本章讲授内容

1、什么是立体视觉

2、双目立体视觉的基本原理

3、立体匹配匹配算法

本章的学习目的

1、了解立体视觉的目的和意义

2、掌握立体视觉的基本原理

3、掌握立体匹配的基本方法

1 引言

- 视觉系统的目的：
  - 利用图像信息
  - 计算3D环境物体的位置和形状等几何信息
  - 识别物体

目标：恢复3D物体

1 引言

➢ 2D 和 3D 的关系

- **现实存在的问题**
  - 一般的物体(Objects)都是三维的；
  - 图像(Images)却是有关灰度，颜色等信息的阵列；
  - 3D的深度(Depth)信息在一幅图像上不能明显的显示出来。
- **2D的分析需要3D的信息**
  - 物体表面是连续，平滑(Smooth)的；
  - 物体都有特定的形状和边界。
- **3D的信息可以通过2D的图像计算出来**
  - 视差(Disparity)，深度(Depth)信息等等。

1 引言

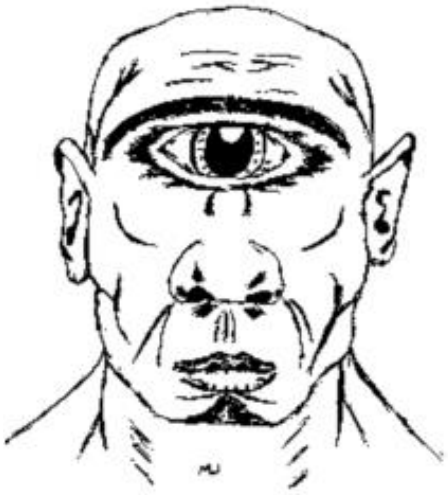
目标：恢复3D物体

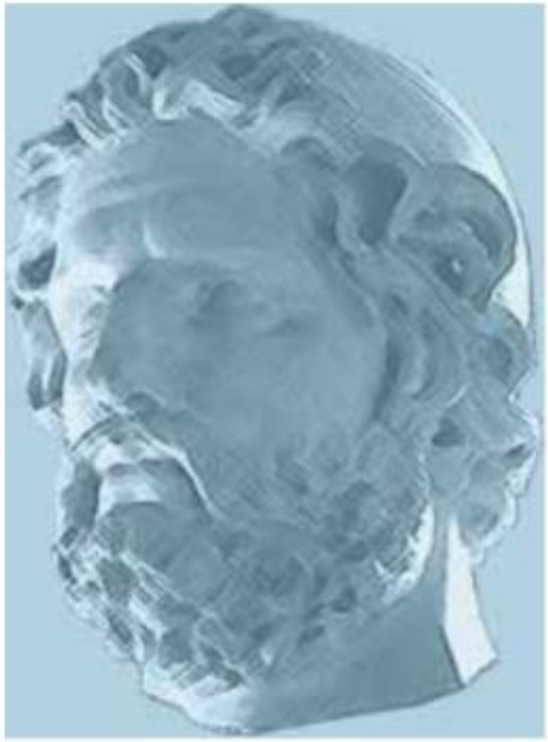
我们从这幅图像中能获取到哪些信息？

能给我们一些什么样的启发呢？

1 引言

为什么需要两个眼睛？



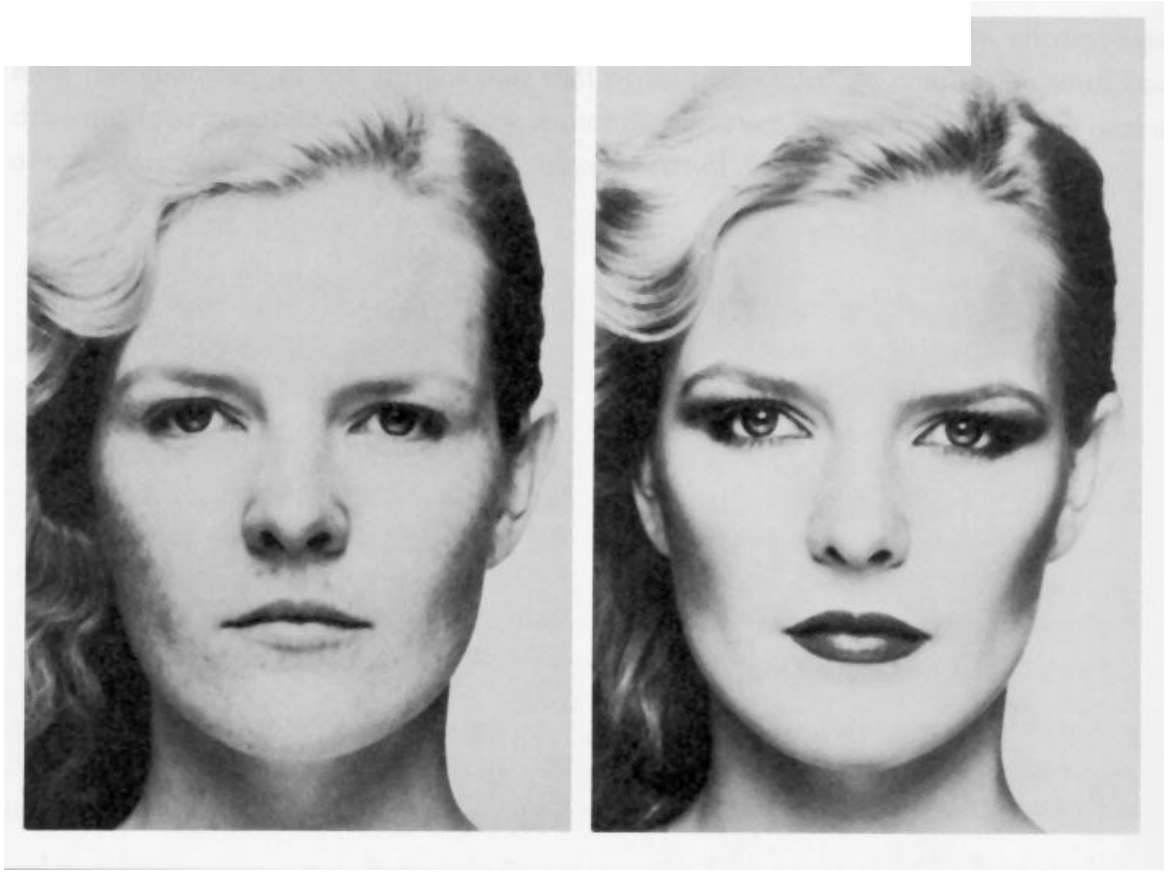


- 物体的深度信息不能通过单眼所获得。

1 引言

- 视觉提示信息

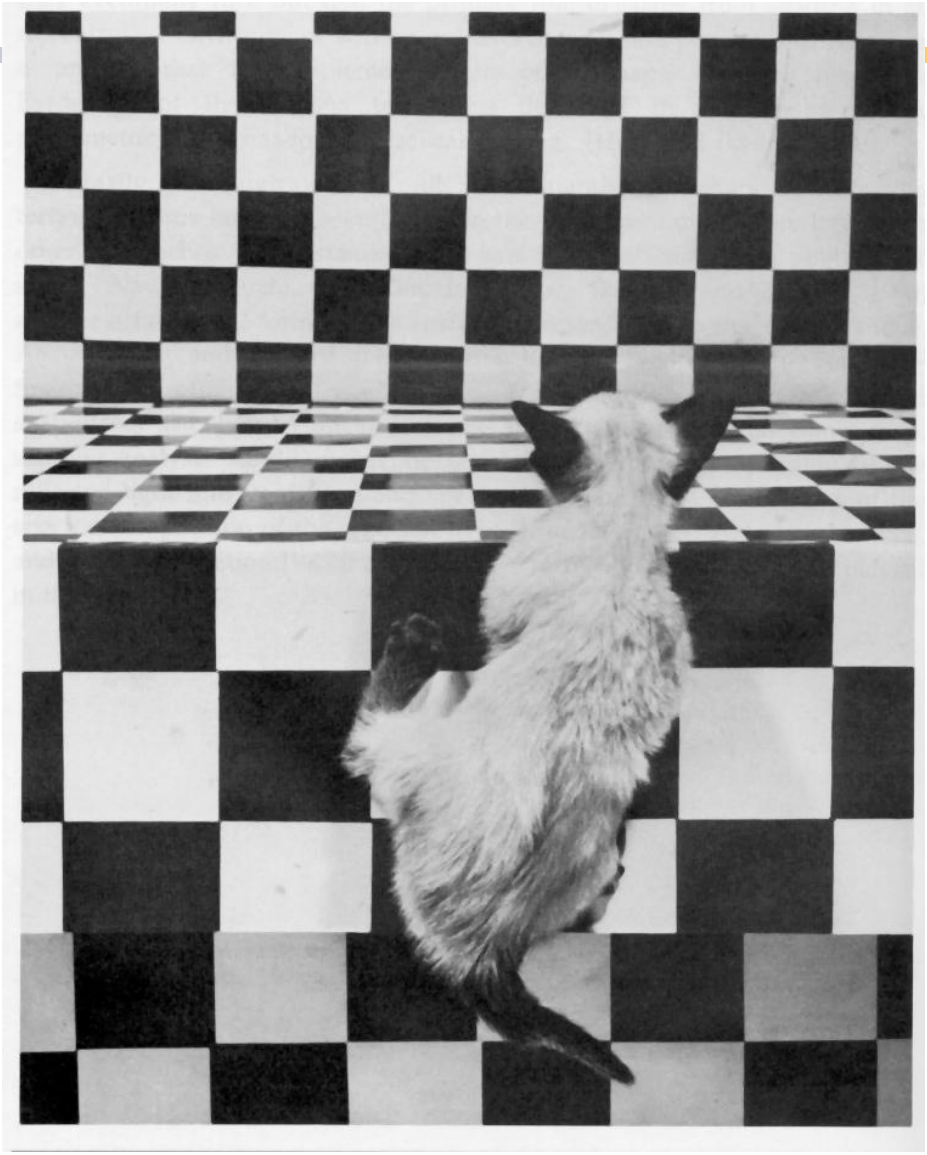
  - **Shading**



Merle Norman Cosmetics, Los Angeles

1 引言

- 视觉提示信息
  - Shading
  - **Texture**



The Visual Cliff, by William Vandivert, 1960

1 引言

- 视觉提示信息
  - Shading
  - Texture
  - **Focus**

From *The Art of Photography*, Canon

1 引言

- 视觉提示信息
  - Shading
  - Texture
  - Focus
  - **Perspective**

4.1 引言

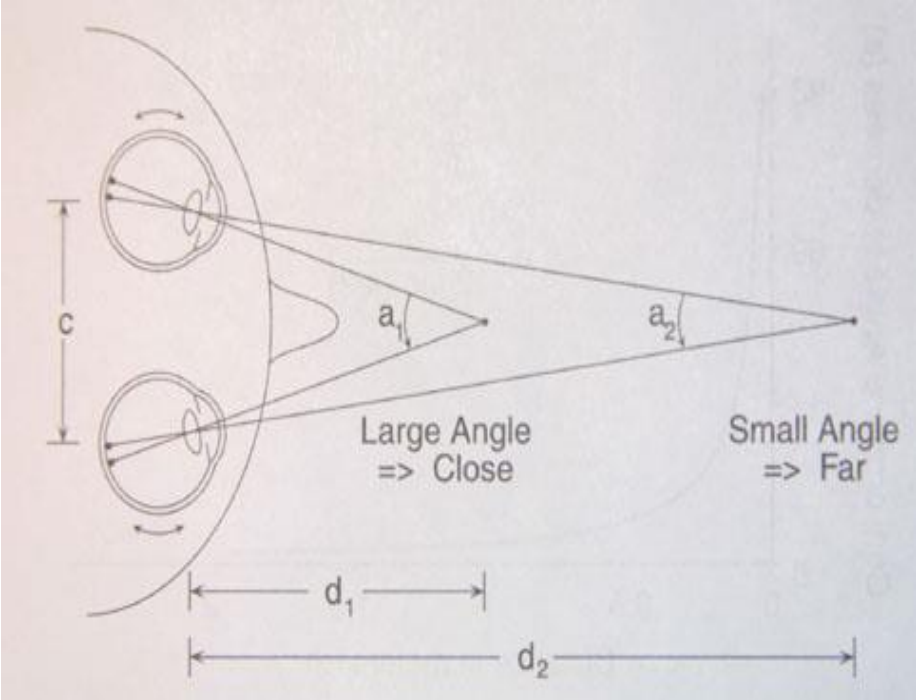
- 视觉提示信息
  - Shading
  - Texture
  - Focus
  - Perspective
  - **Motion**

形状信息的获取依赖于

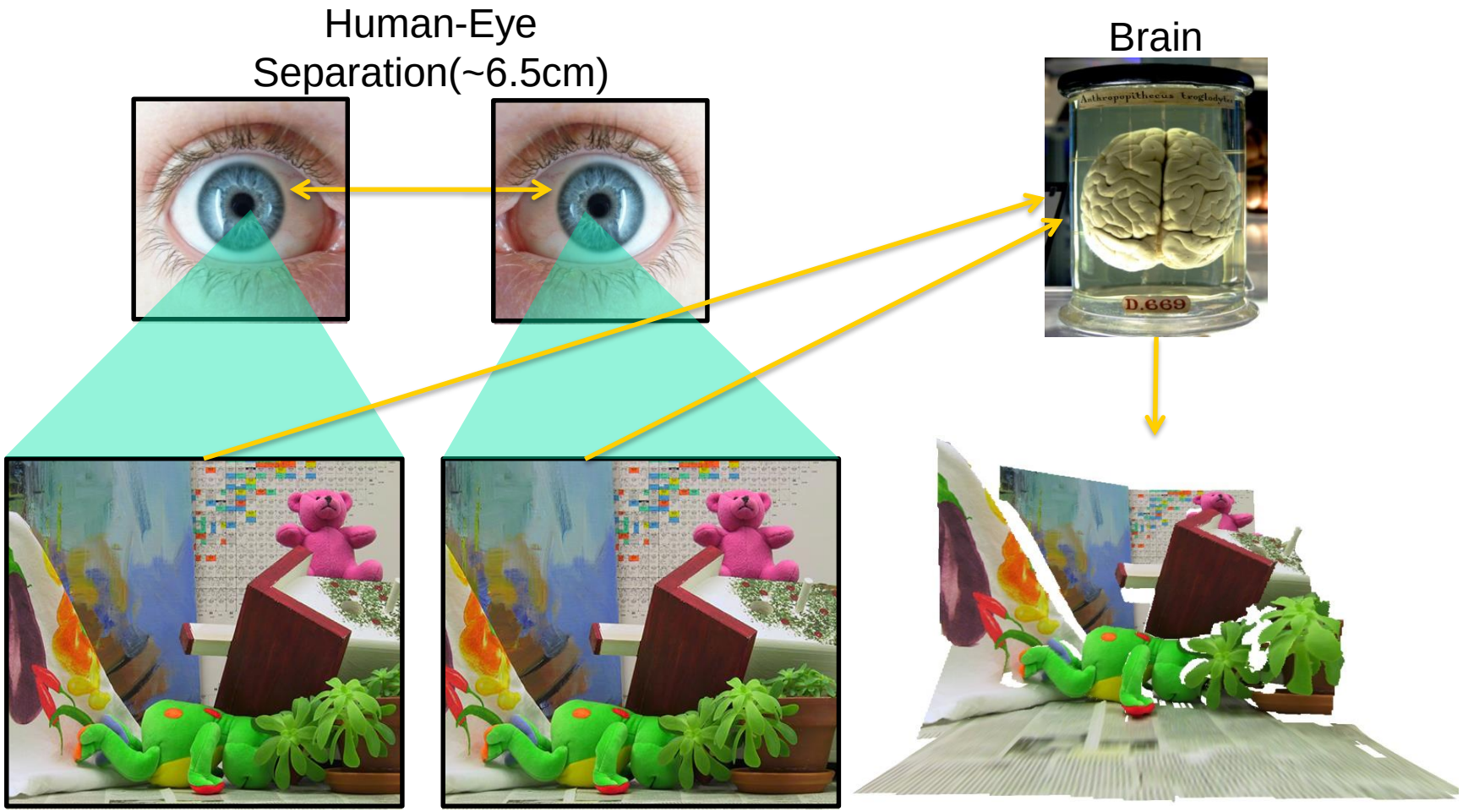
- **shading, texture, focus, motion, …**

1 引言

目标：恢复3D物体



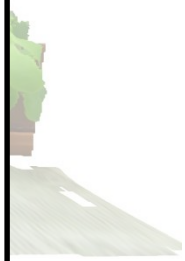
3D Perception



3D Perception

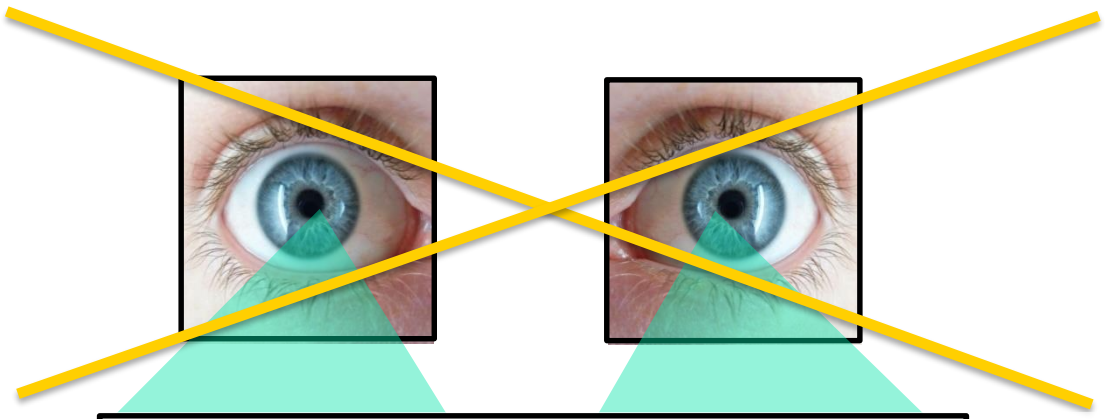
If we ensure that the left eye sees a 2D image and the right eye sees another one, our brain will try to overlay the images to generate a 3D impression.

How can we use this for watching 3D movies?



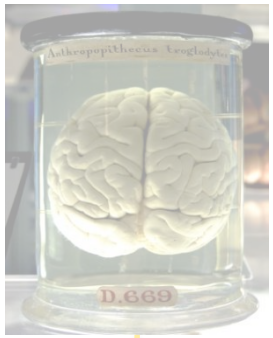
Left 2D Image Right 2D Image 3D View

Computational Stereo



Replace human eyes with a pair of slightly displaced cameras.

Brain



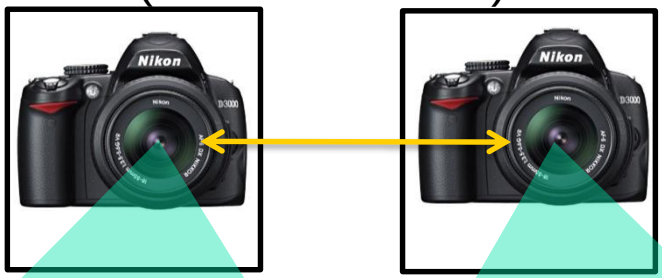
Left 2D Image

Right 2D Image

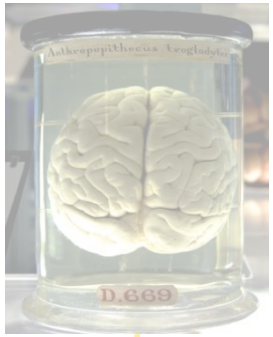
3D View

Computational Stereo

Displacement
(Stereo Baseline)



Brain



Replace human eyes with a pair of slightly displaced cameras.

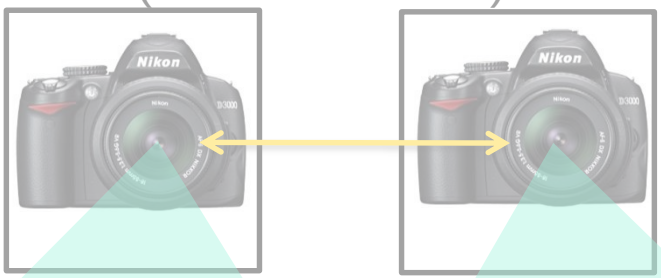
Left 2D Image

Right 2D Image

3D View

Computational Stereo

Displacement
(Stereo Baseline)



Brain

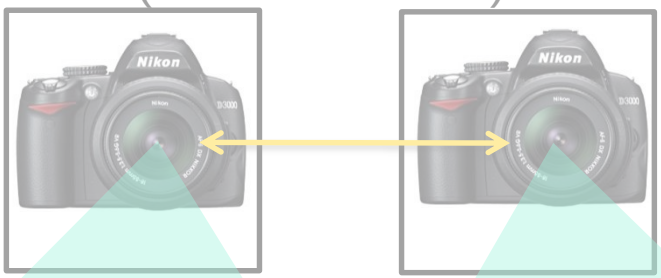
Left 2D Image

Right 2D Image

3D View

Computational Stereo

Displacement
(Stereo Baseline)



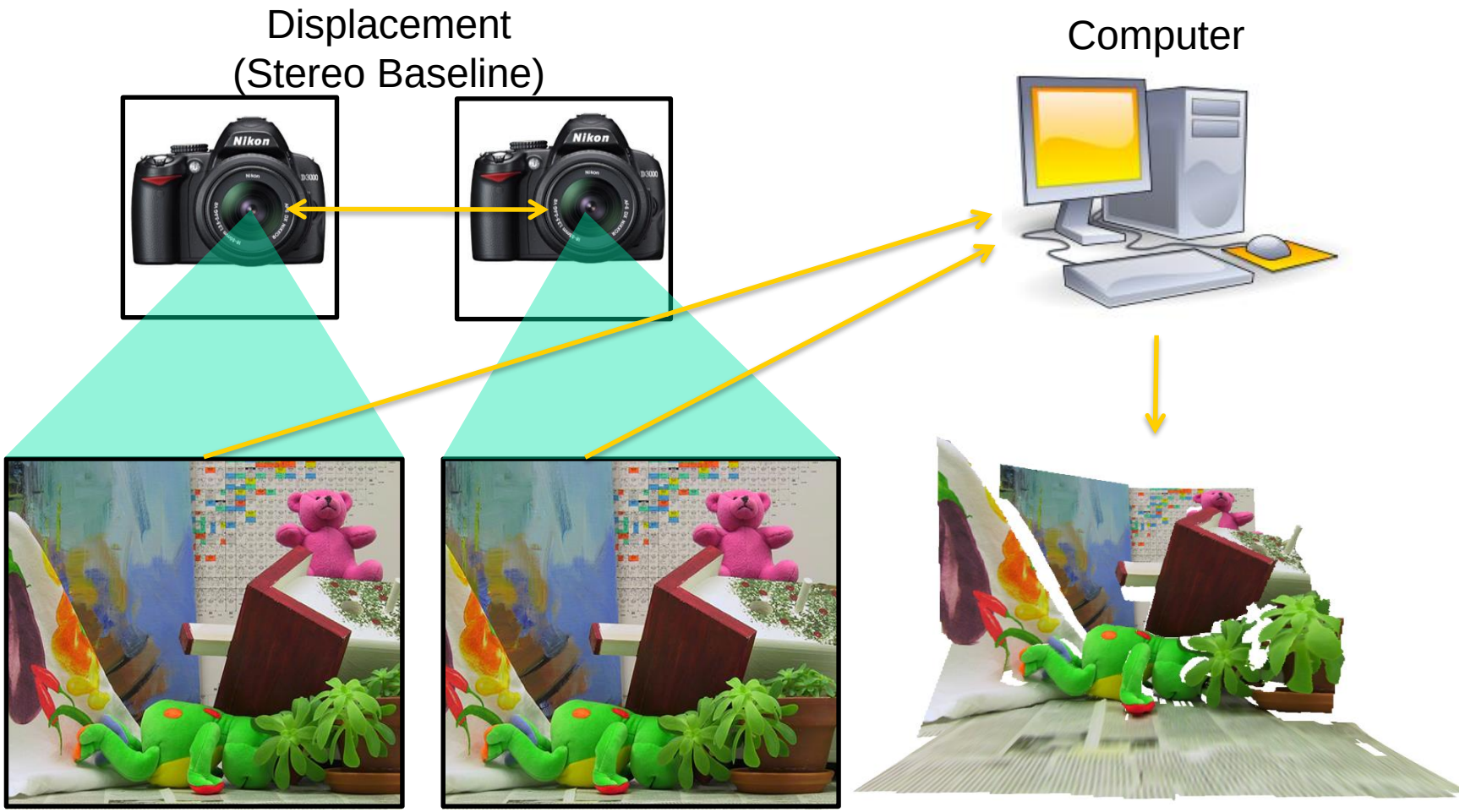
Computer

Left 2D Image

Right 2D Image

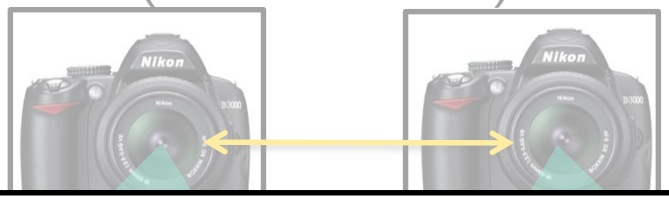
3D View

Computational Stereo



Computational Stereo

Displacement
(Stereo Baseline)



Computer

How can we accomplish a fully automatic 2D to 3D conversion?

Left 2D Image

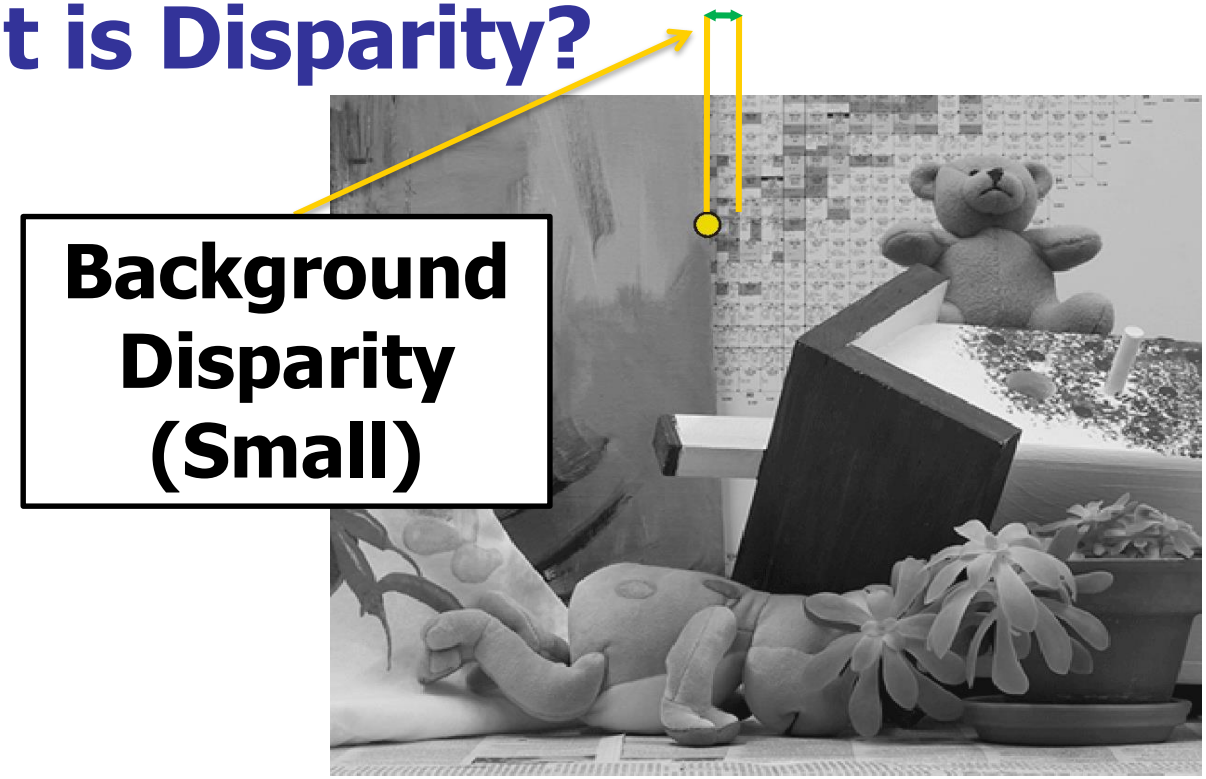
Right 2D Image

3D View

What is Disparity?

- The amount to which a single pixel is displaced in the two images is called disparity.
- A pixel's disparity is inversely proportional to its depth in the scene.

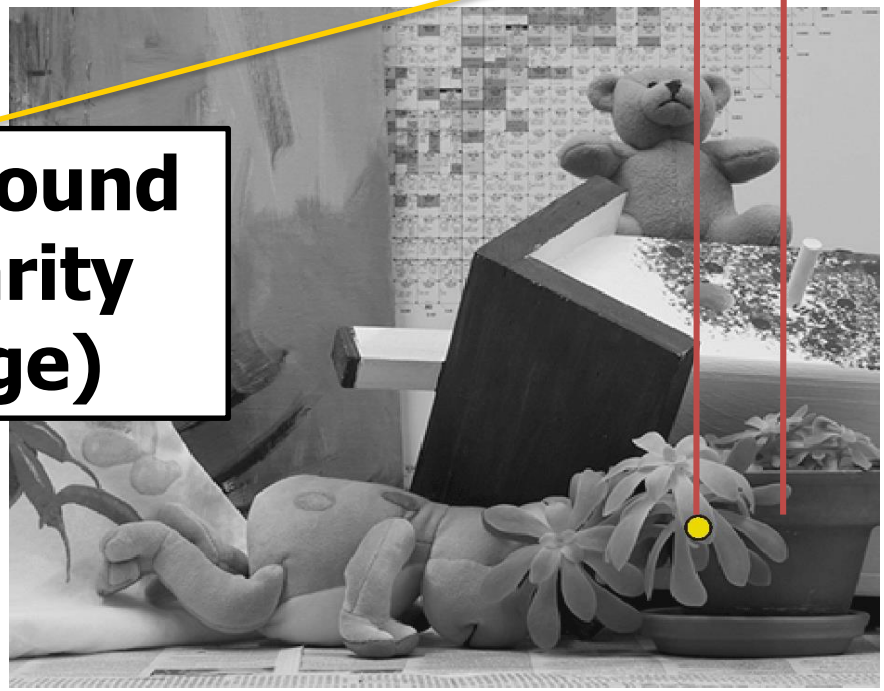
What is Disparity?



- The amount to which a single pixel is displaced in the two images is called disparity.
- A pixel's disparity is inversely proportional to its depth in the scene.

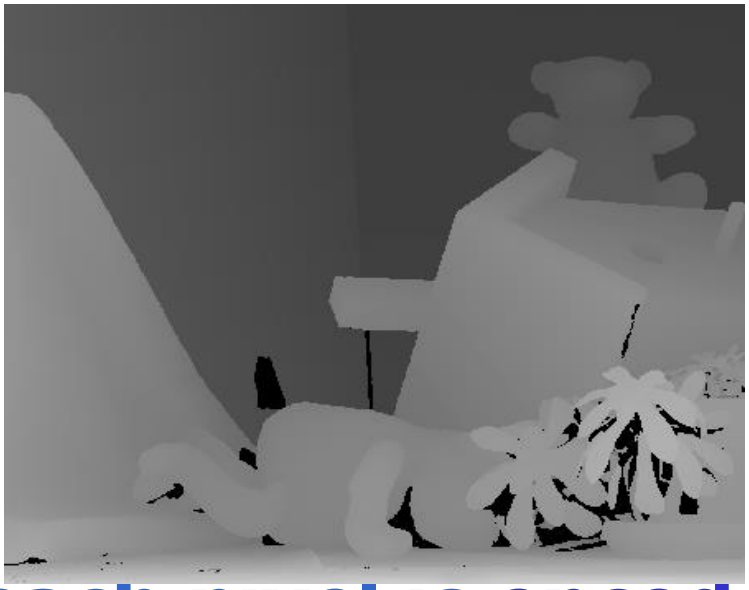
视差就是从有一定距离的两个点上观察同一个目标所产生的方向差异。

What is Disparity?



- The amount to which a single pixel is displaced in the two images is called disparity.
- A pixel's disparity is inversely proportional to its depth in the scene.

Disparity Encoding



- The disparity of each pixel is encoded by a grey value.
- High grey values represent high disparities (and low gray values small disparities).
- The resulting image is called disparity map.

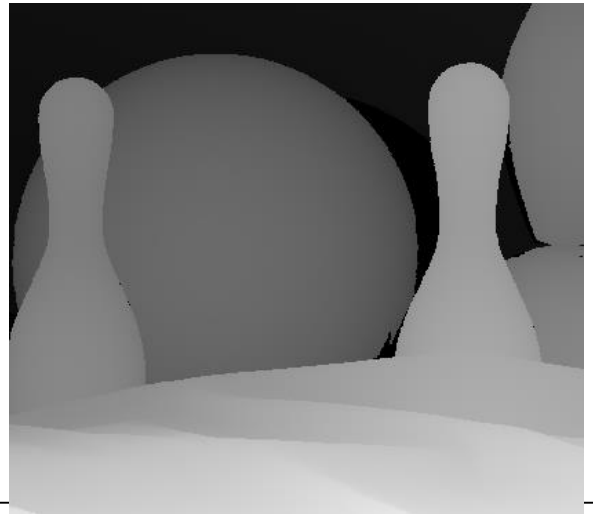
Disparity and Depth

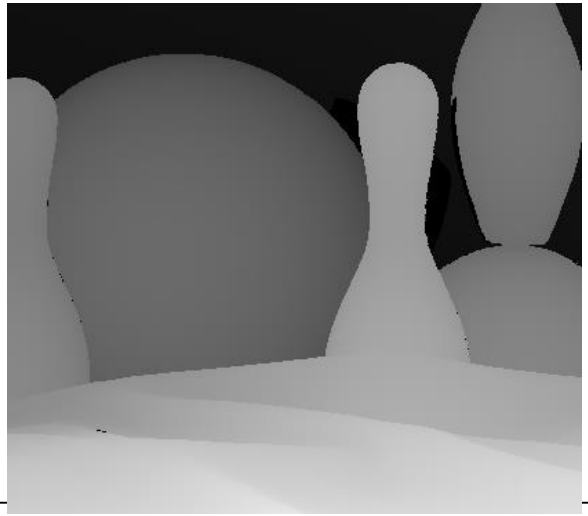
- The disparity map contains sufficient information for generating a 3D model.

1 引言

目标：恢复3D物体

- 人能做到利用一个标校后的立体图像对，再融合其深度图，就能获得空间物体3D信息



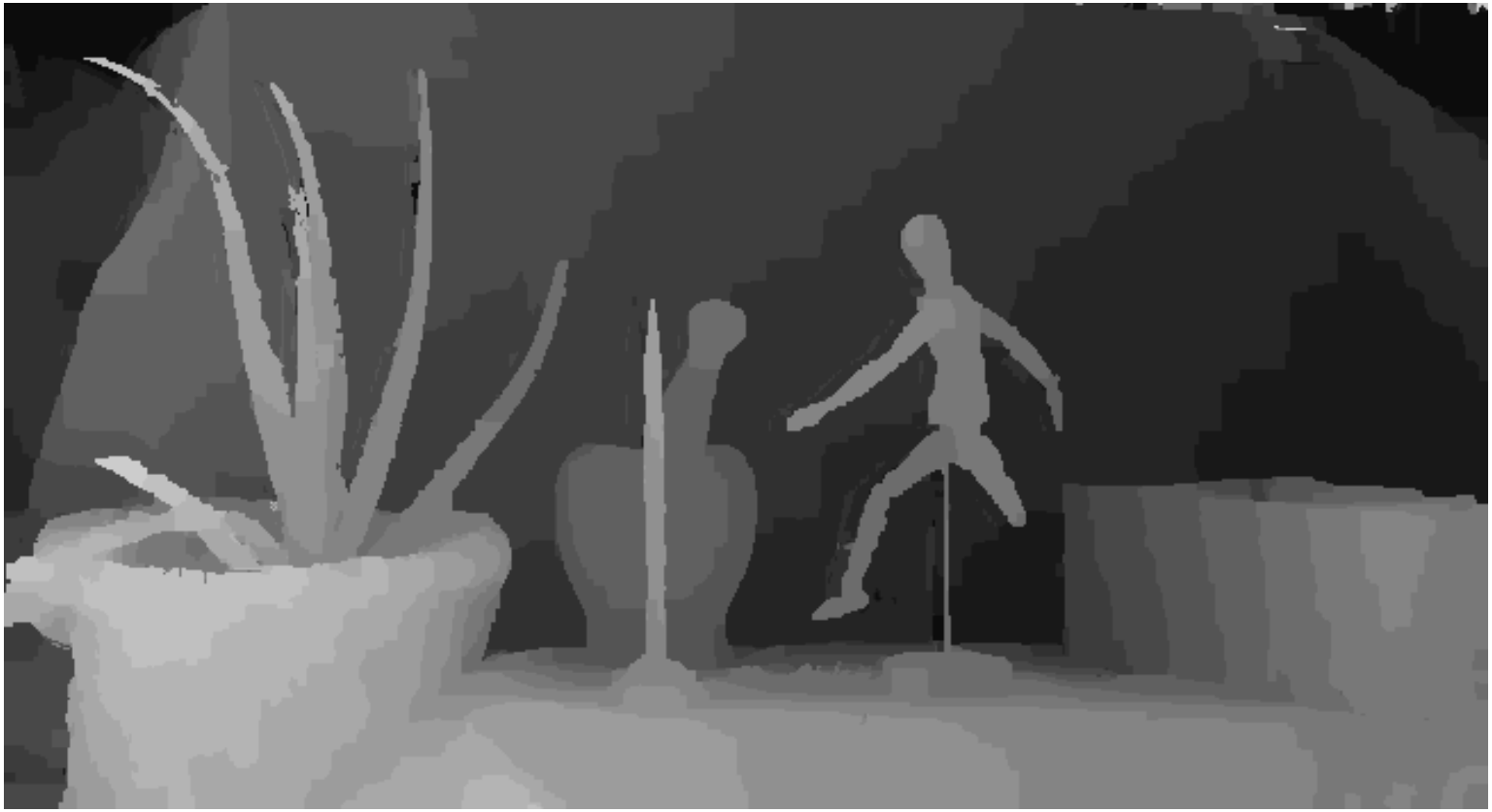


1 引言

右图像

左图像

1 引言



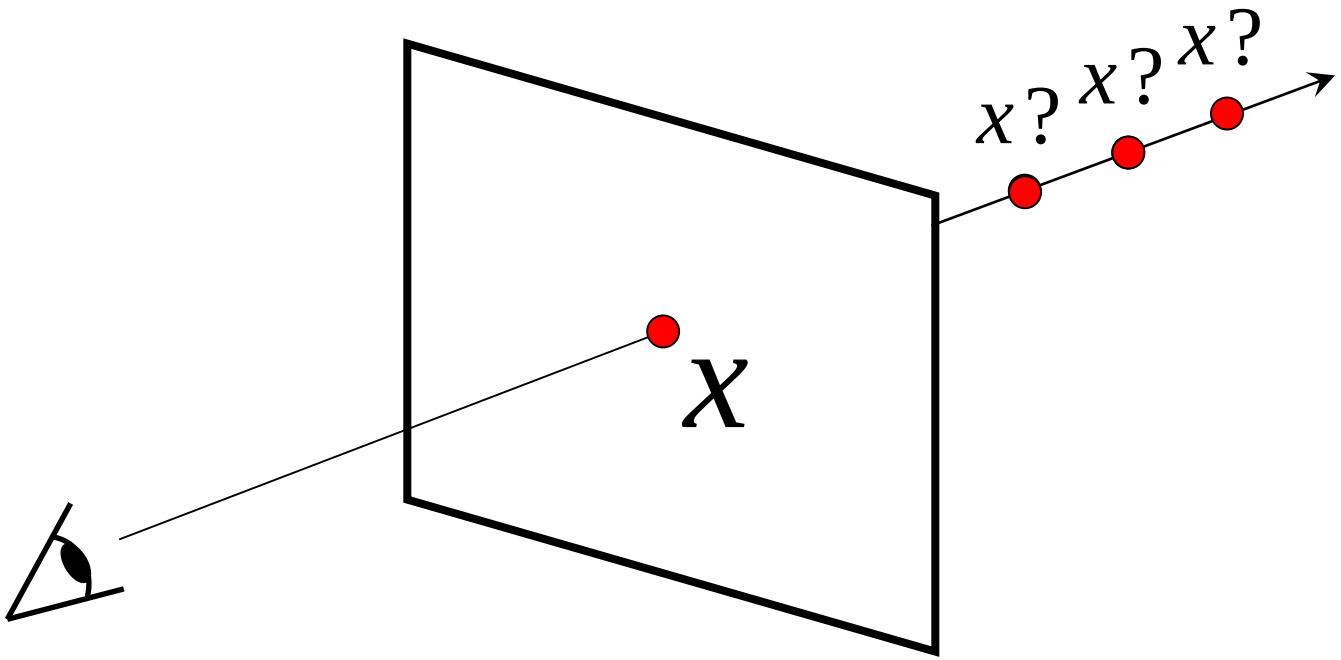
Disparity

1 引言

信息补充

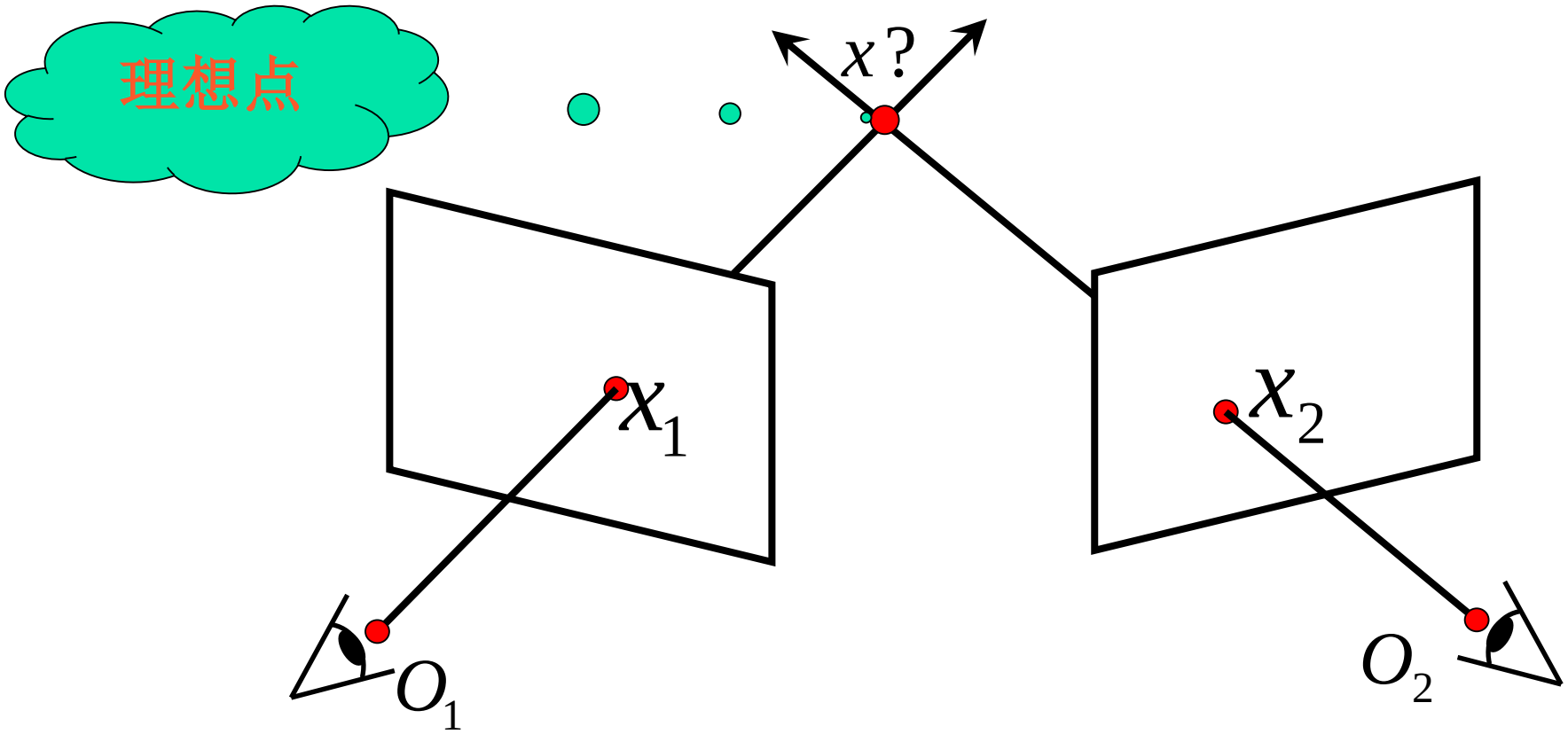
1 引言

目标：恢复3D物体



1 引言

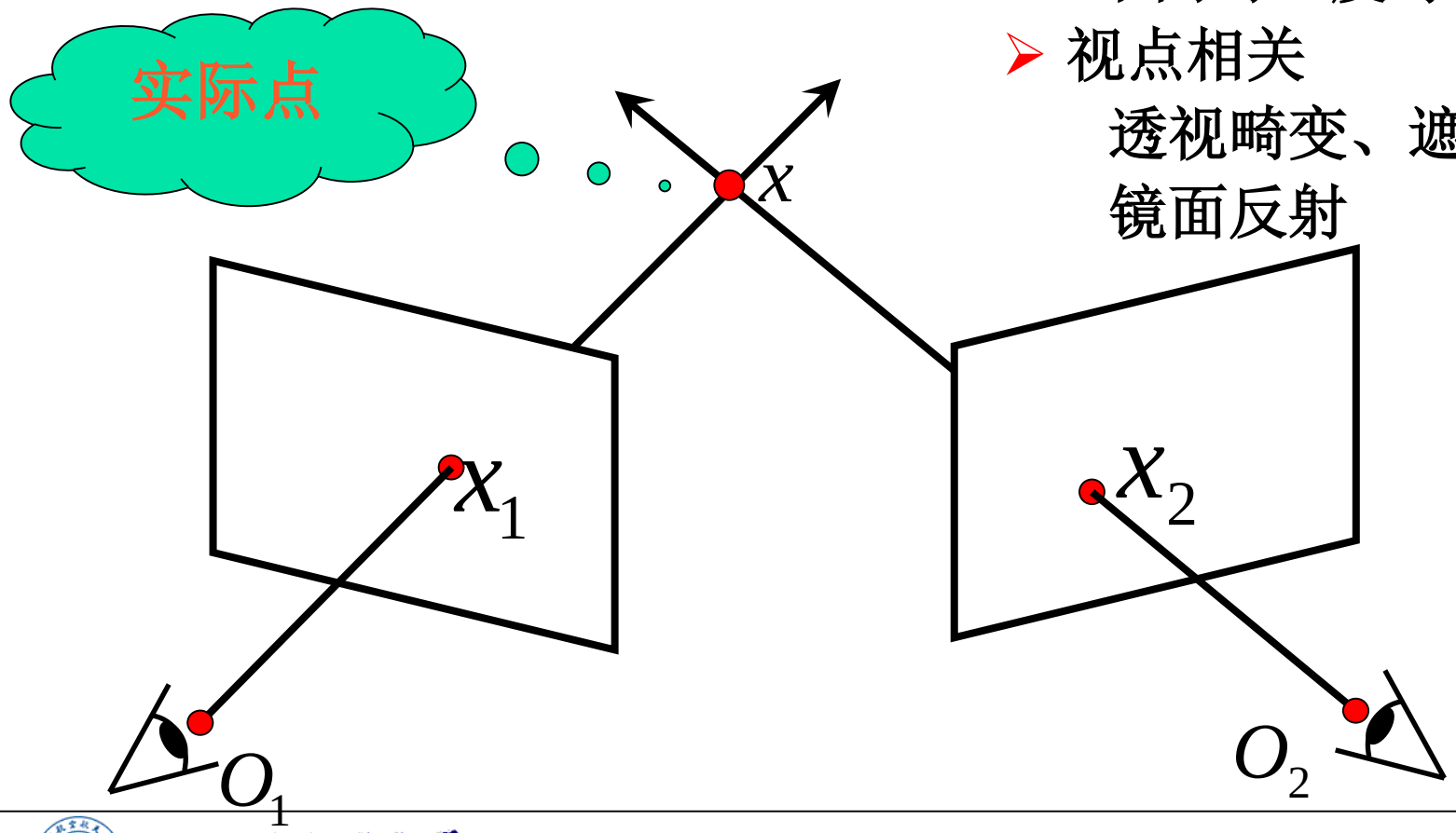
➢ 目标：恢复3D物体



1 引言

目标：恢复3D物体

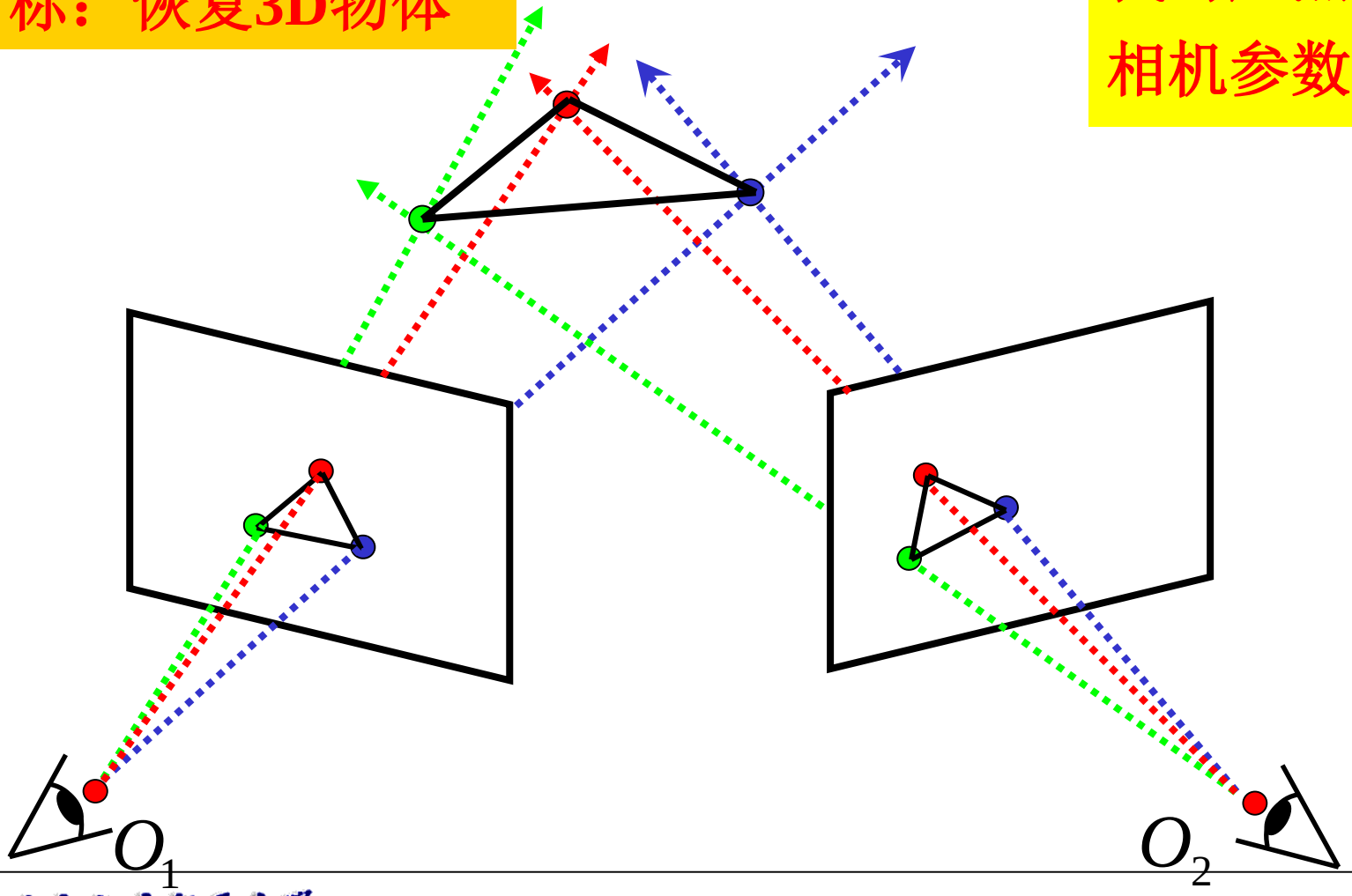
- 摄像机相关
  图像噪声、不同增益、不同对比度等等...
- 视点相关
  透视畸变、遮挡
  镜面反射



1 引言

目标：恢复3D物体

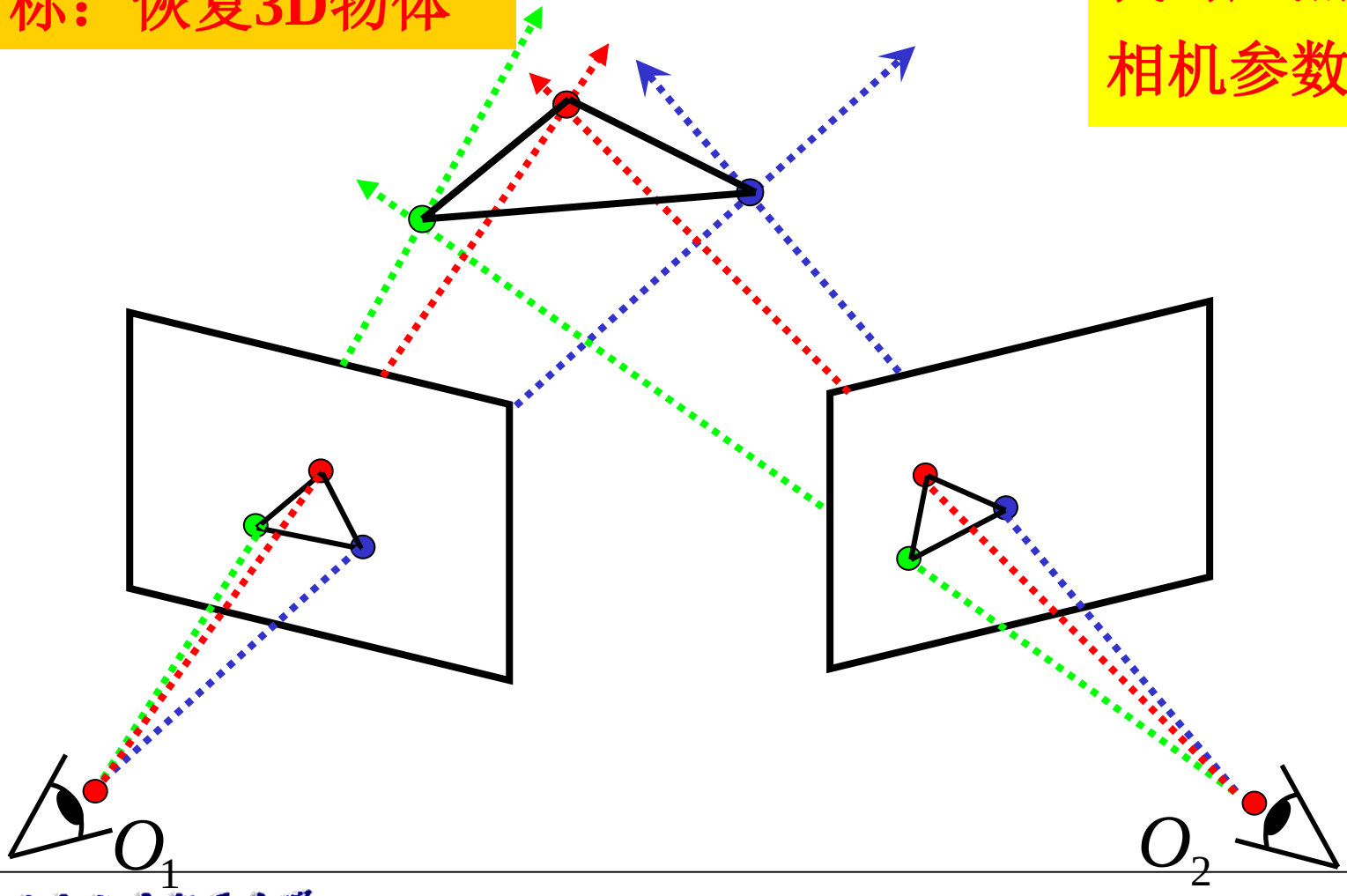
找对应点
相机参数



1 引言

目标：恢复3D物体

找对应点
相机参数



1 引言

什么是立体视觉？

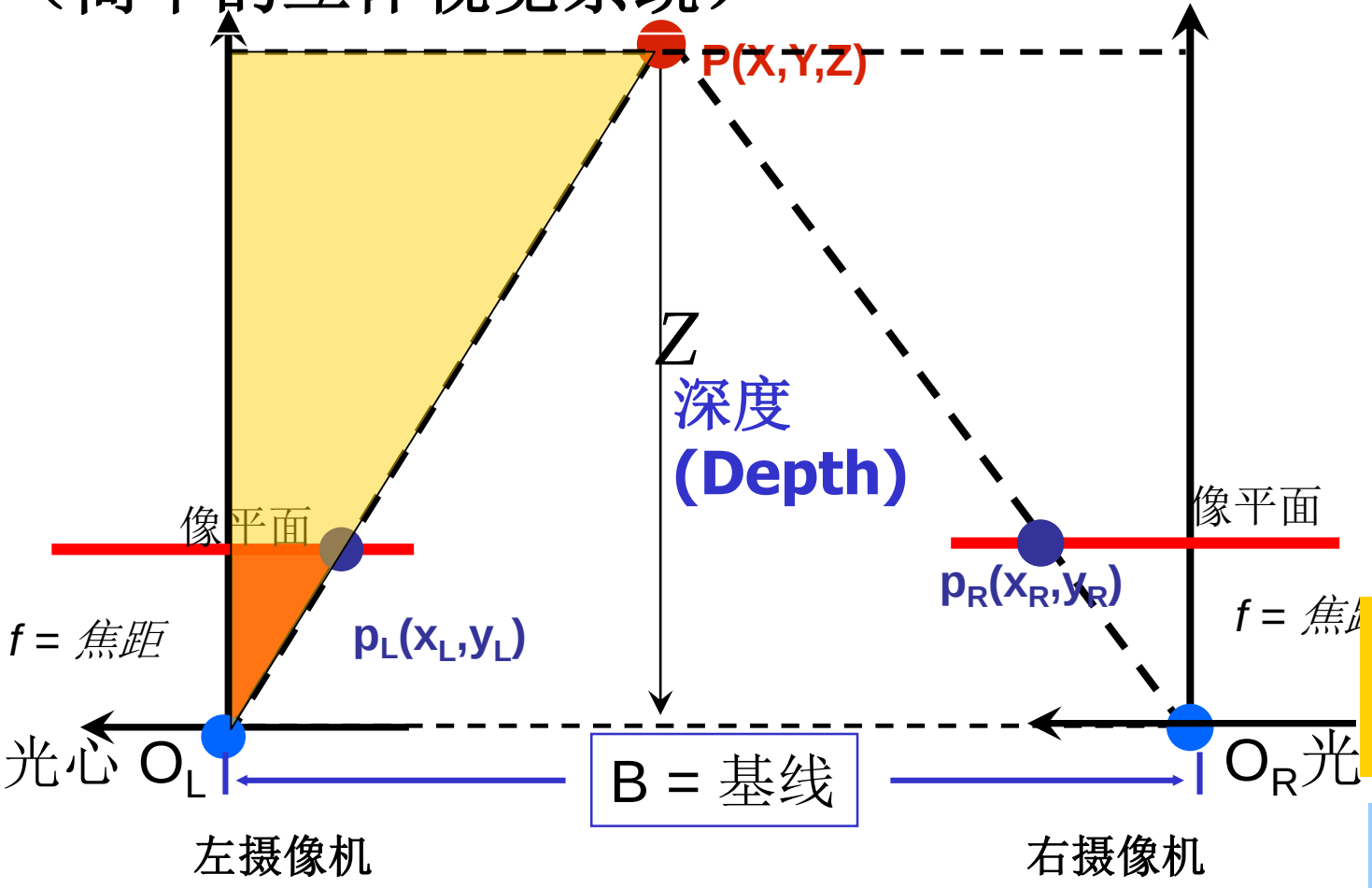
立体视觉技术是由两幅或多幅从不同视点拍摄的图像恢复场景三维信息的技术。

2 双目立体视觉原理

双目立体视觉是基于视差，由三角法原理进行三维信息的获取，即由两个摄像机的图像平面（或单摄像机在不同位置的图像平面）和被测物体之间构成一个三角形。已知两摄像机之间的位置关系，便可以获取两摄像机公共视场内物体的三维尺寸及空间物体特征点的三维坐标。双目立体视觉系统一般由两个摄像机或者由一个运动的摄像机构成。

2 双目立体视觉原理

➢平行光轴立体视觉系统（简单的立体视觉系统）



$$\frac{f}{Z}=\frac{x_L}{X}$$

$$\frac{f}{Z}=\frac{x_R}{X-B}$$

$$Z=\frac{Bf}{x_L-x_R}$$

$$dx=x_L-x_R$$

视差 (Disparity)

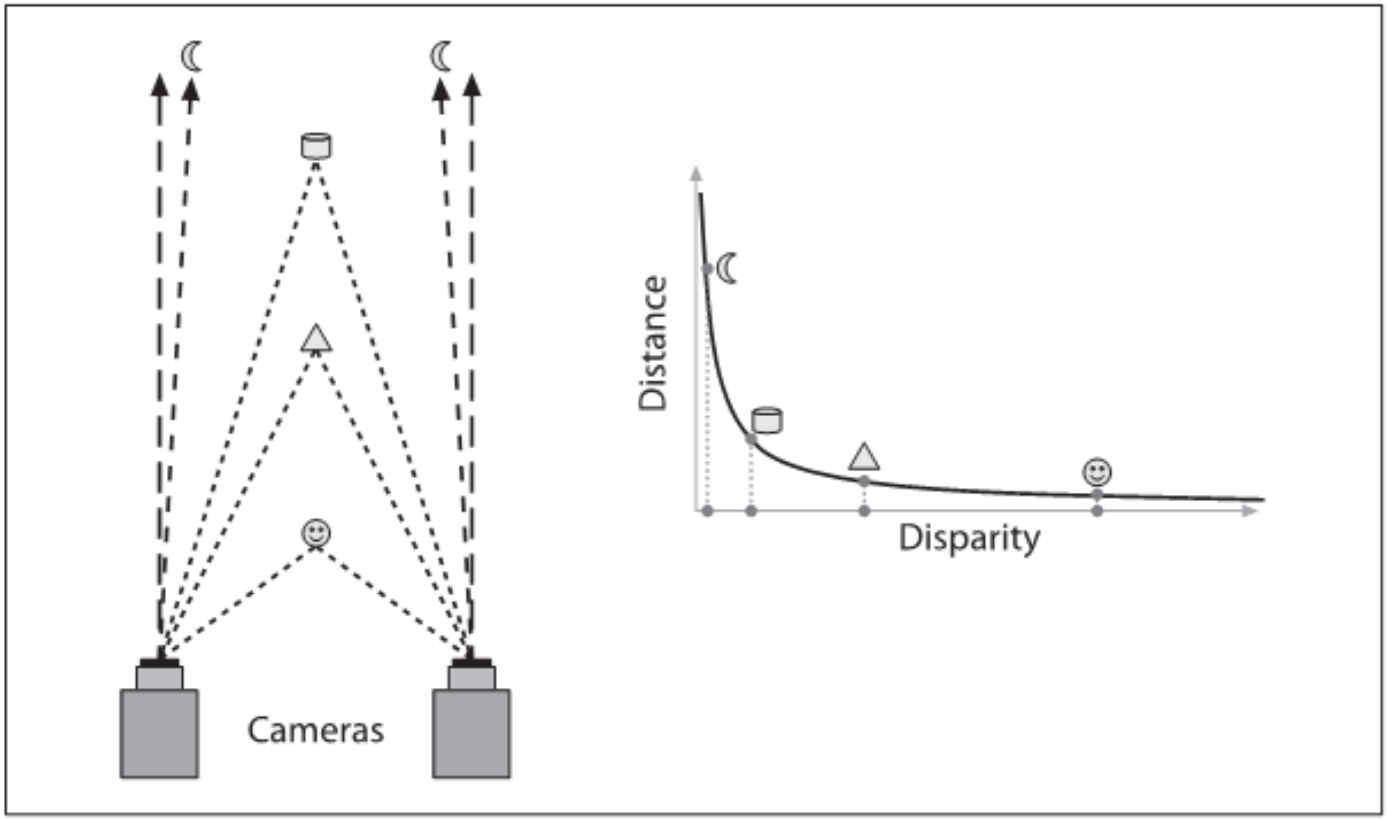
可求空间坐标

2 双目立体视觉原理

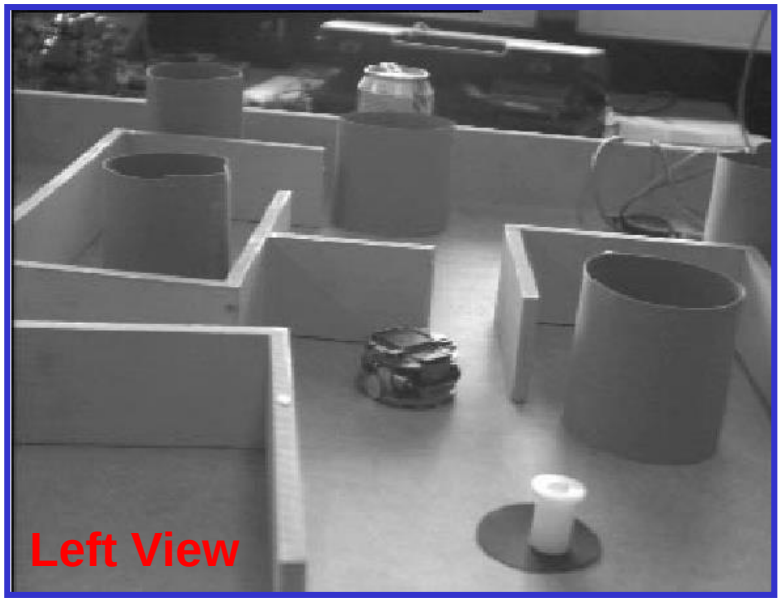
➢视差(Disparity)与深度(Depth)的关系

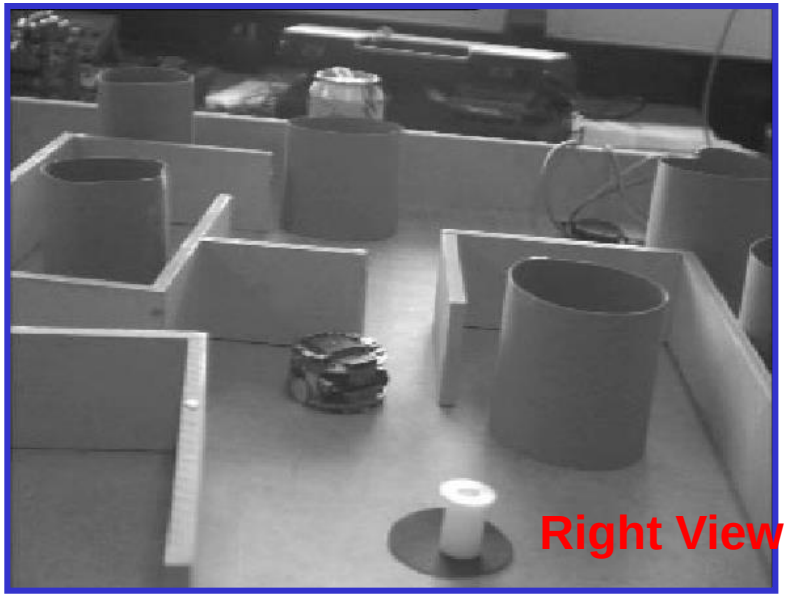
视差和深度成反比关系：

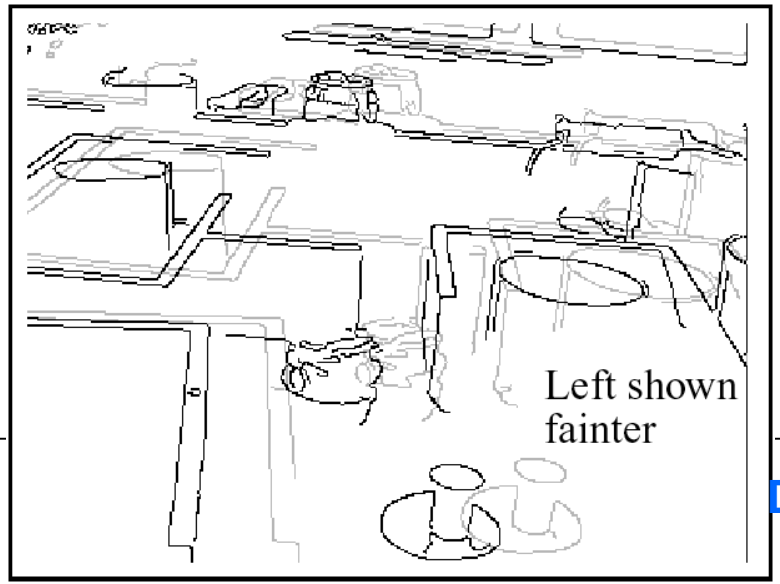
$$\frac{B-(x_L-x_R)}{Z-f}=\frac{B}{Z} \Rightarrow Z=\frac{Bf}{x_L-x_R}$$



2 双目立体视觉原理







Disparity

2 双目立体视觉原理

- 立体视觉技术是由两幅或多幅从不同视点拍摄的图像恢复场景三维信息的技术

- 两个主要的子问题
  - 匹配问题 (立体匹配) -> 视差图

    相似而不是相同

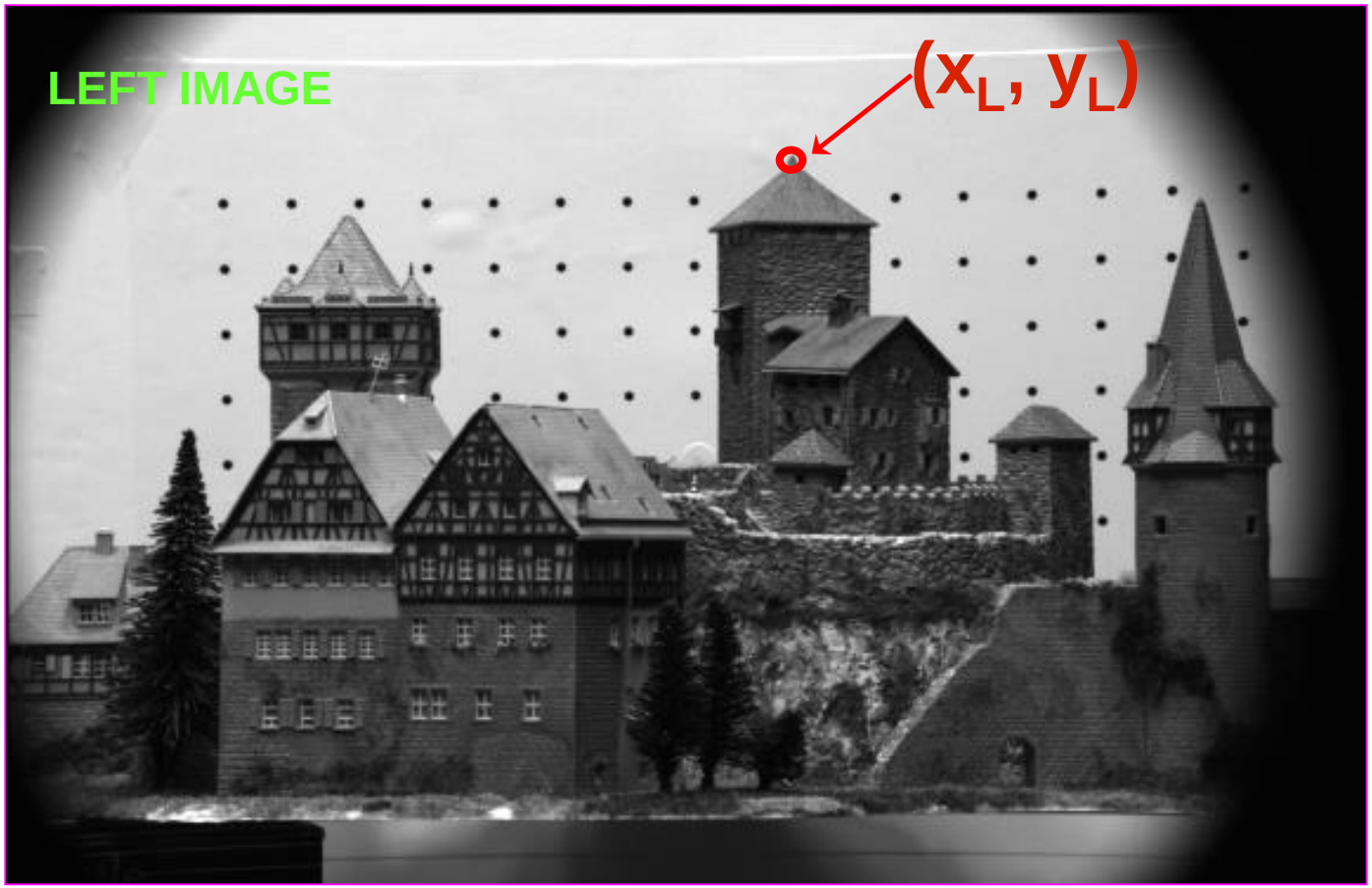
    遮挡问题: 场景的某些部分只在一幅图像中可见
  - 重建问题 -> 3D

    重建所需要的摄像机参数

    立体摄像机标定

2 双目立体视觉原理

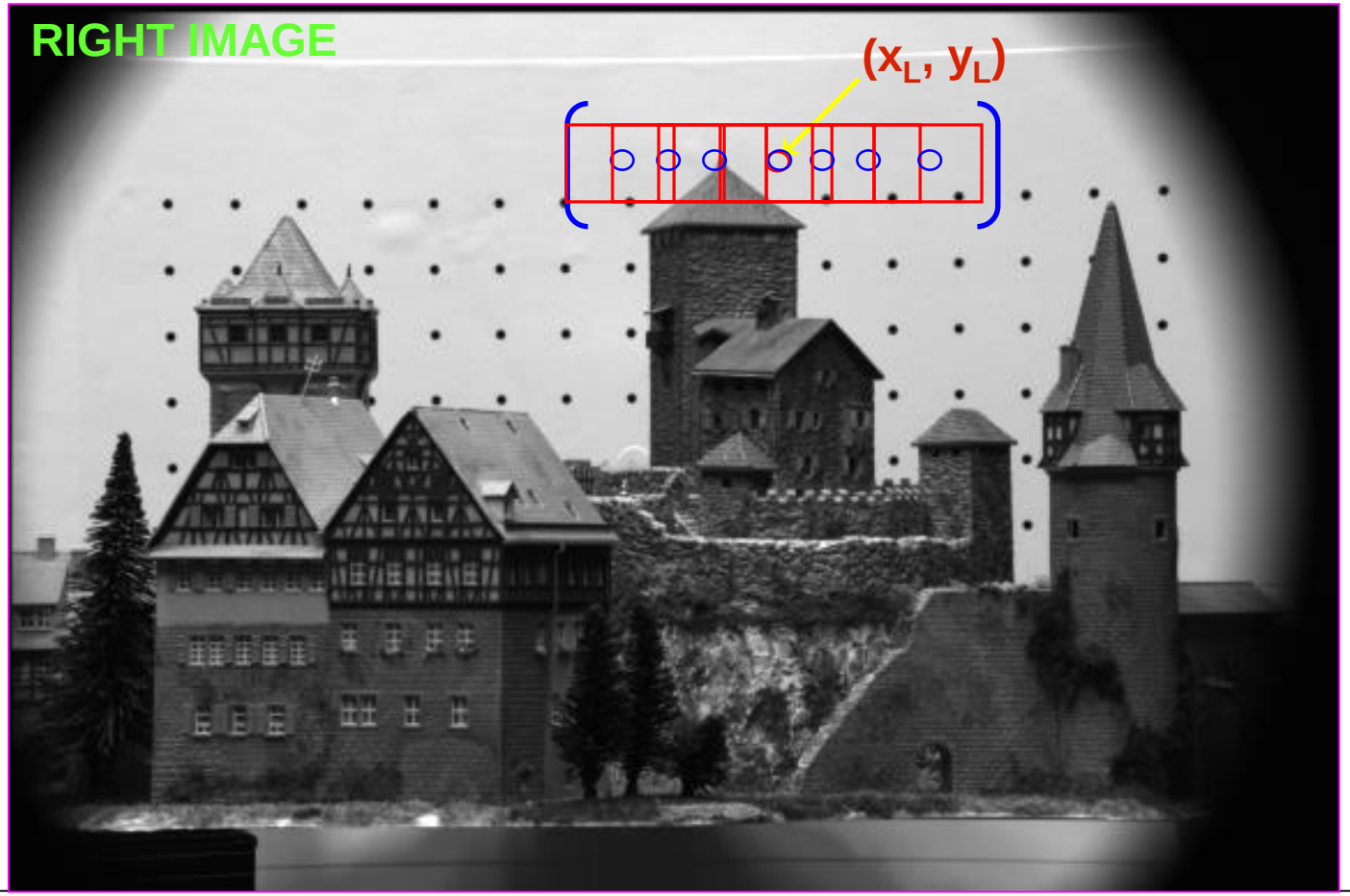
- 对于左图像上的每一个点 (x_L, y_L)，以这个点为中心在右图像定义一个搜索窗口



相关方案

2 双目立体视觉原理

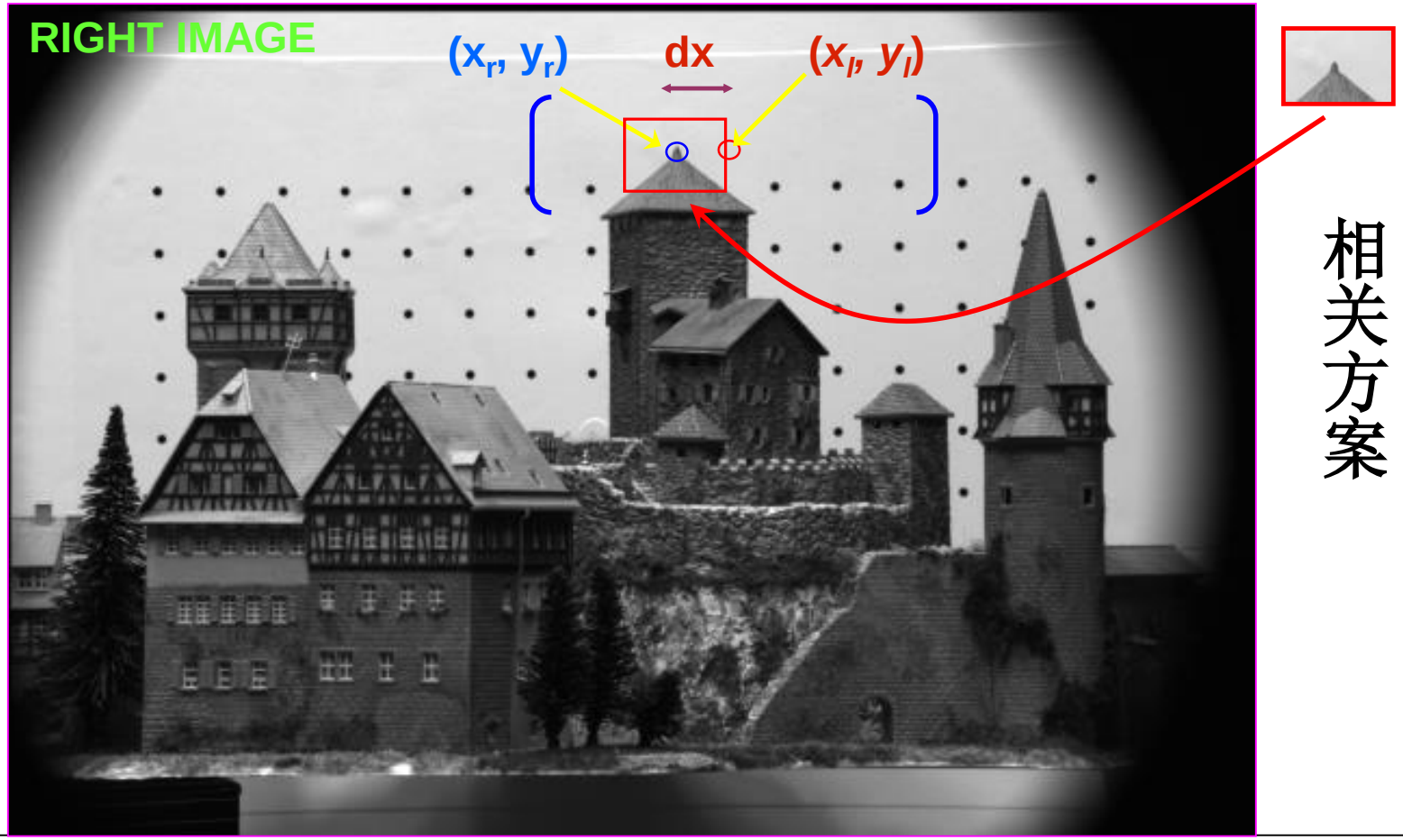
- 在右图像的搜索区内搜索对应点



相关方案

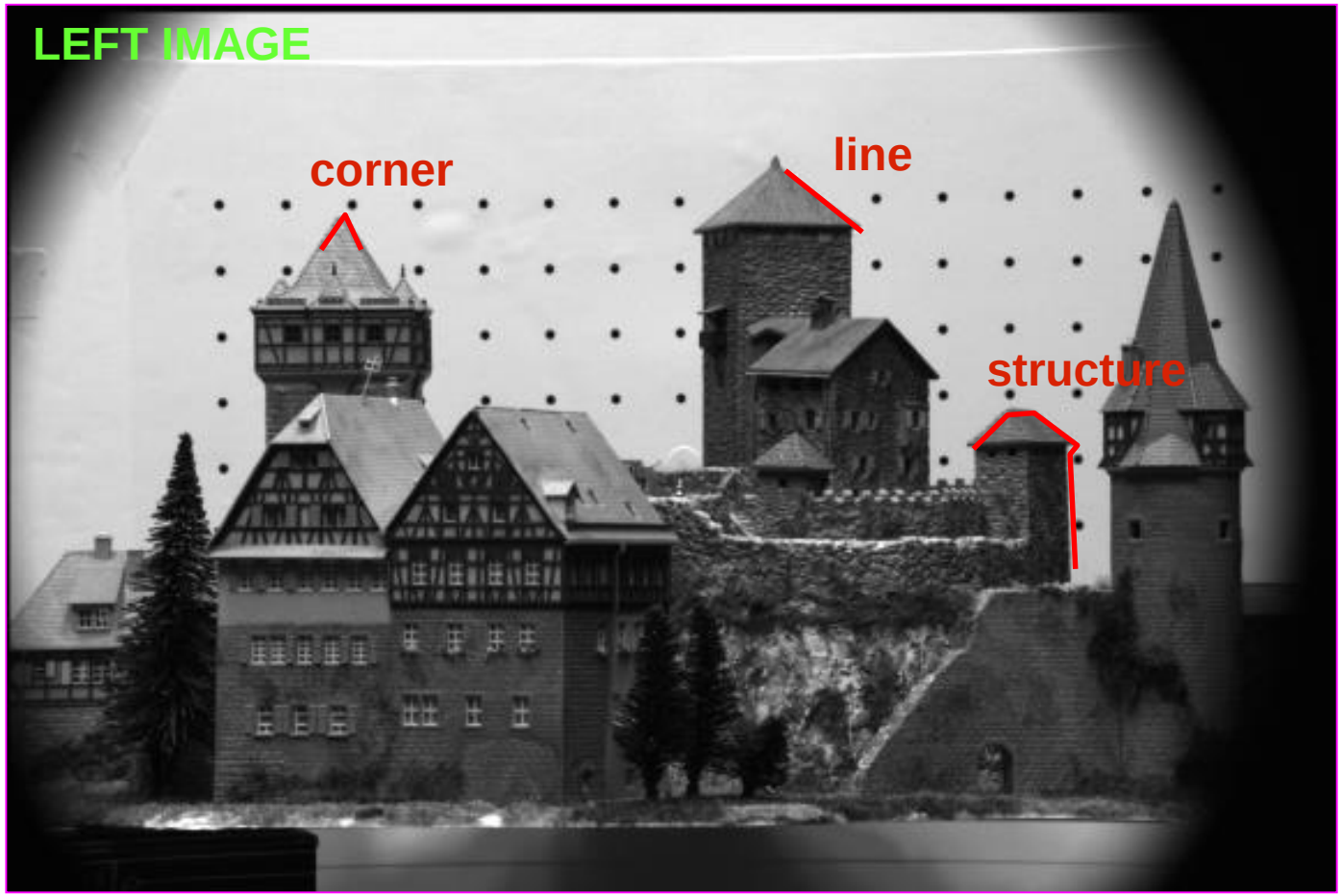
2 双目立体视觉原理

- 找到对应点后，得到视差（d_x，d_y）



2 双目立体视觉原理

- 对左图像中的每一个特征



基于特征

3 双目立体视觉对应点

- 简单的立体视觉系统

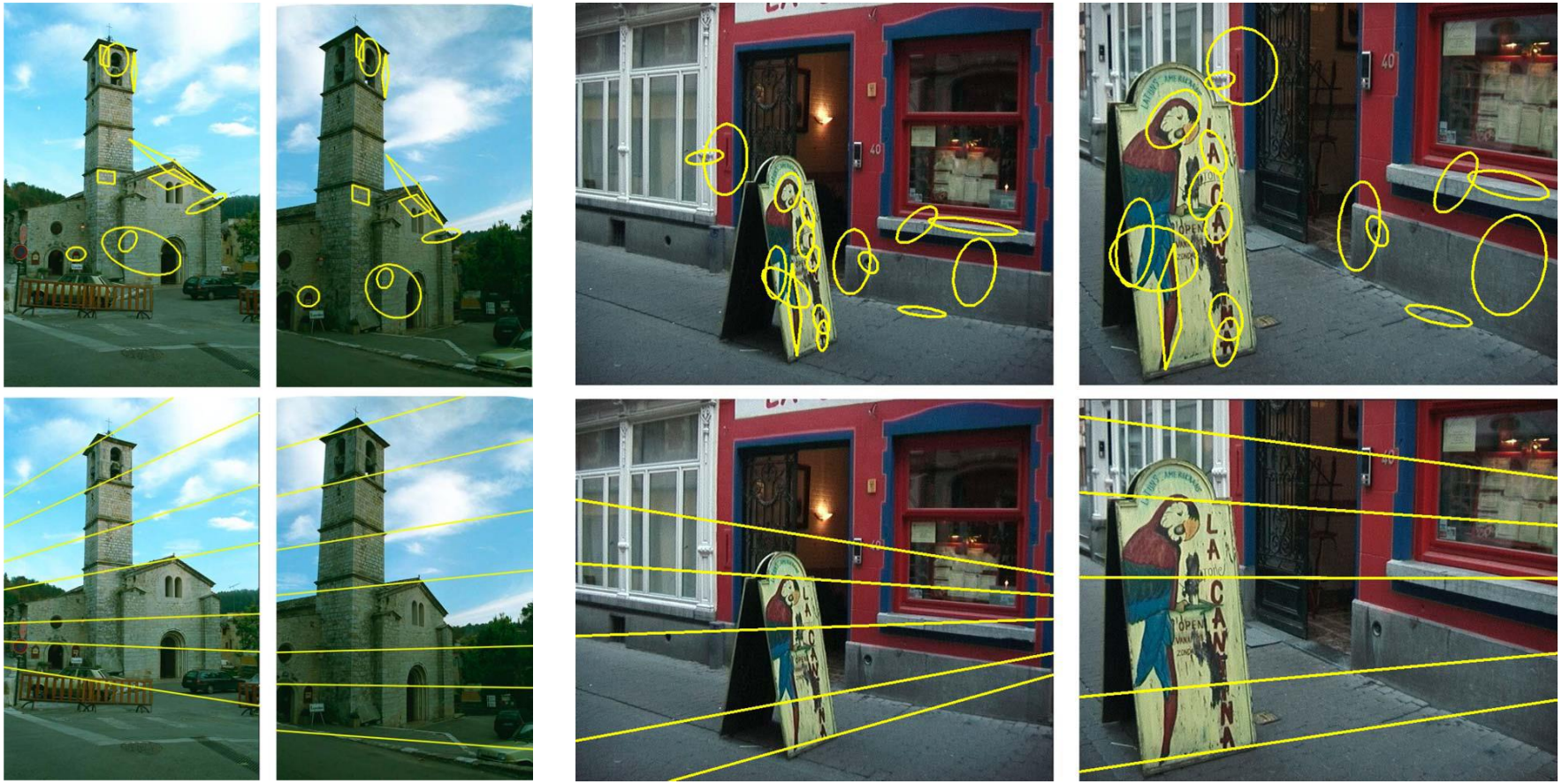
image I(x,y)

Disparity map D(x,y)

image I′(x′,y′)

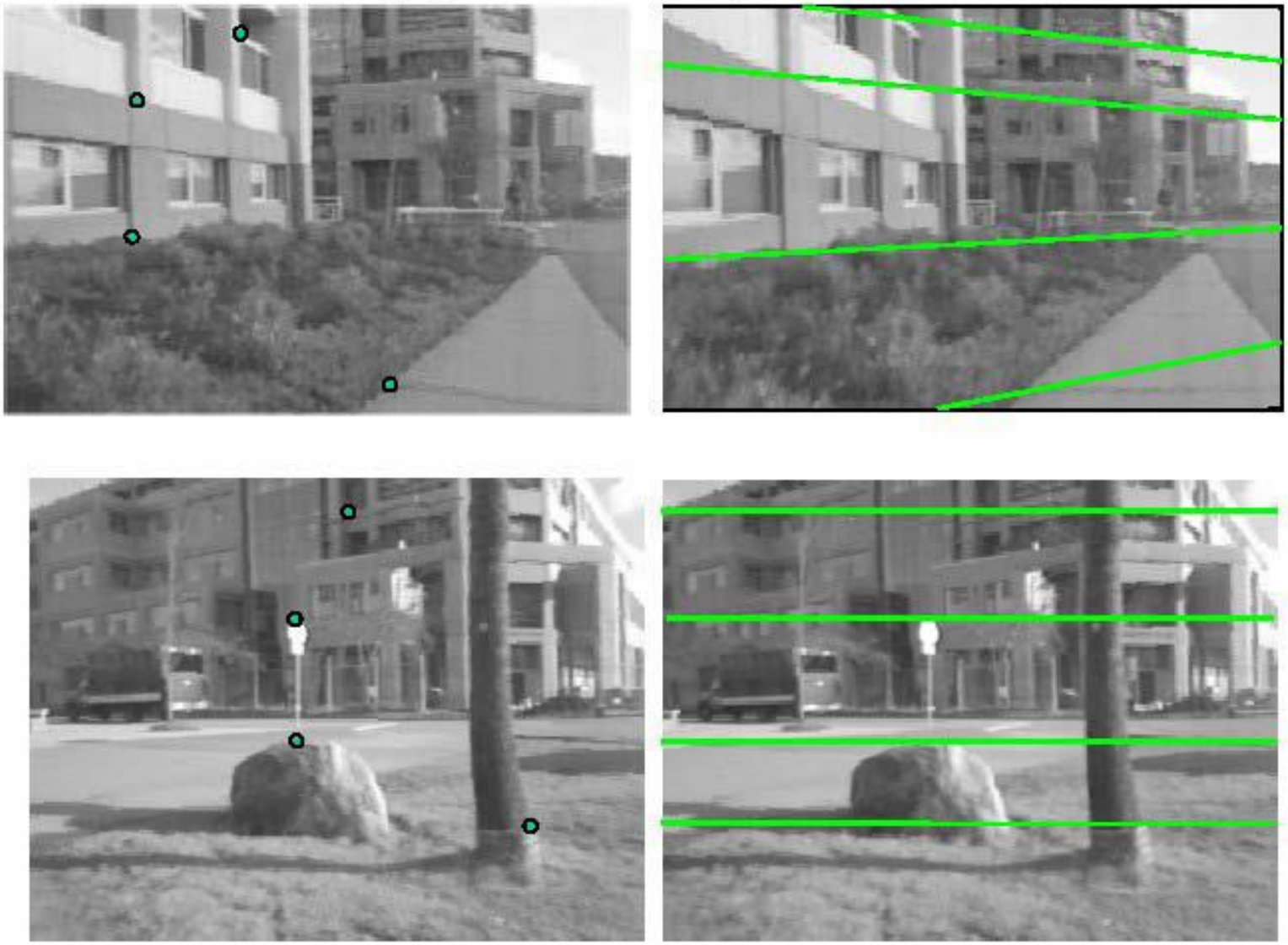
$$(x',y')=(x+D(x,y),y)$$

3 双目立体视觉对应点

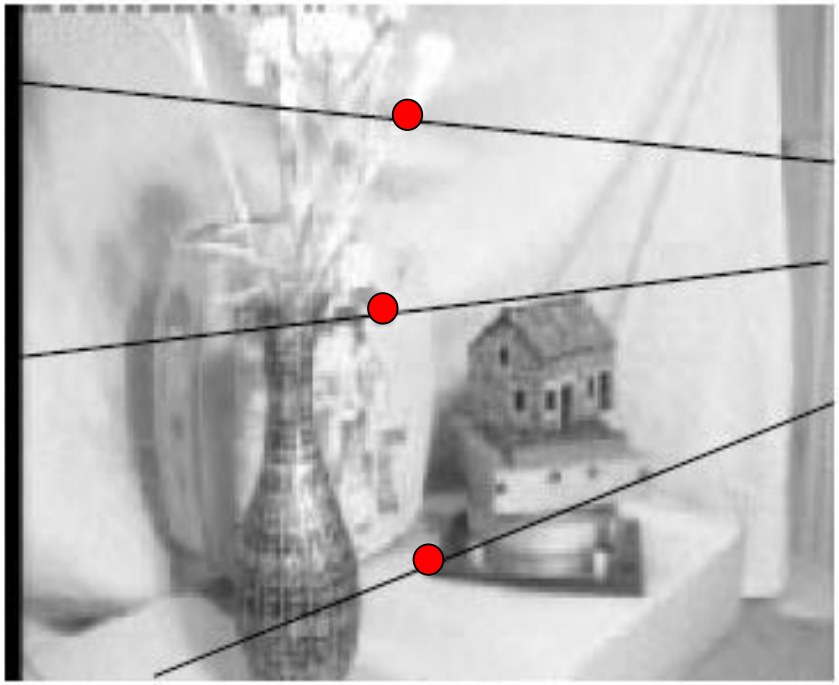


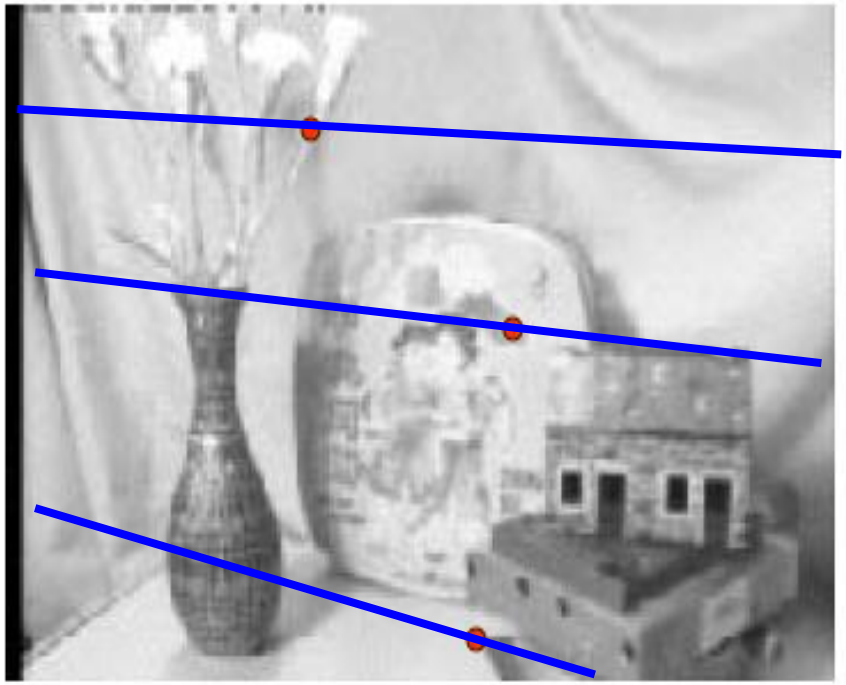
T. Tuytelaars and L. Van Gool, ***"Matching Widely Separated Views based on Affine Invariant Regions"*** Int. Journal on Computer Vision, 59(1), pp. 61-85, 2004.

3 双目立体视觉对应点

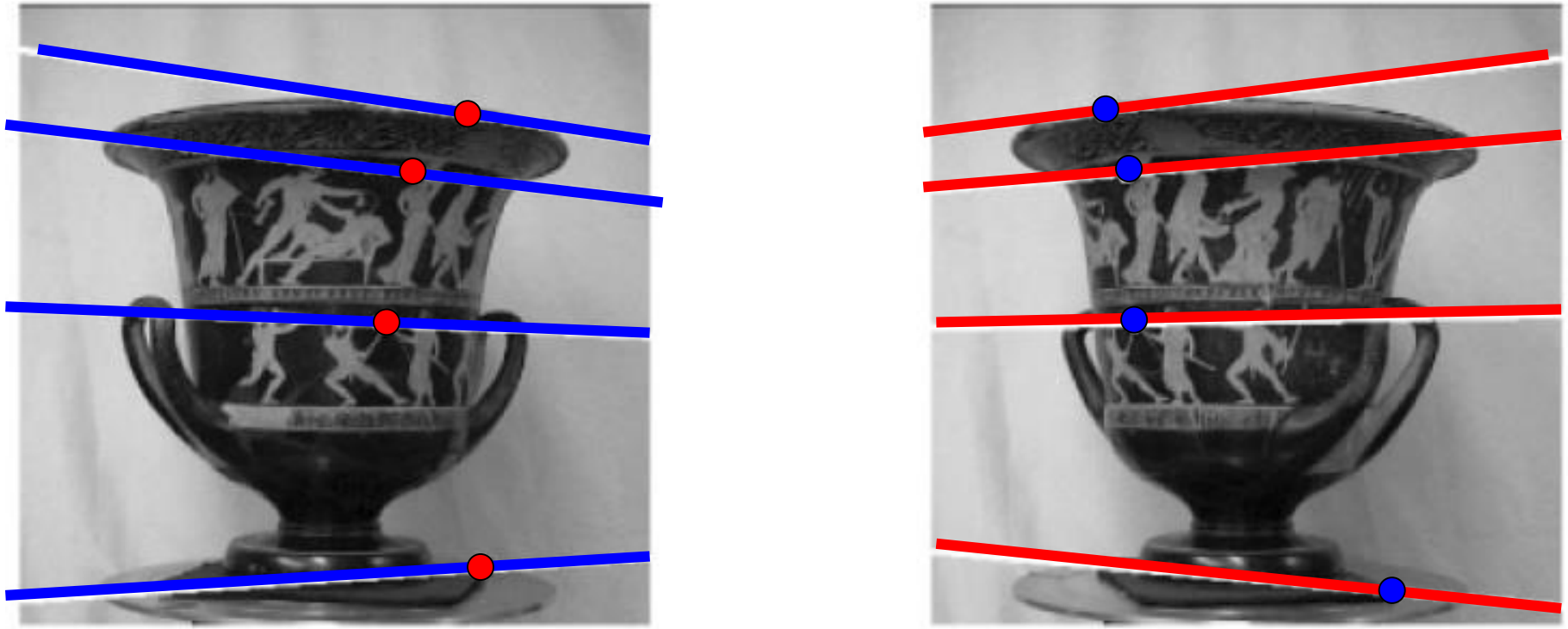


3 双目立体视觉对应点



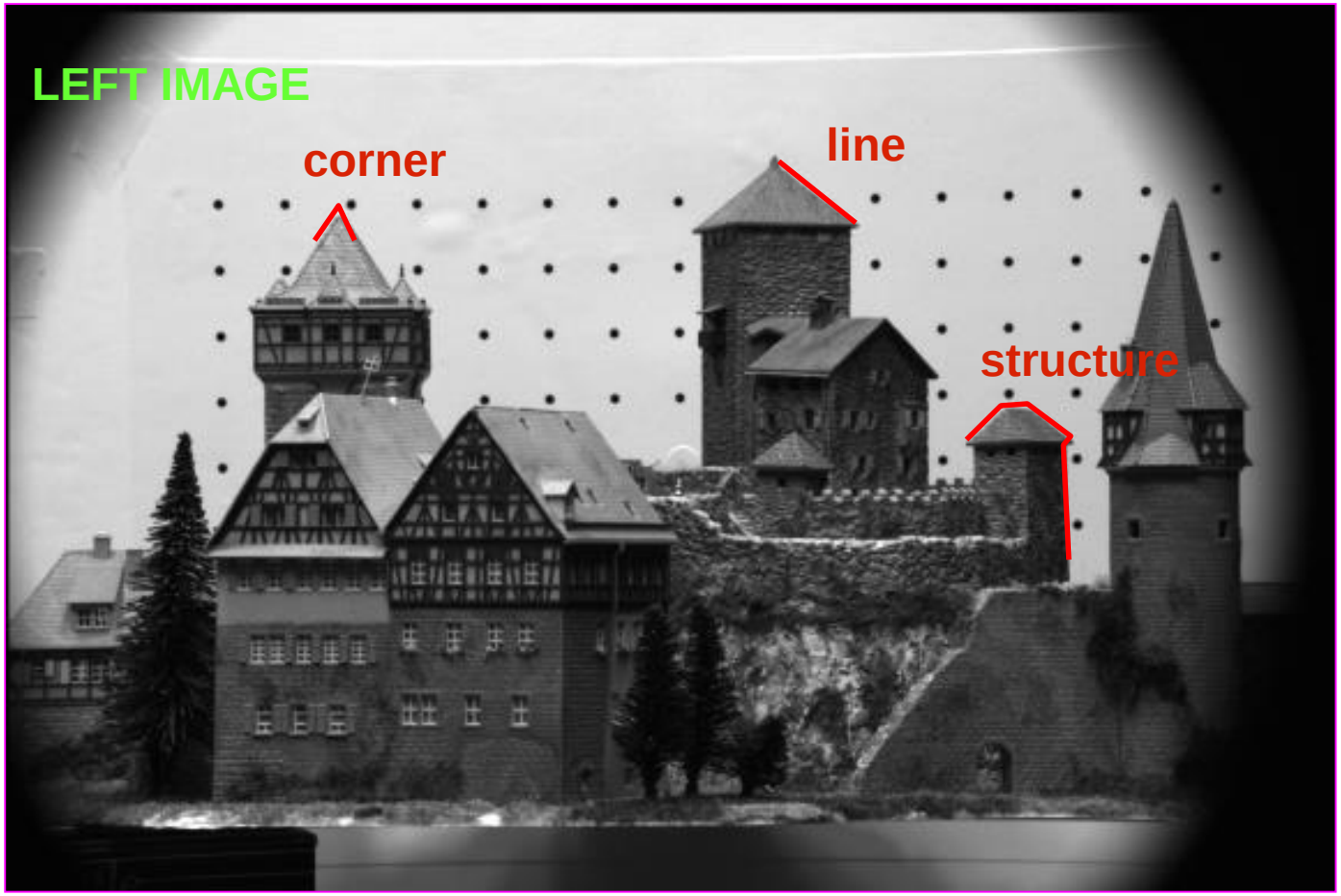


3 双目立体视觉对应点



立体匹配

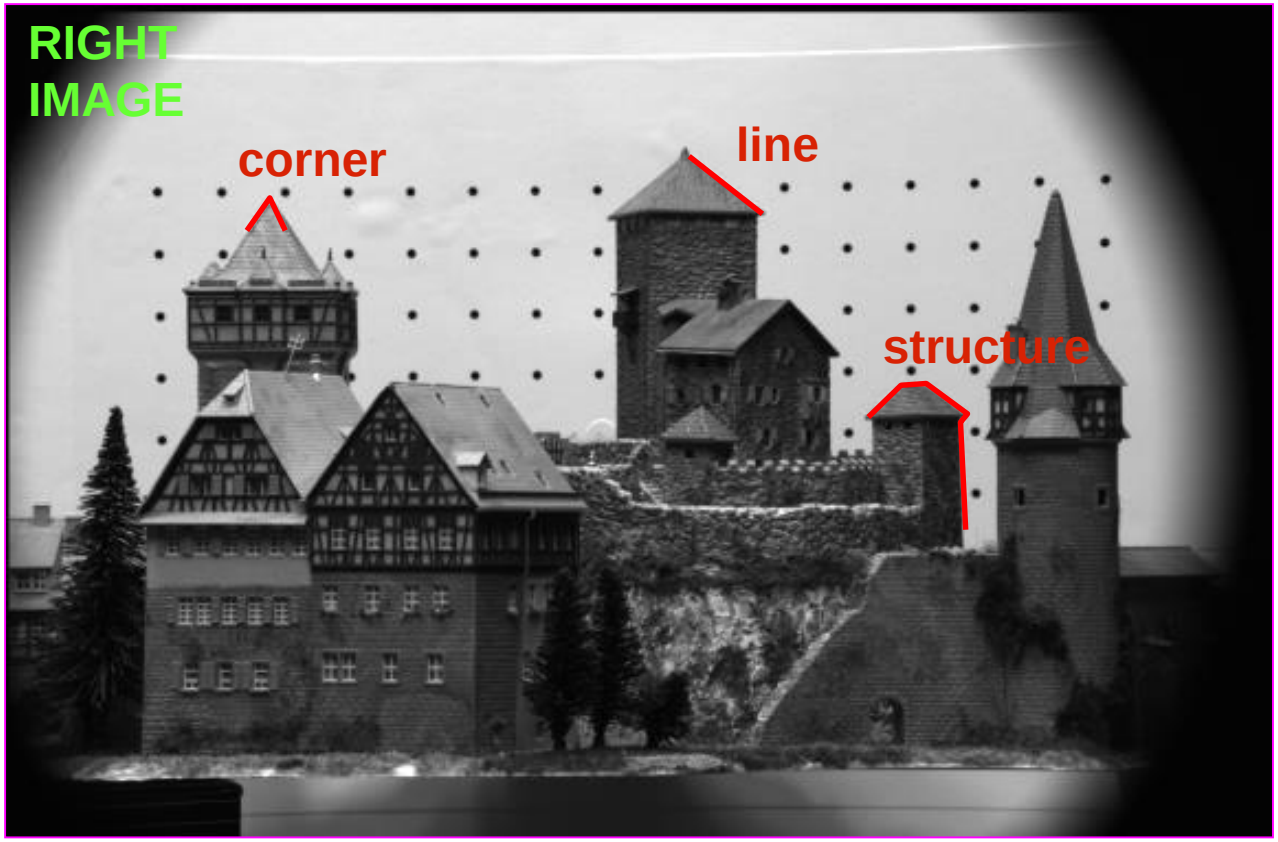
- 基于特征



对于左图像中的每一个特征…

▪ 立体匹配

➢ 基于特征



在右图像中寻找…

当相似度达到最大时的偏移量就是视差**(dx, dy)**

立体匹配

- 基于特征
  - 优点
    - 对光照变化不敏感
    - 有遮挡时，也能很好工作
    - 精度高
    - 计算速度快
  - 缺点
    - 获得稀疏的深度图，需经内插计算完成整幅深度图
    - 特征提取时，会存在部分特征被提取
    - 如何确定两个特征线间的测量相似度

立体匹配

算法评估

- 以真实视差场为参照，对计算得到的视差场进行评估，统计视差场的准确度，以此反映匹配方法的性能

- http://vision.middlebury.edu/stereo

立体匹配

立体匹配的困难

镜面反射

重复场景

遮挡

无纹理