

Robot Vision: A Holistic View

Contents

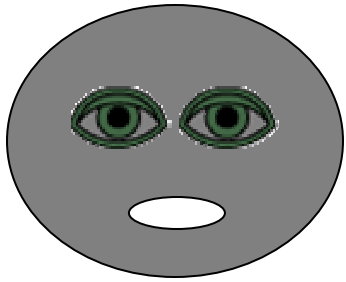
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge

Reconstructive Vision



Contents

- Introduction

Introduction

- Forward Reconstruction

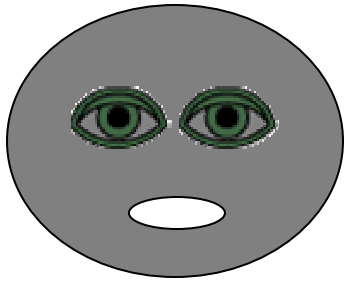
Forward Reconstruction

- Backward (or Inverse) Reconstruction

*Backward (or Inverse)
Reconstruction*

- Future Challenge

Future Challenge



Contents

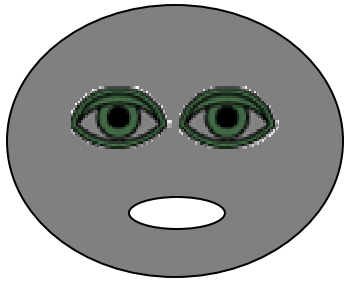
Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge

Introduction

- Reconstructive vision is popularized by David Marr, Olivier Faugeras, Takeo Kanade, and many others.
- Reconstructive vision studies the aspect of inferring 3D geometry of a scene or object from (stereo) images. It is believed that reconstructive vision is a necessary step before visual guidance in robotics, and object recognition in machine perception.
- The general setting of reconstructive vision is a vision system with two cameras.
- In practice, one can add in more cameras to form special arrangements, such as: multiple-view, or multiple-focus, vision.
- However, the scientific problems concerning reconstructive vision are the same. They are: a) calibration, b) binocular correspondence, and c) geometry estimation.
- But, the most critical problem is “binocular correspondence”!!!



Introduction

Binocular vision has, at least, two eyes.

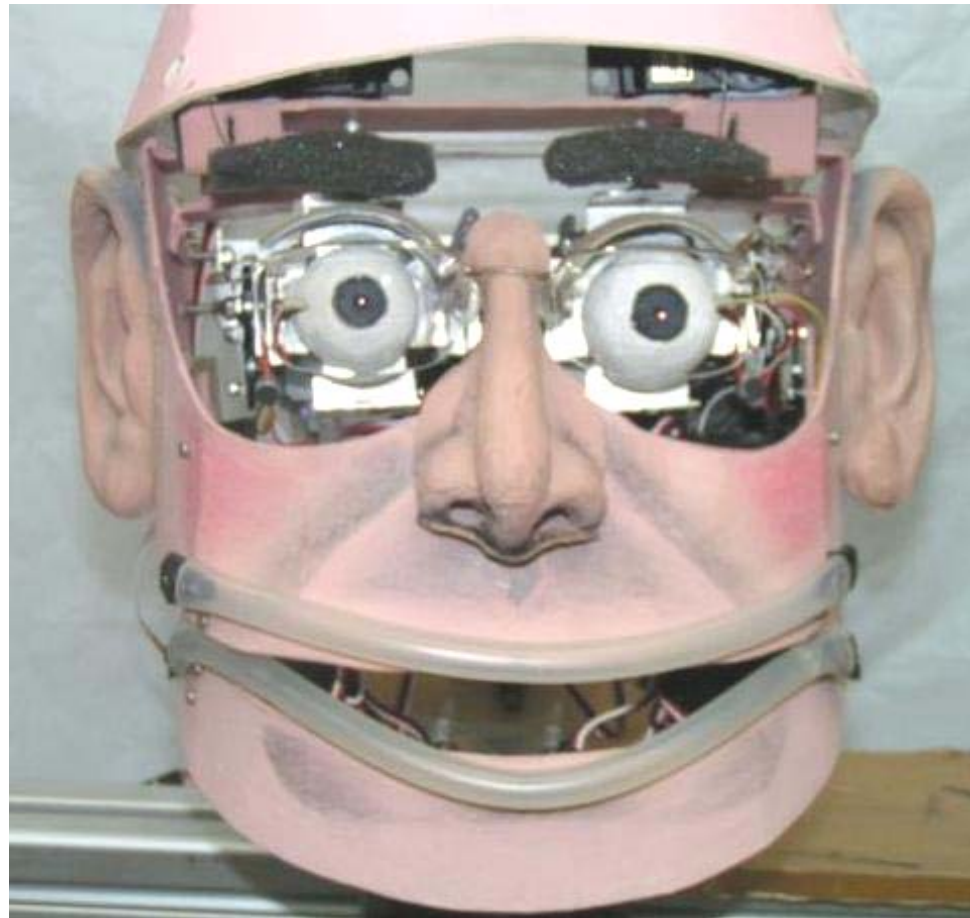
Contents

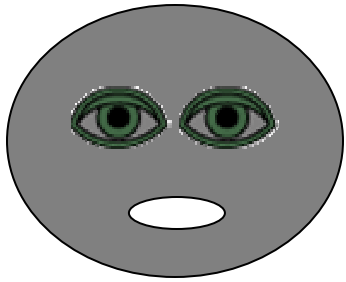
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge





Introduction

The Most Critical Problem: Binocular Correspondence

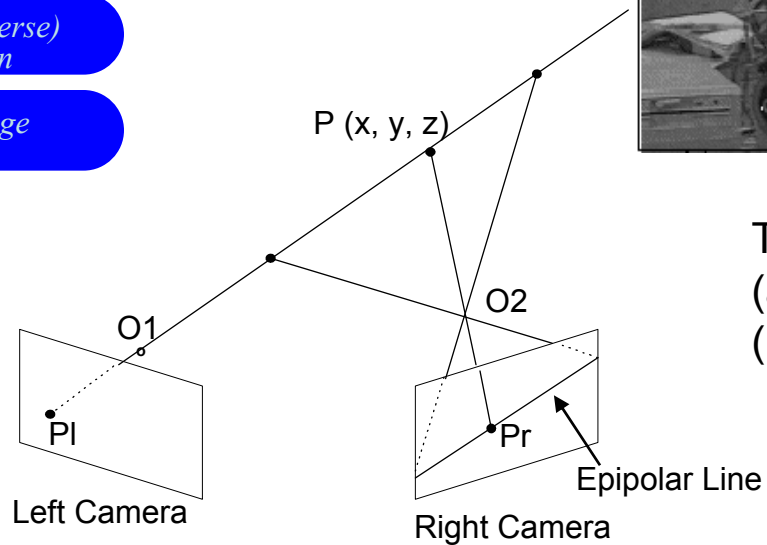
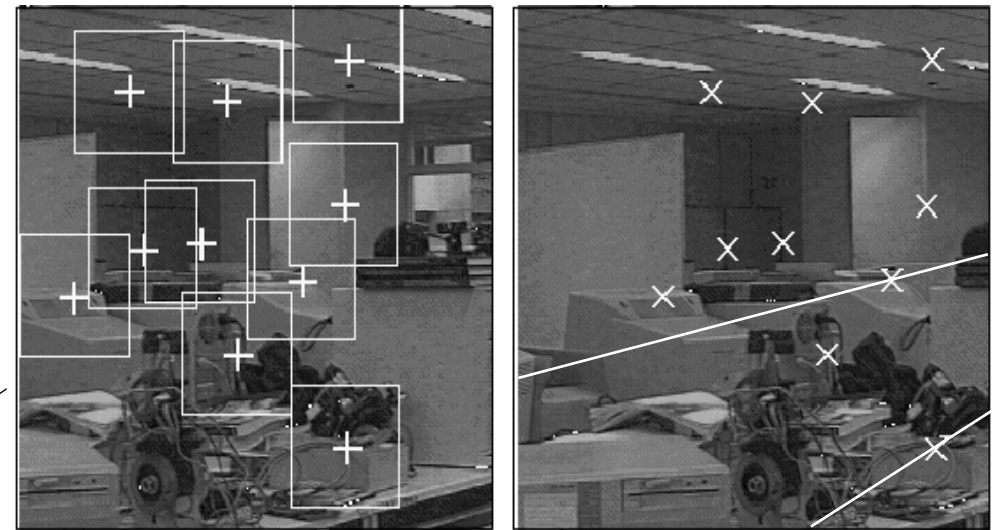
Contents

Introduction

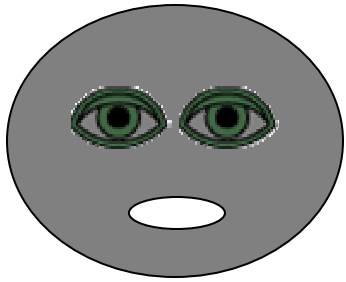
Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge

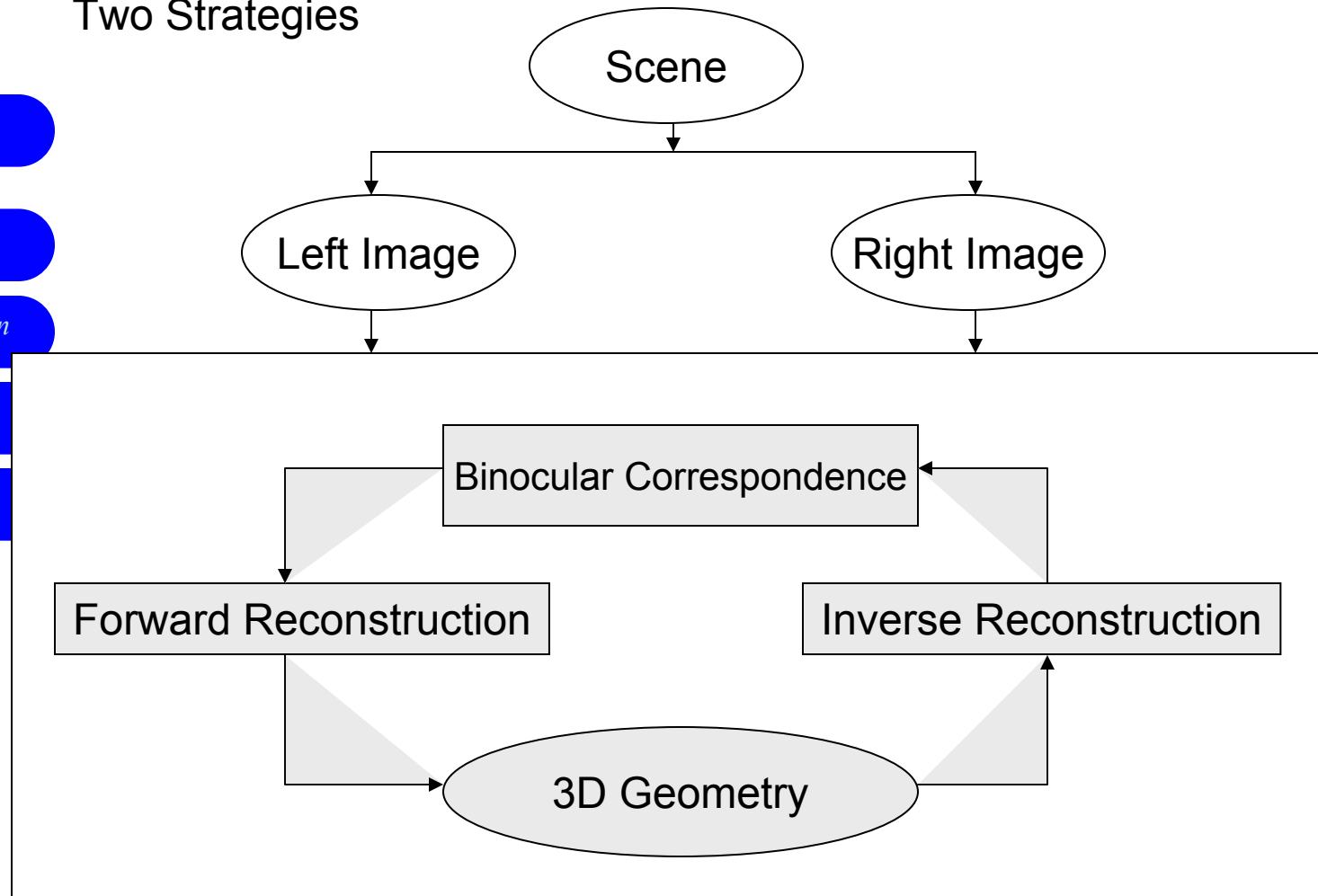


This difficulty leads to two strategies:
(a) Forward Reconstruction, and
(b) Backward (or Inverse) Reconstruction.



Introduction

Two Strategies



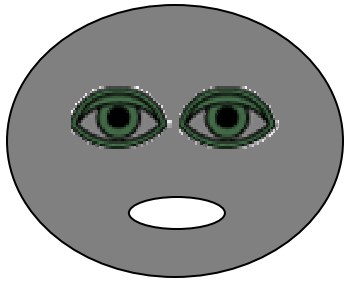
Contents

Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge



Contents

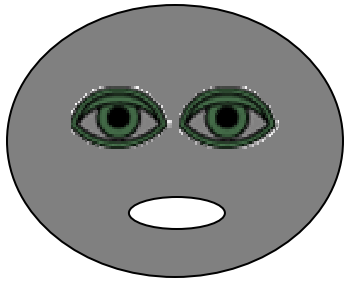
Introduction

*Backward (or Inverse)
Reconstruction*

Future Challenge

Forward Reconstruction

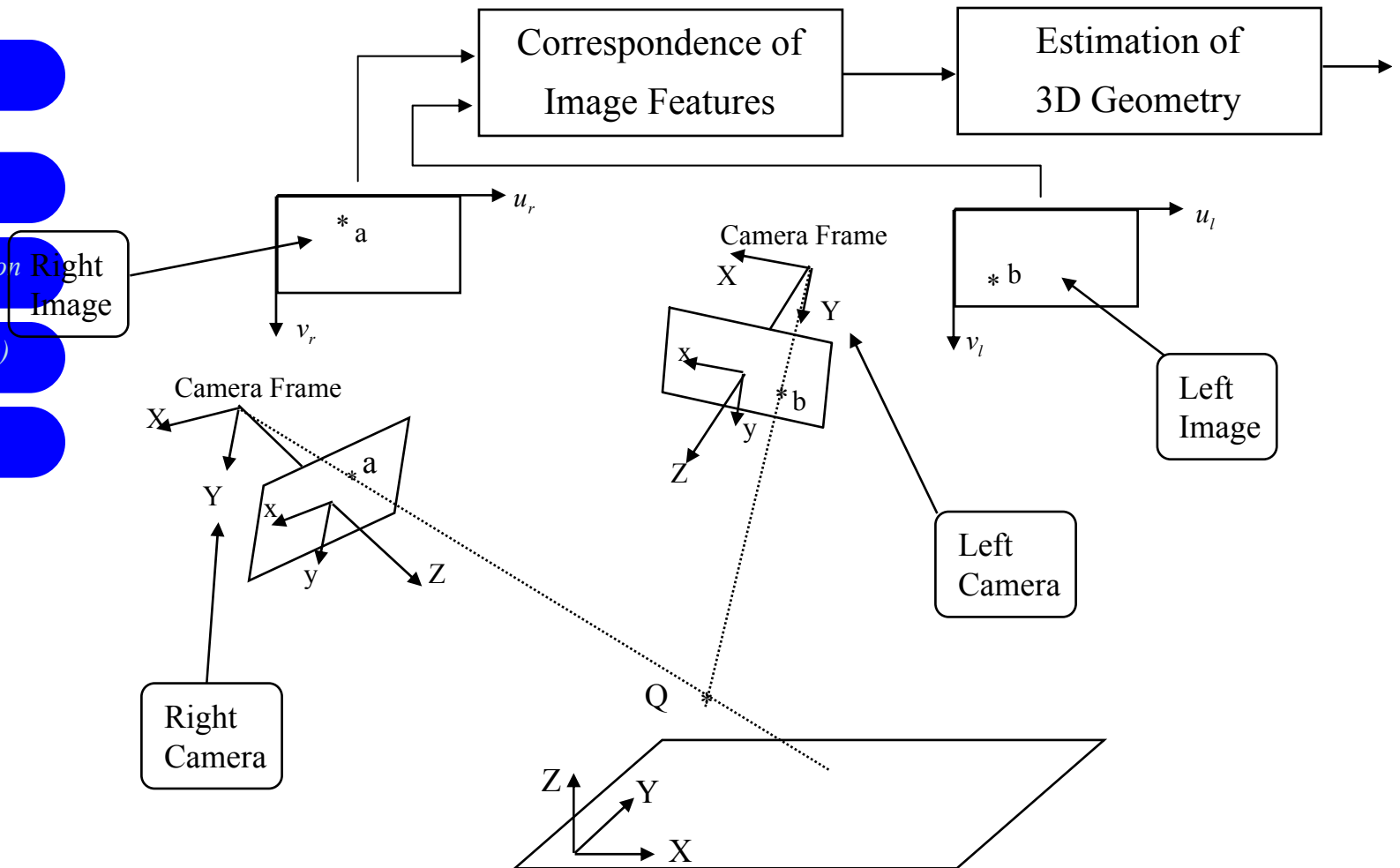
- In its standard version, the forward reconstruction starts with binocular correspondence, which is also called stereo matching.
- So far, there is no commonly accepted solution to binocular correspondence.
- This explains why there are so many stereo matching algorithms in literature, each of which has its own merits and shortcomings.
- However, it is noted that it is relatively easy to tackle stereo matching with more structured features than with individual pixels.
- Given the correct results of binocular correspondence, it is straightforward to estimate 3D geometry, assuming that the cameras are calibrated.

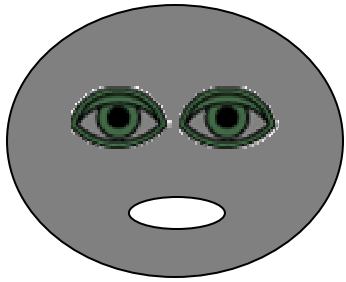


Forward Reconstruction

Illustration

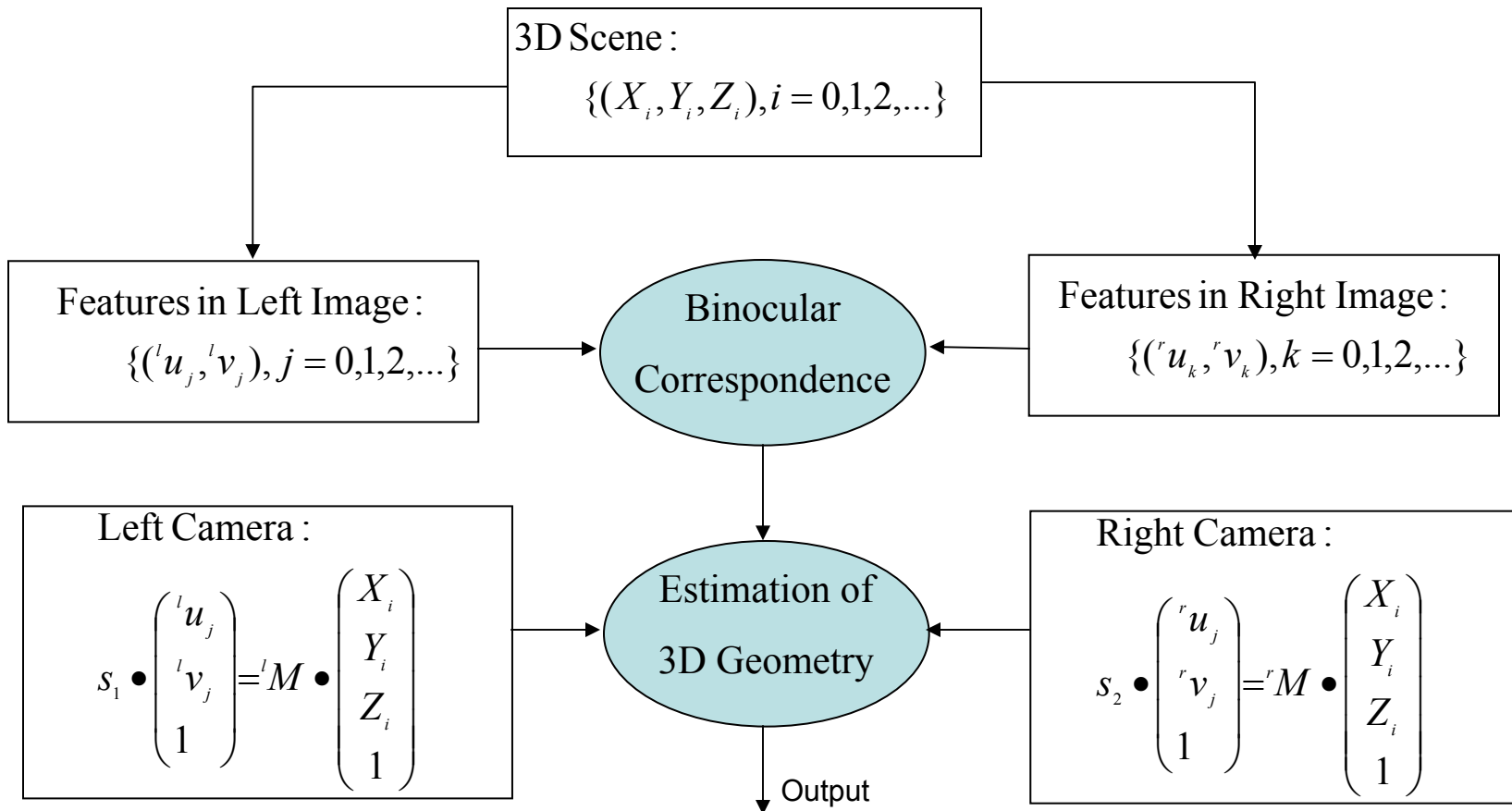
- Contents
- Introduction
- Forward Reconstruction**
- Backward (or Inverse) Reconstruction
- Future Challenge

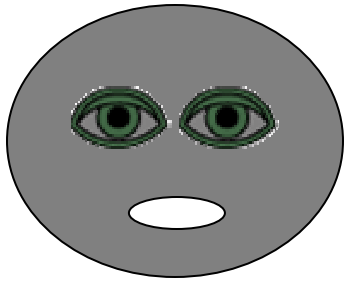




Forward Reconstruction

Schematic Diagram





Forward Reconstruction

Example

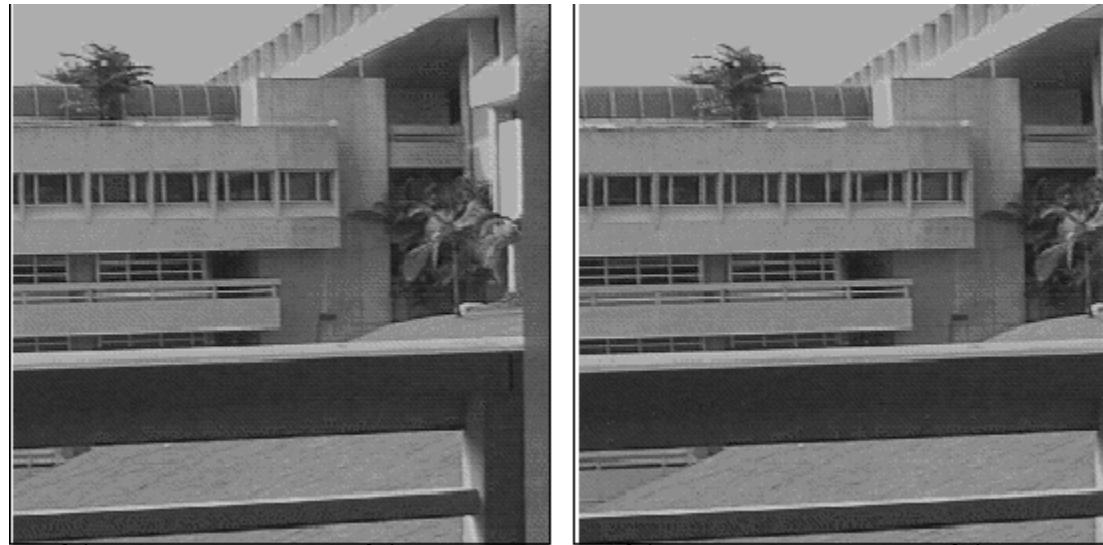
Contents

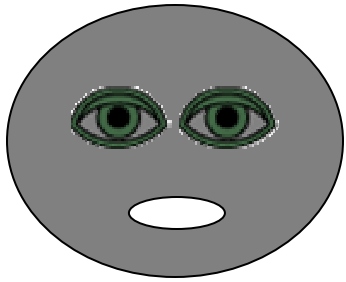
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge





Forward Reconstruction

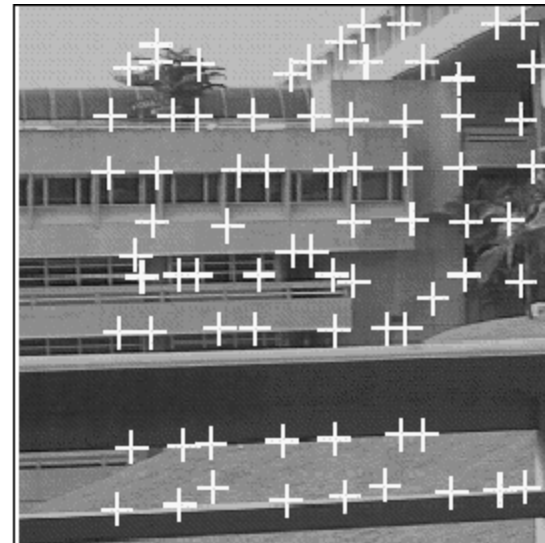
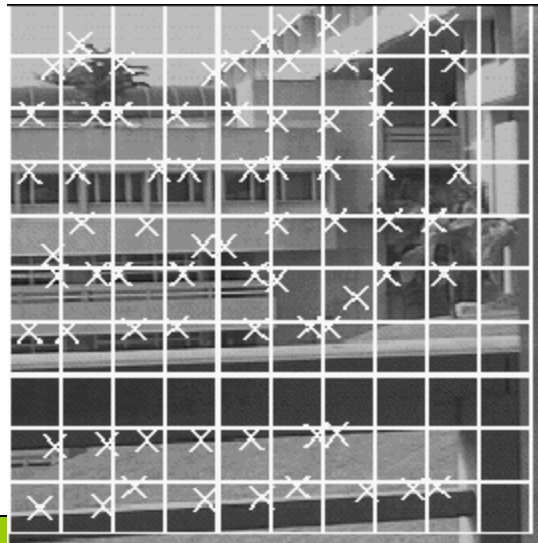
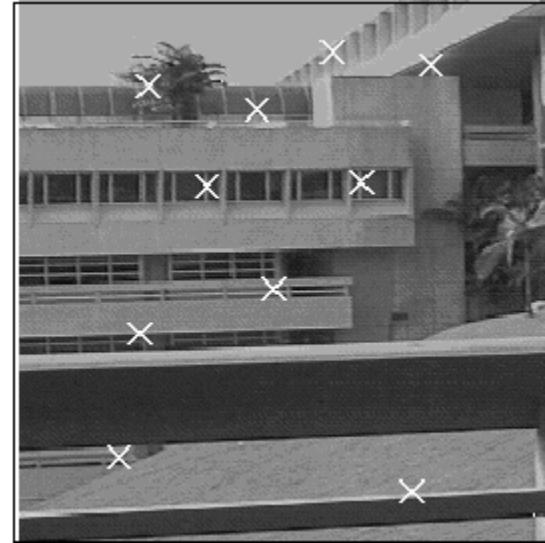
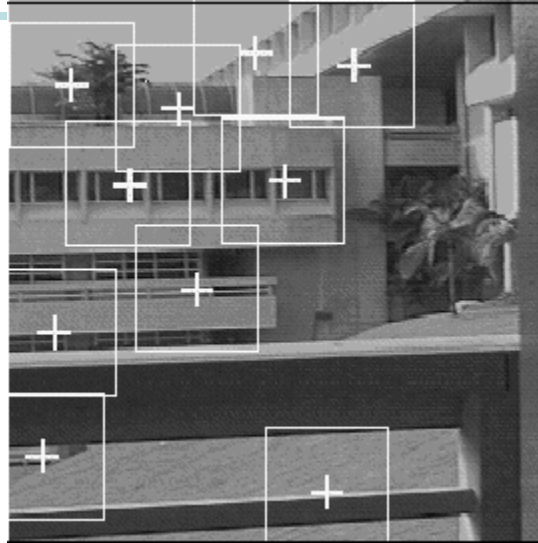
Contents

Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge

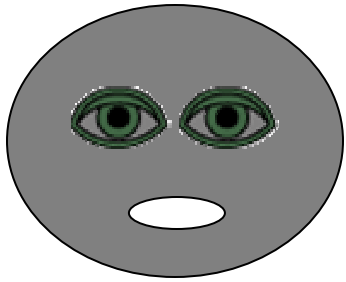


Reconstructive Vision

Send inquiries and comments to:
<http://www.ntu.edu.sg/home/mmxie>

11





Contents

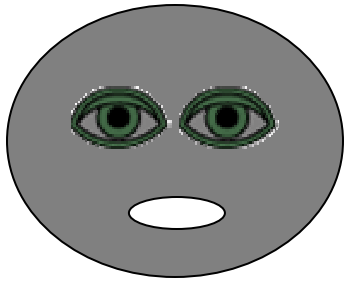
Introduction

Forward Reconstruction

Future Challenge

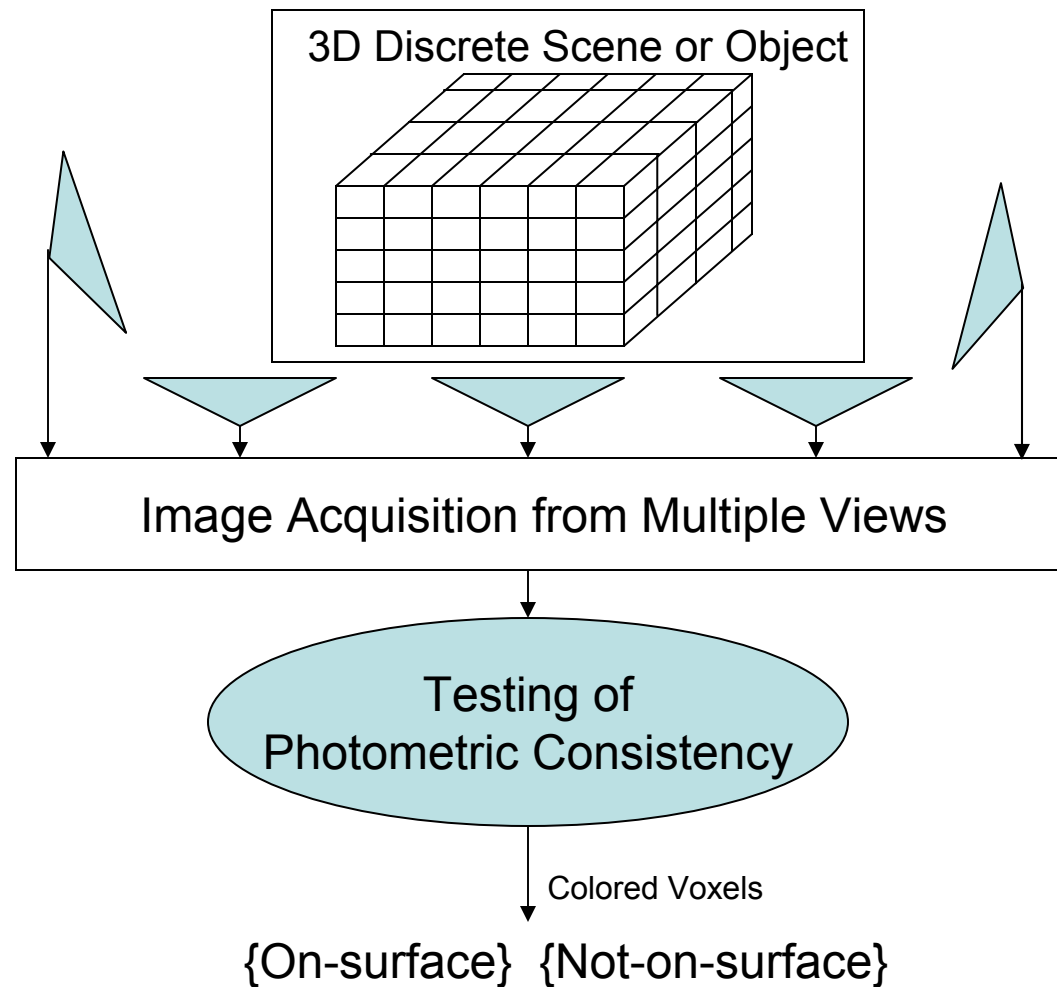
Inverse Reconstruction

- Inverse Reconstruction is a new terminology in robot vision.
- There are two established algorithms, which justify the importance of inverse reconstruction. They are: a) the algorithm of voxel coloring, and b) the algorithm of discrete epipolar line.
- Voxel coloring algorithm and its variants are advocated by Yang et al (1993), Collins (1996), and Seitz et al (1999).
- Discrete epipolar-line algorithm is advocated by the speaker (1997), and is simpler and more practical.
- Inverse reconstruction starts with 3D discrete scene and ends with feature matching in binocular, or multiple, views.
- Inverse reconstruction has three notable advantages: a) controllable accuracy of 3D geometry, b) fast (e.g. time-independent of image-resolution), and c) less ambiguity of matching (but it still suffers the ambiguity of matching due to occlusions and photometric discrepancy in stereo images!).



Inverse Reconstruction

Voxel Coloring Algorithm:



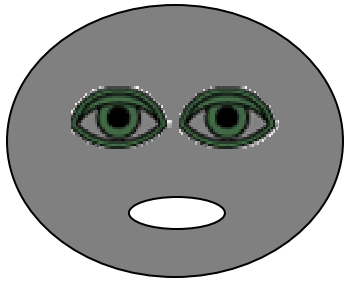
Contents

Introduction

Forward Reconstruction

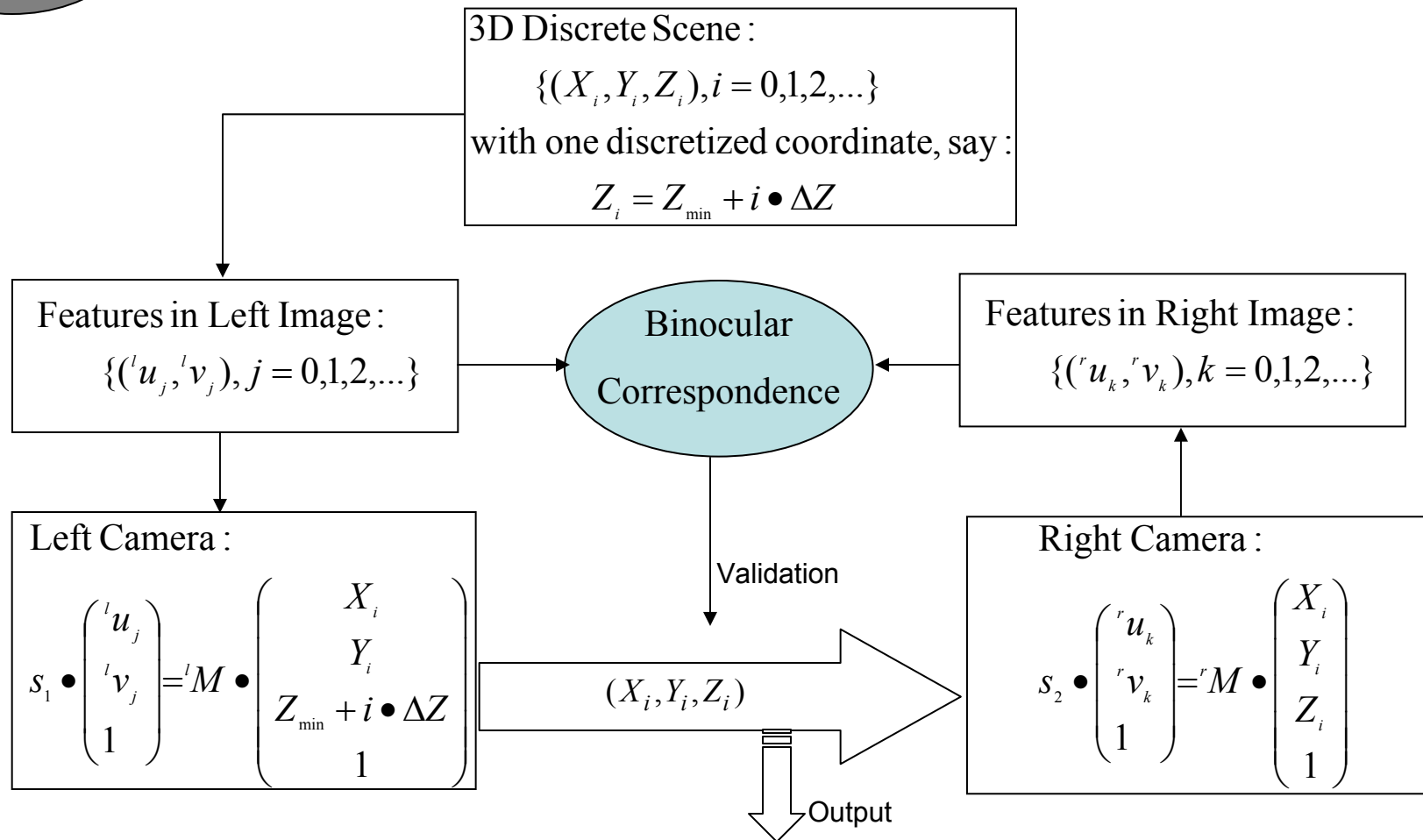
*Backward (or Inverse)
Reconstruction*

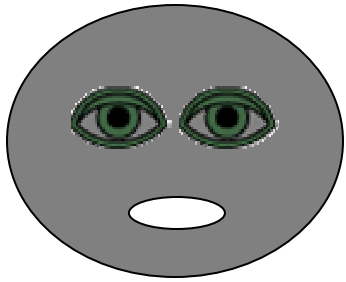
Future Challenge



Inverse Reconstruction

Discrete Epipolar-line Algorithm:





Inverse Reconstruction

Illustration of Discrete Epipolar Line

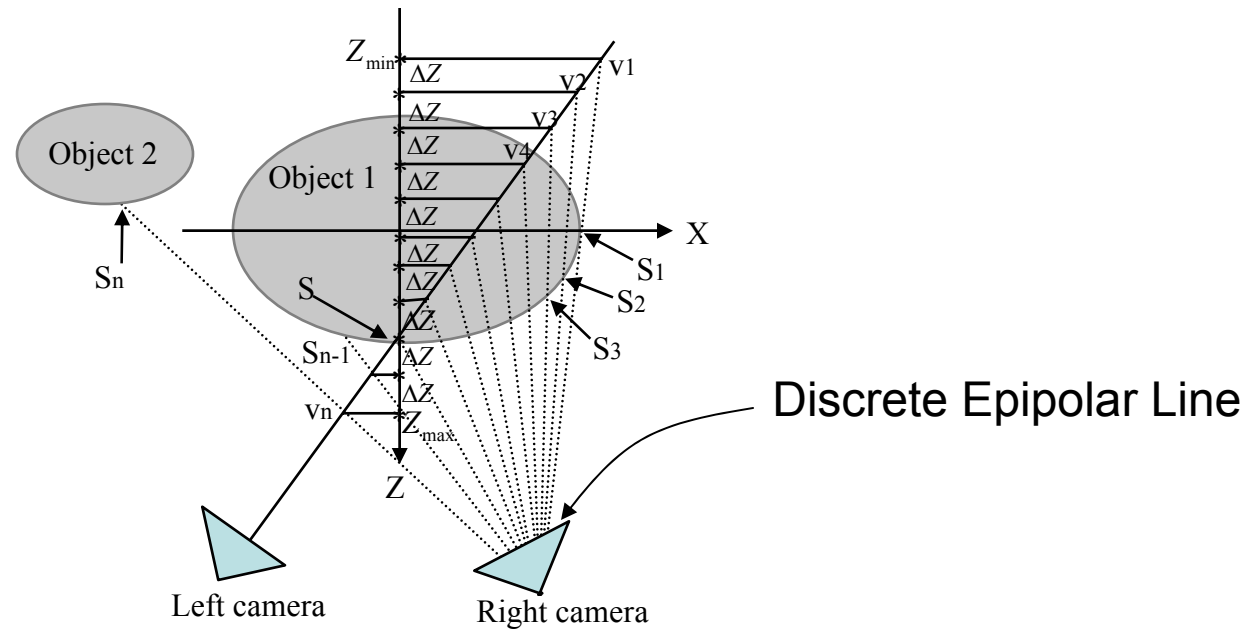
Contents

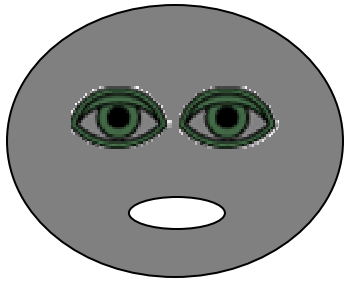
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

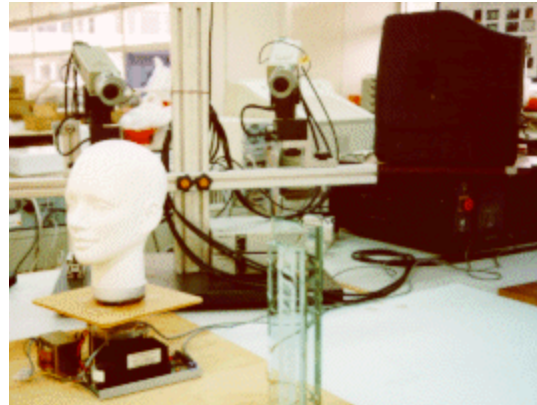
Future Challenge





Inverse Reconstruction

Example



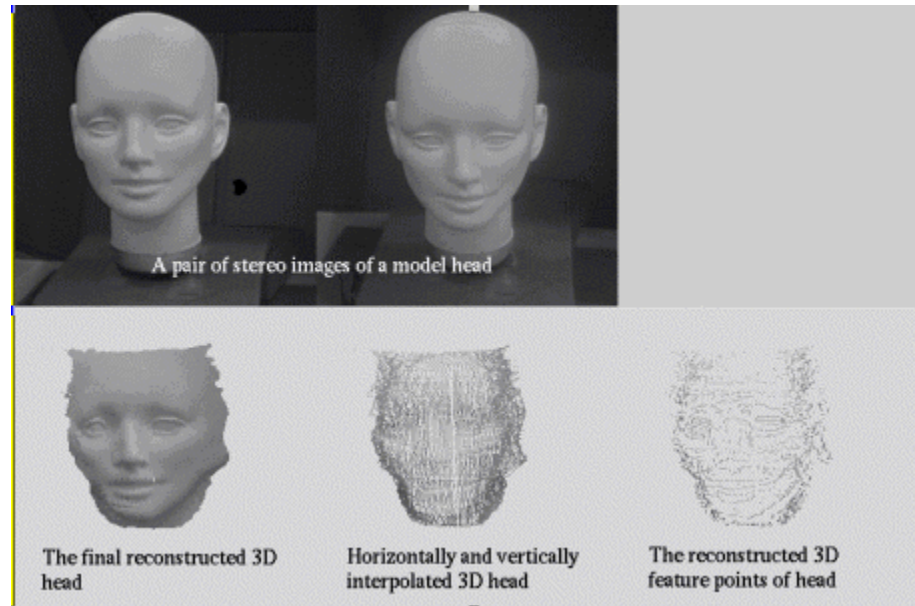
Contents

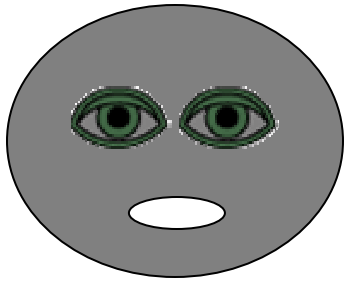
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge





Contents

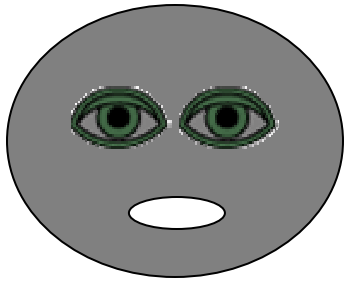
Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

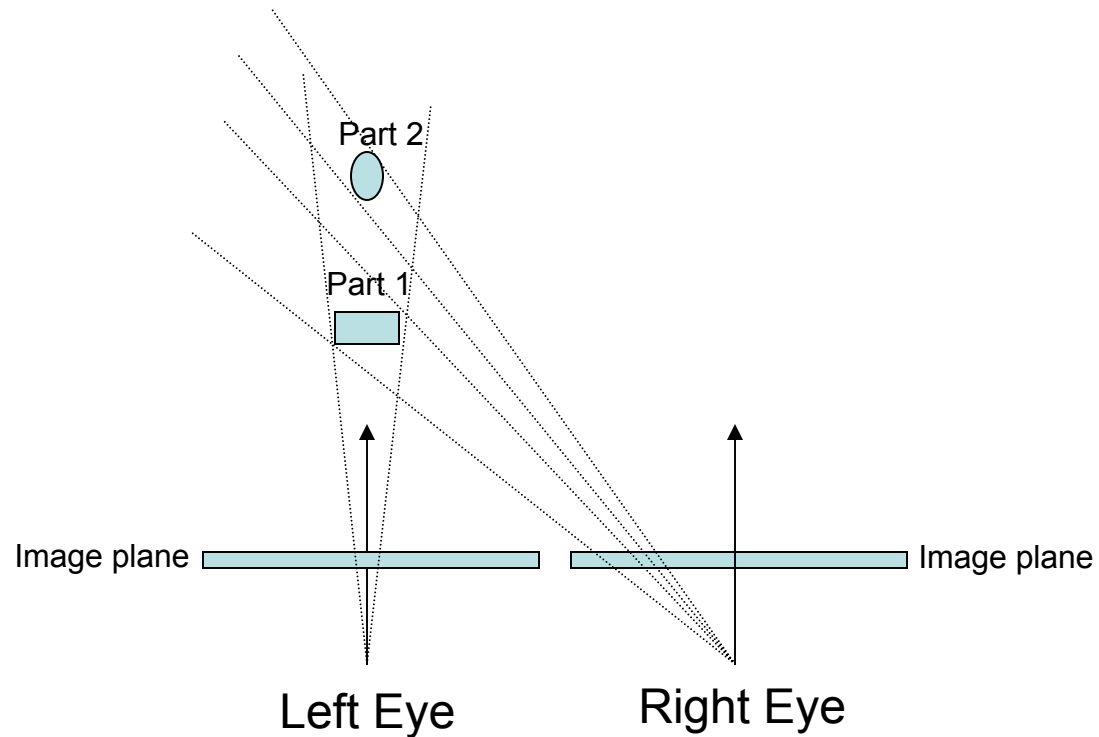
Future Challenge

- Until today (by the time of writing), it is still a challenge to infer the geometry of a 3D object or scene in a general setting of binocular vision.
- The major obstacle is “binocular correspondence” in general.
- There are two perpetual problems, which cause the trouble (i.e. the ambiguity of matching) to binocular correspondence.
- They are: a) occlusion, and b) photometric discrepancy.

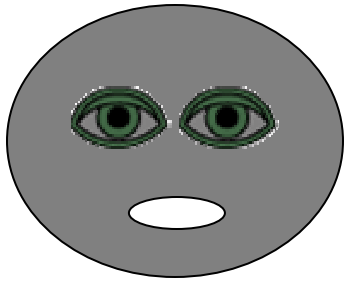


Future Challenge

Problem of occlusion:

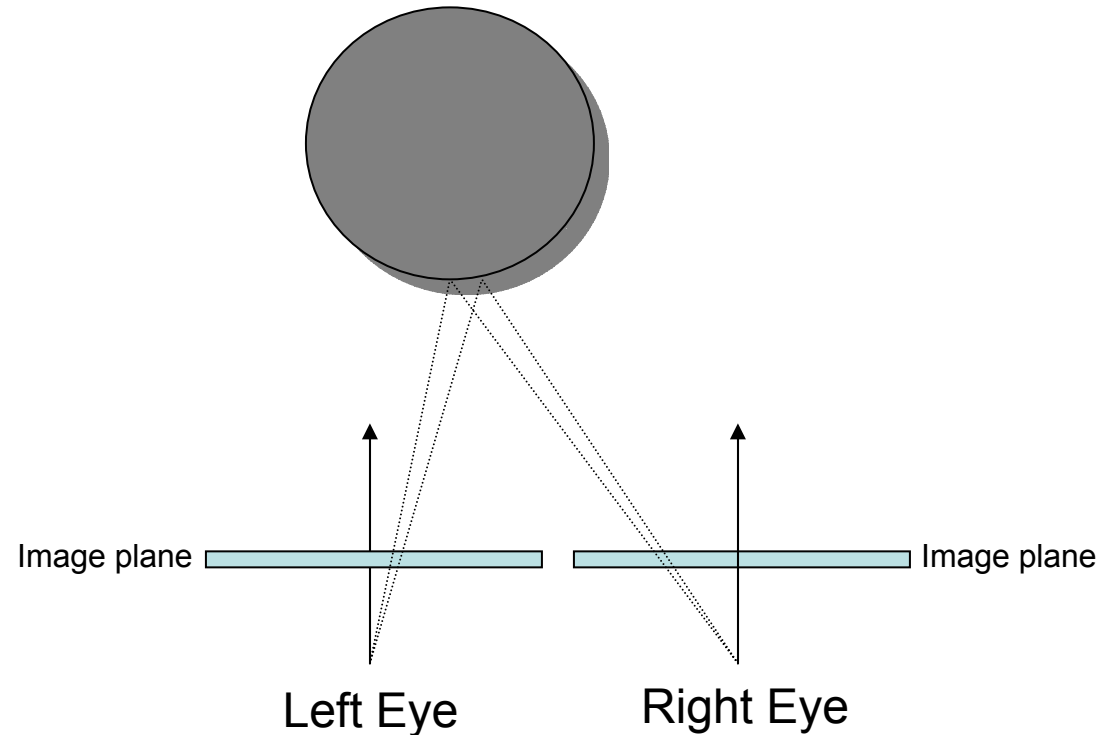


We have to have solutions that are able to live with occlusions!

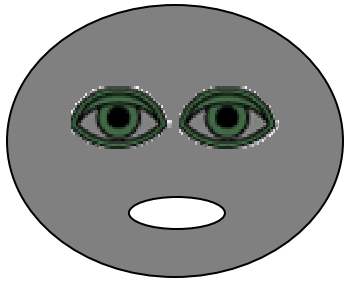


Future Challenge

Problem of photometric discrepancy:



We have to have solutions that are able to tolerate appearance variations!



Contents

Introduction

Forward Reconstruction

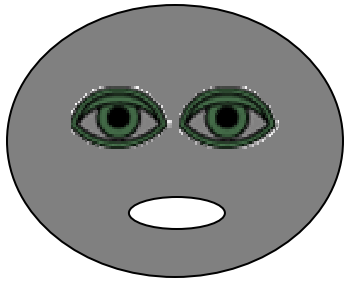
*Backward (or Inverse)
Reconstruction*

Future Challenge

Future Challenge

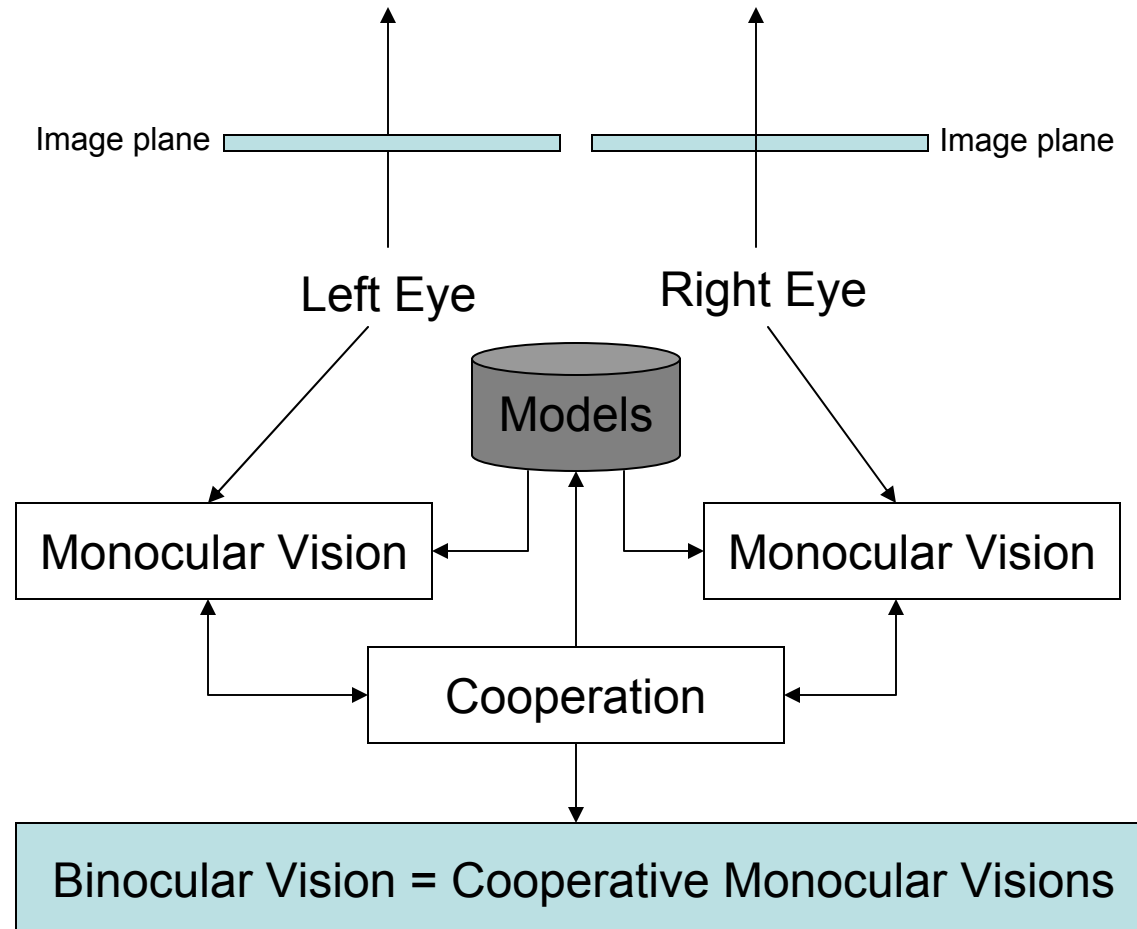
- We believe that a binocular vision should be treated as the combination of two cooperative monocular visions.
- In particular, each monocular vision must consider “models” and “meanings” at the level of knowledge, instead of geometry alone.
- This idea leads us to further believe in the importance of model-based, or even knowledge-based (i.e. cognitive), vision.

(to continue ...)



Future Challenge

Cooperative Monocular Visions, Which are Model-based.



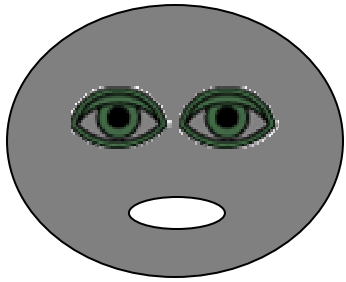
Contents

Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge



Contents

Introduction

Forward Reconstruction

*Backward (or Inverse)
Reconstruction*

Future Challenge

End of Reconstructive Vision