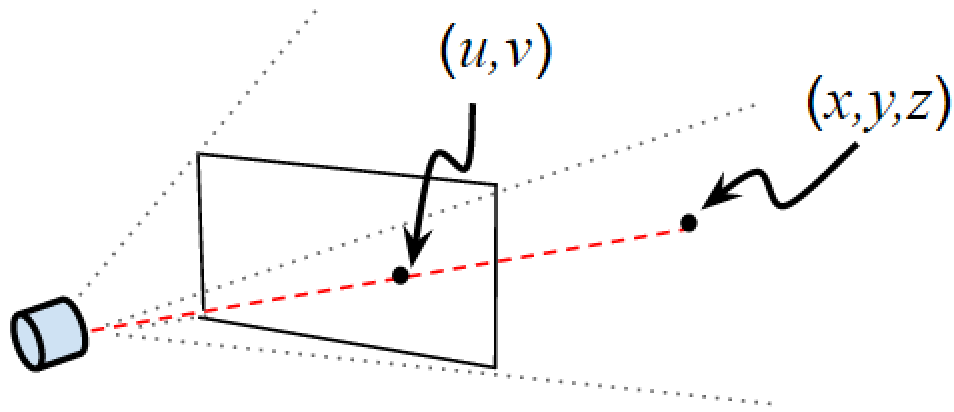
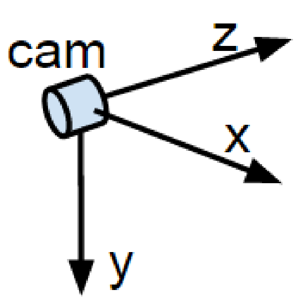
I. Ground Detection

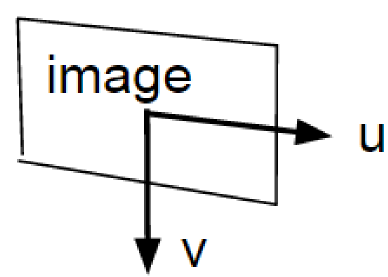
II. RGB-Depth Image Alignment

Preliminaries



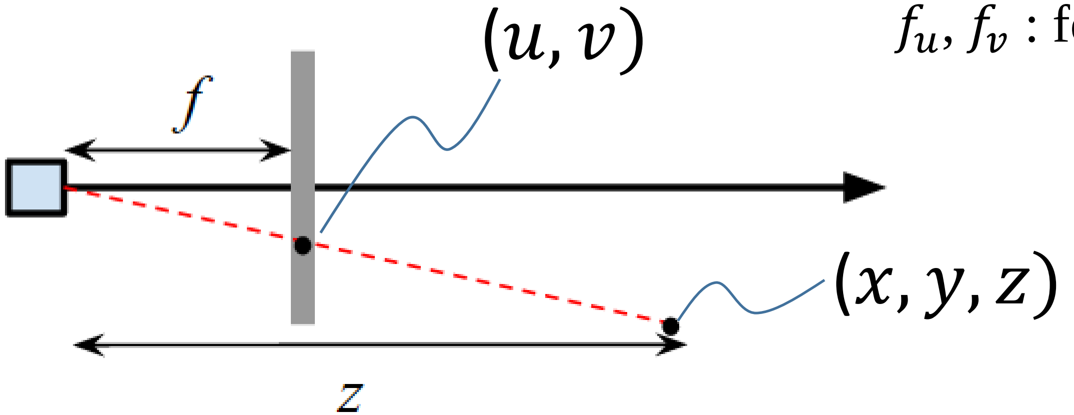


(3D) Camera coordinate frame



(2D) Image coordinate frame

Preliminaries



f_u, f_v : focal length

$$\frac{u}{f_u} = \frac{x}{z} \qquad \frac{v}{f_v} = \frac{y}{z}$$

Projection of a 3D point on the image plane

Preliminaries

- Plane model in x-y-z domain

$$a_0 x + a_1 y + a_2 z + a_3 = 0$$

Projection

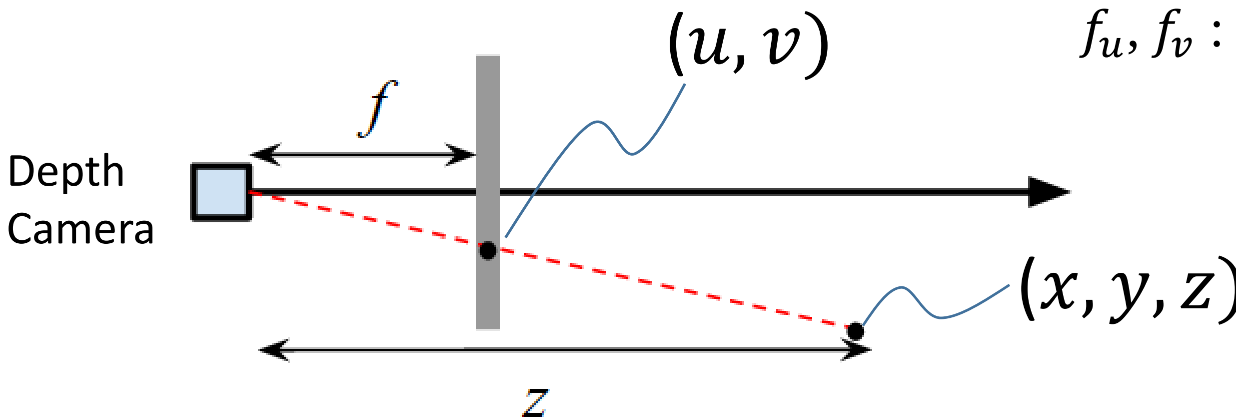
$$u = f_u \frac{x}{z} \qquad v = f_v \frac{y}{z}$$

- Can use image (u-v) and inverse depth ($d := z^{-1}$) domain

$$a_0' u + a_1' v + a_2' + a_3' d = 0$$

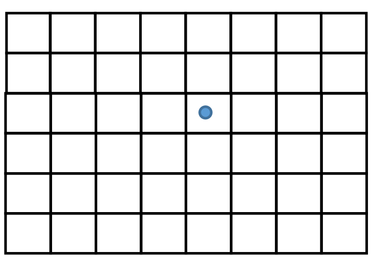
I. Ground Detection
    1) Aligned Camera
    2) Rotated Camera
II. RGB-Depth Image Alignment

Understanding Depth Image



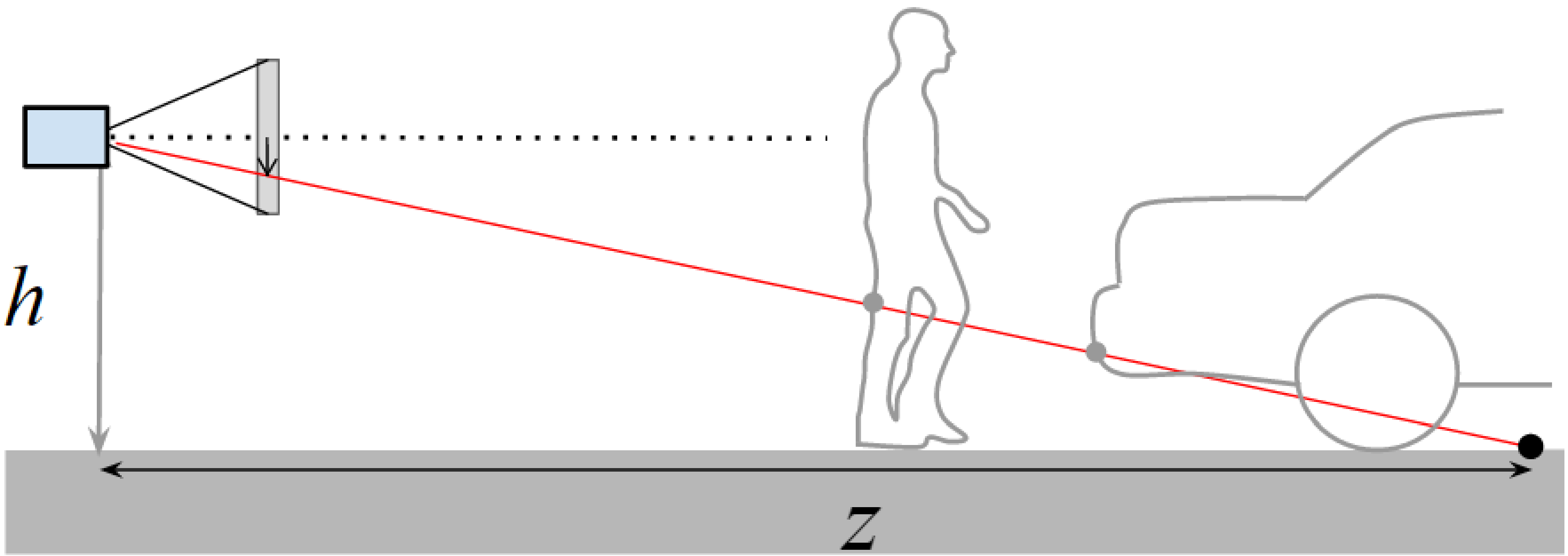
f_u, f_v : focal length

Depth Image



Pixel value at (u,v): z-value of the point in 3D

Ground Detection *(1) Aligned Camera*



Ground Plane model

$$y = h$$

Projection

$$\frac{v}{f_v} = \frac{y}{z}$$

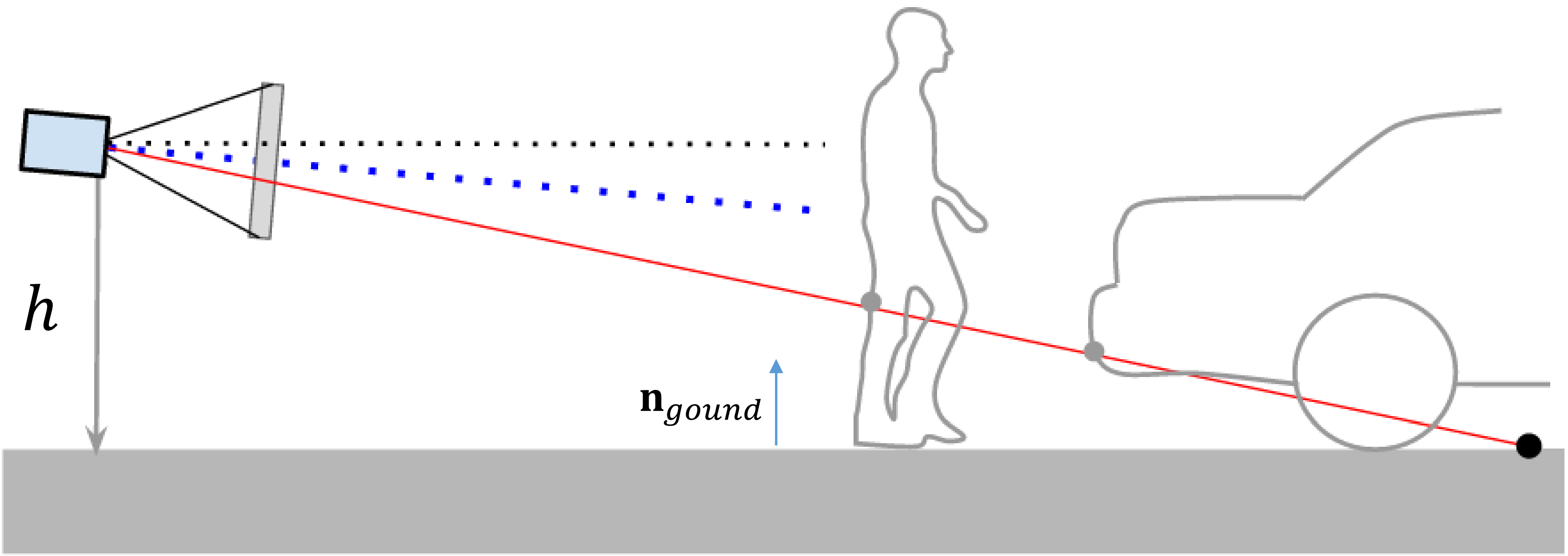
A ground point should satisfy this:

$$\left| \frac{v}{f_v} - \frac{h}{z} \right| < \varepsilon$$

*h,f are constants!

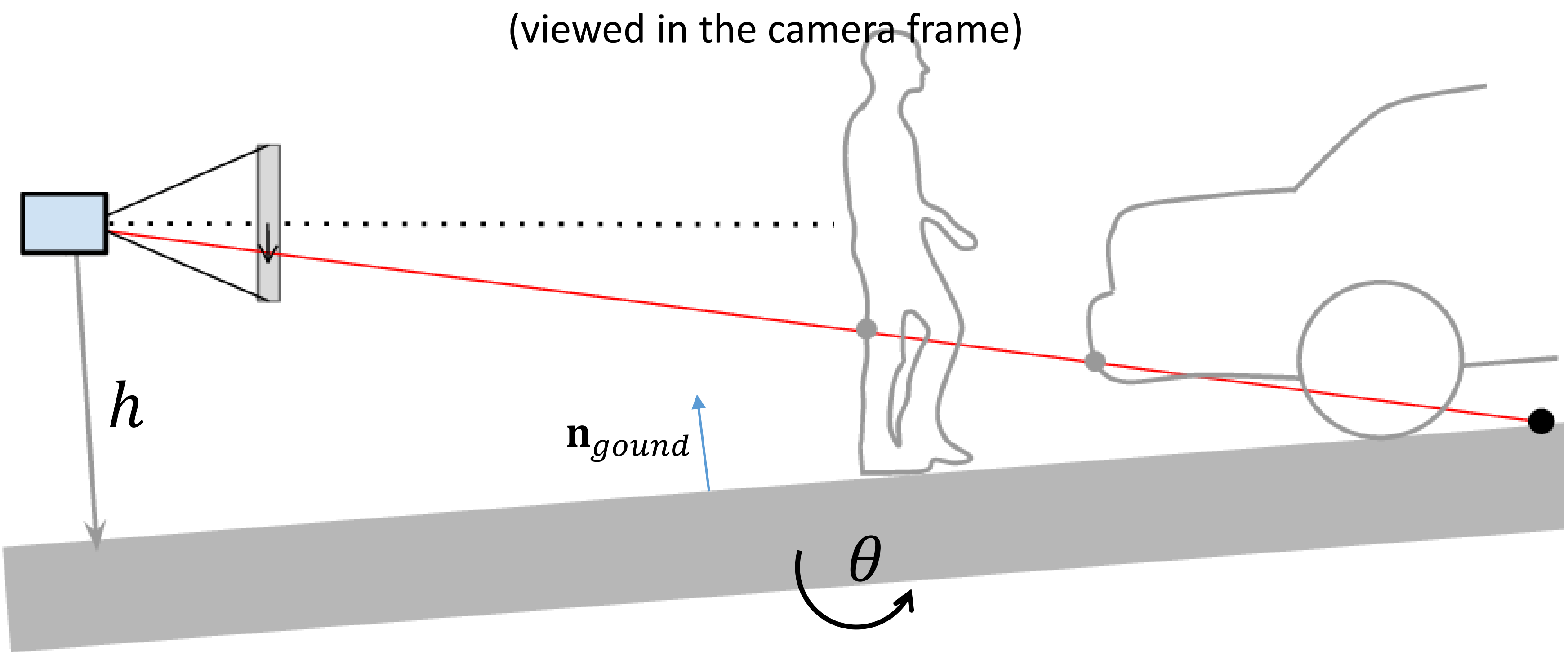
Ground Detection *(2) Rotated Camera*

(viewed in the global frame)



$$\mathbf{n}_{gound} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

Ground Detection *(2) Rotated Camera*



Ground Plane model

$$a_0x + a_1y + a_2z + a_3 = 0$$

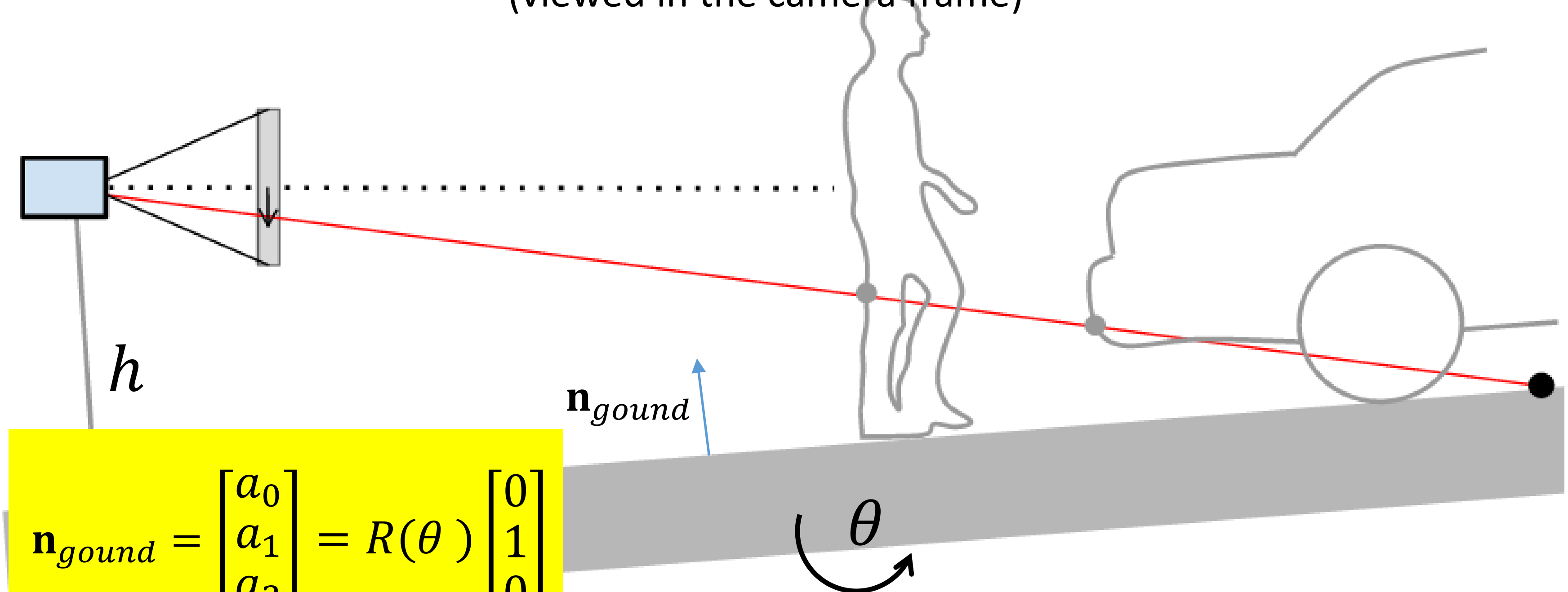
Projection

A ground point should satisfy this:

$$|a'_0u + a'_1v + a'_2 + a'_3d| < \varepsilon$$

Ground Detection *(2) Rotated Camera*

(viewed in the camera frame)



$$\mathbf{n}_{gound} = \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = R(\theta\ ) \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$a_3 = -h$$

Ground Plane model

$$a_0 x + a_1 y + a_2 z + a_3 = 0$$

Projection

A ground point should satisfy this:

$$|a_0' u + a_1' v + a_2' + a_3' d\ | < \varepsilon$$

Coefficients are computed from this, where θ is the camera pose.

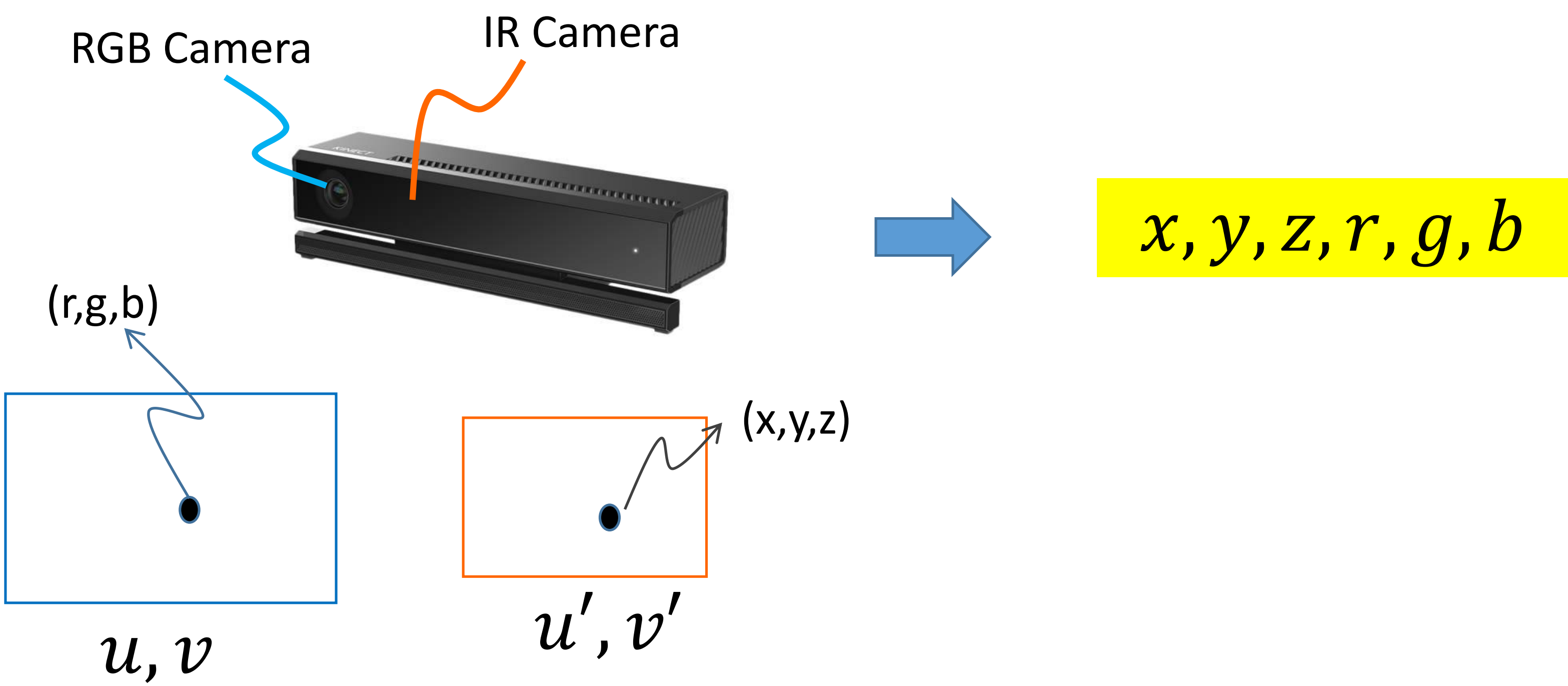
I. Ground Detection

II. RGB-Depth Image Alignment

RGB-Depth Image Alignment

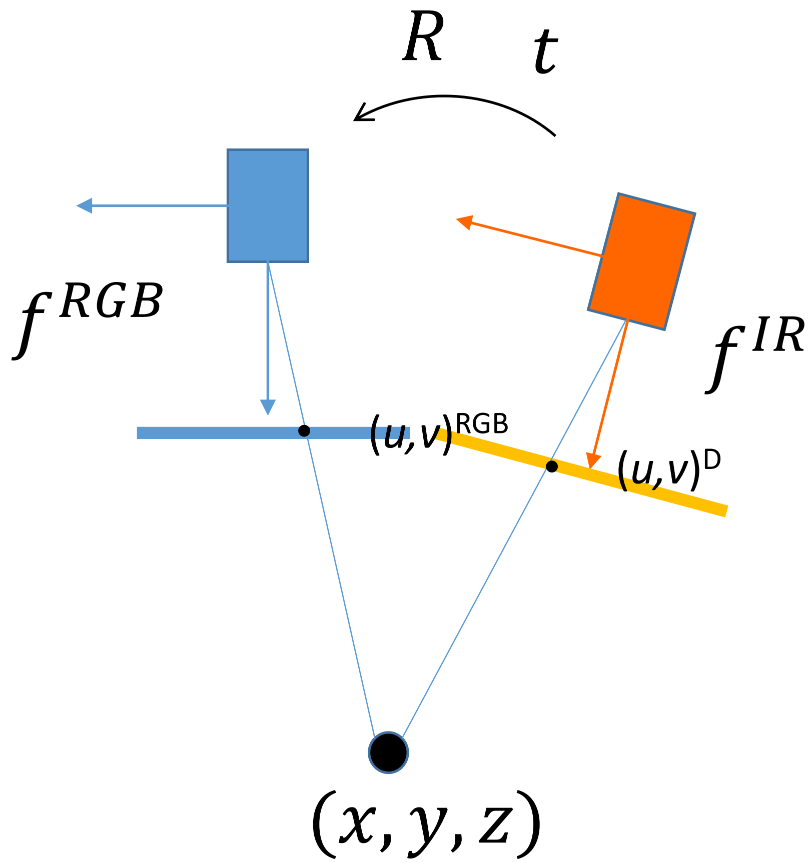
Aim: we want to obtain the tuple of 3d point and its color.

Issue: RGB images are obtained from the RGB camera, Depth images are from the IR camera. They are physically separated, and have different camera parameters.



RGB-Depth Image Alignment

Essential Problem: Given all camera parameters(R,t,f), find the corresponding points of a RGB and a depth image.



RGB-Depth Image Alignment

Recall this: $$\frac{u}{f_u} = \frac{x}{z}$$

1) Compute the 3d coordinate X^{IR} in IR camera frame

$$x^{IR} = uz/f^{IR} \quad y^{IR} = vz/f^{IR}$$

$$X^{IR} = [x^{IR} \quad y^{IR} \quad z^{IR}]$$

2) Transform into the RGB camera frame

$$X^{RGB} = RX^{IR} + t$$

3) Reproject them on to the image plane

$$u^{RGB} = f^{RGB}\frac{x^{RGB}}{z^{RGB}} \quad v^{RGB} = f^{RGB}\frac{x^{RGB}}{z^{RGB}}$$

4) Read (r,g,b) at $(u,v)^{RGB}$

RGB-Depth Image Alignment

Recall this: $$\frac{u}{f_u} = \frac{x}{z}$$

1) Compute the 3d coordinate X^{IR} in IR camera frame

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$$u^{RGB} = f^{RGB}\frac{x^{RGB}}{z^{RGB}} \quad v^{RGB} = f^{RGB}\frac{x^{RGB}}{z^{RGB}}$$

4) Read (r,g,b) at $(u,v)^{RGB}$

This is the color of **this** point.