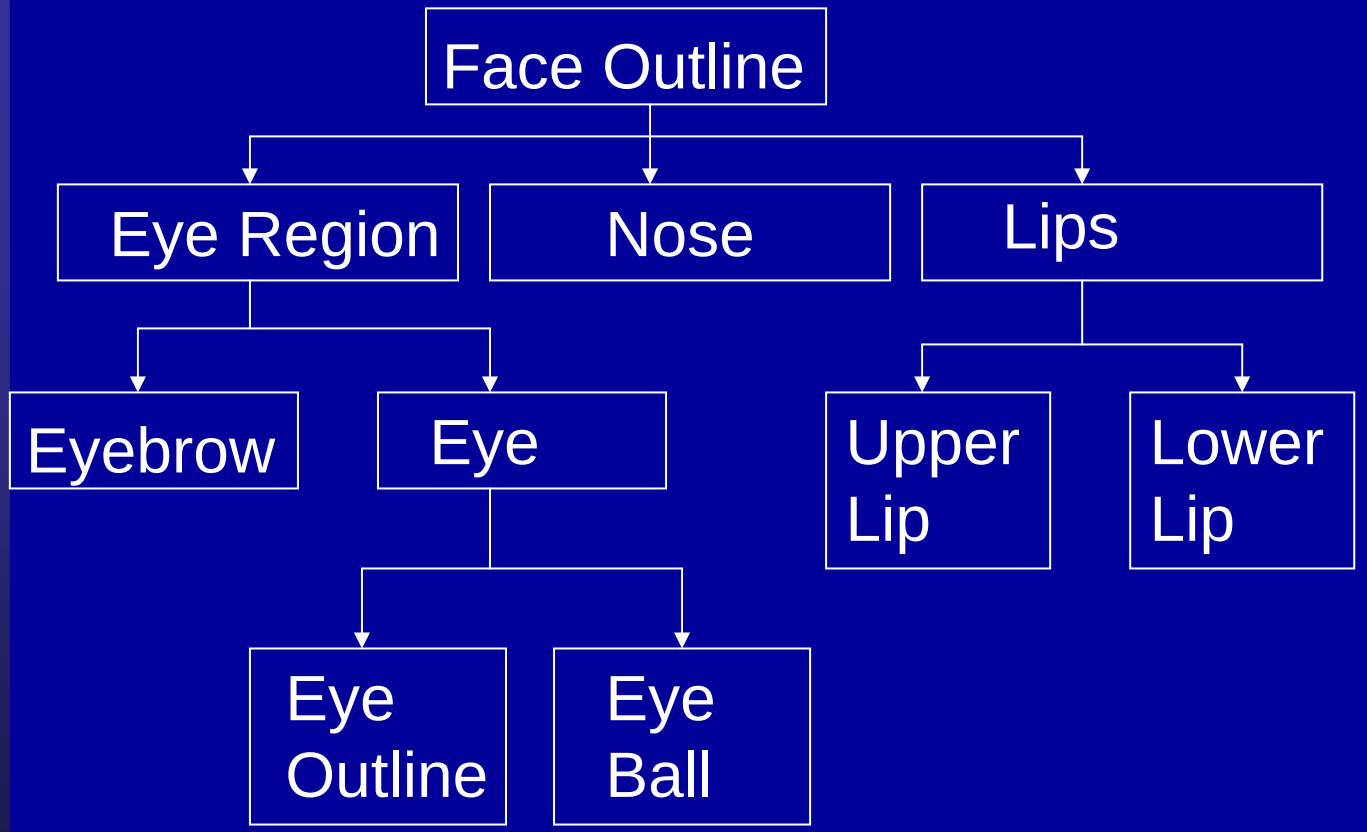
- HDTs



4. Reconstruction

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- Deformation Stage
- Texture Mapping Stage

4. Reconstruction

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- Deformation Stage
  - Input
    - 2D Contours from Extraction
    - 3D Generic Face
    - 3D Feature Rings
  - Output
    - Adapted Face

4. Reconstruction

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- Feature Rings
  - Formed by feature vertices of a generic face (3D correspondence of HDTs)
  - They are deformed first according to the 2D contours
- Non-feature Vertices
  - They are deformed according to the displacements of feature ring

4. Reconstruction

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  - Deformation
  - **Feature Rings**
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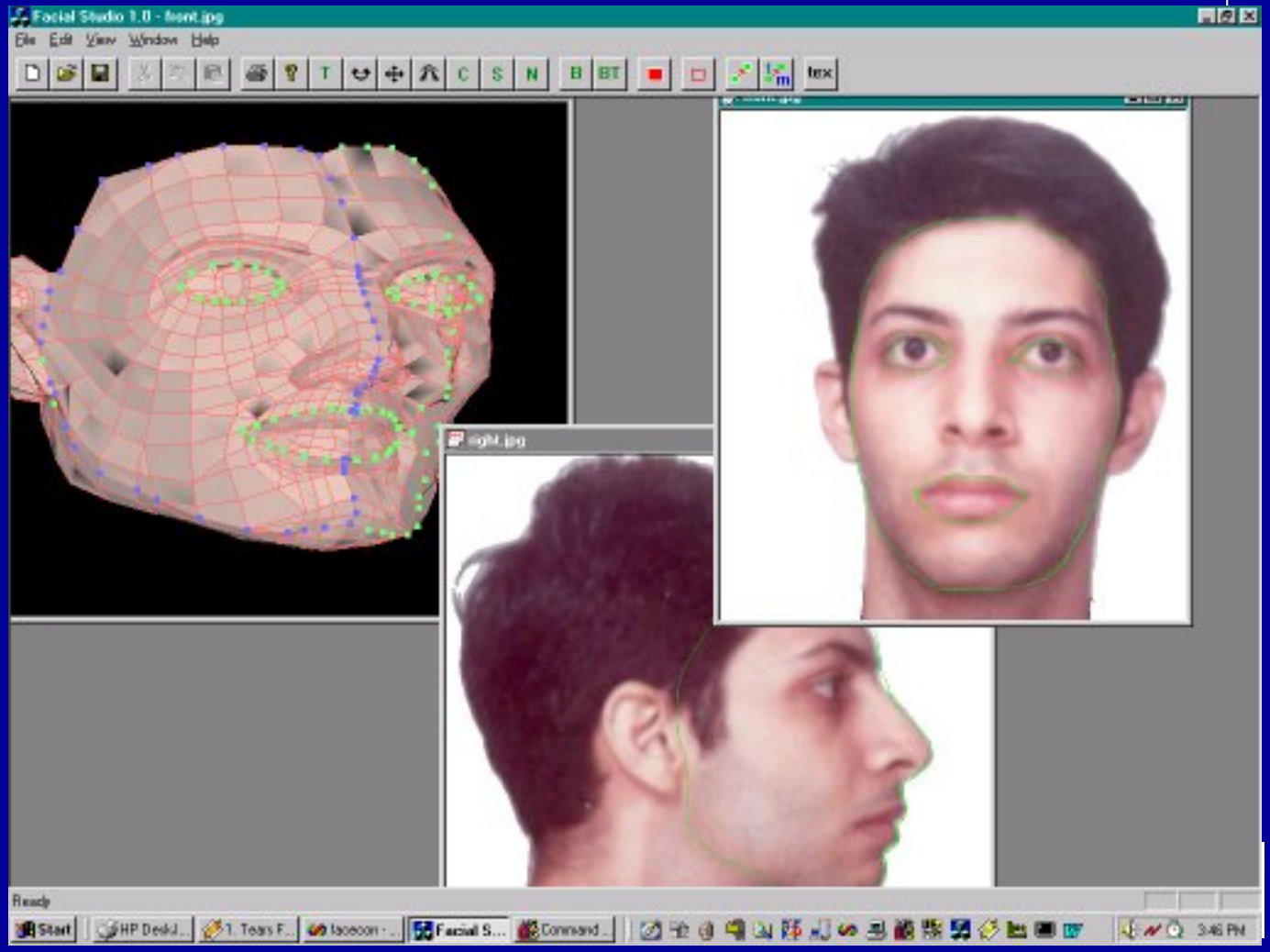
- Feature Rings



4. Reconstruction

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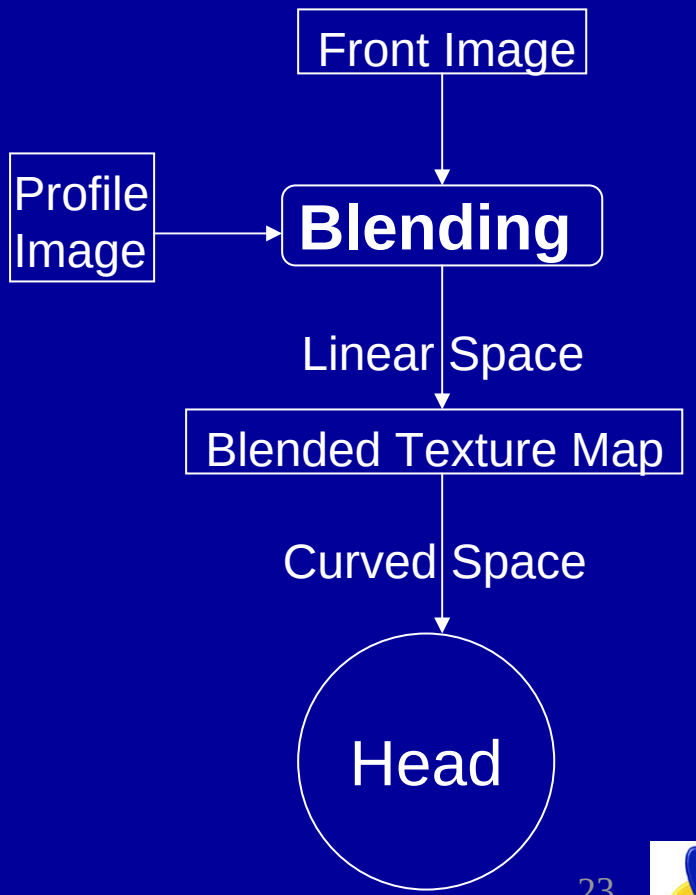
- Texture Mapping Process
  - Producing the Blended Image
  - Transform from Texture to Model Space



4. Reconstruction

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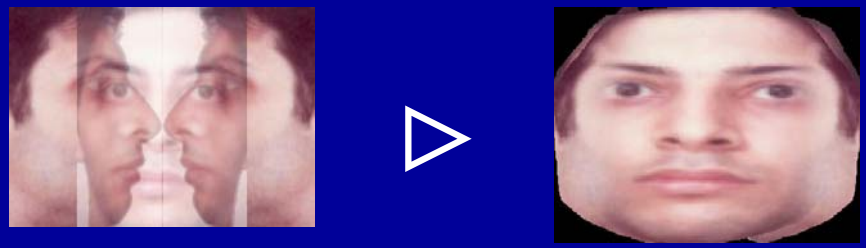
- Texture Mapping
  - Input/Output



5. Results/Demo

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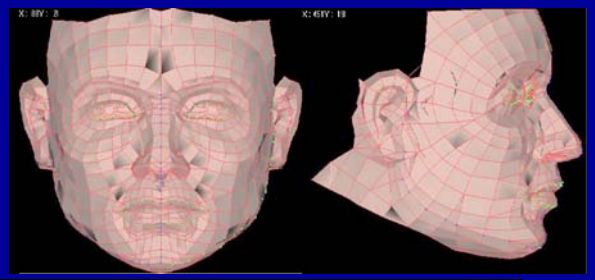

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5. Results/Demo

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- Using only one portrait

6. Conclusion

- Contribution
  - We proposed a minimalist approach to facial reconstruction
  - We applied cognitive and anatomical heuristics
- Future Work
  - Further Enhancing Snakes
  - Better Texture Mapping
- Acknowledgement
  - NUS grant RP3982704

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Acknowledgement