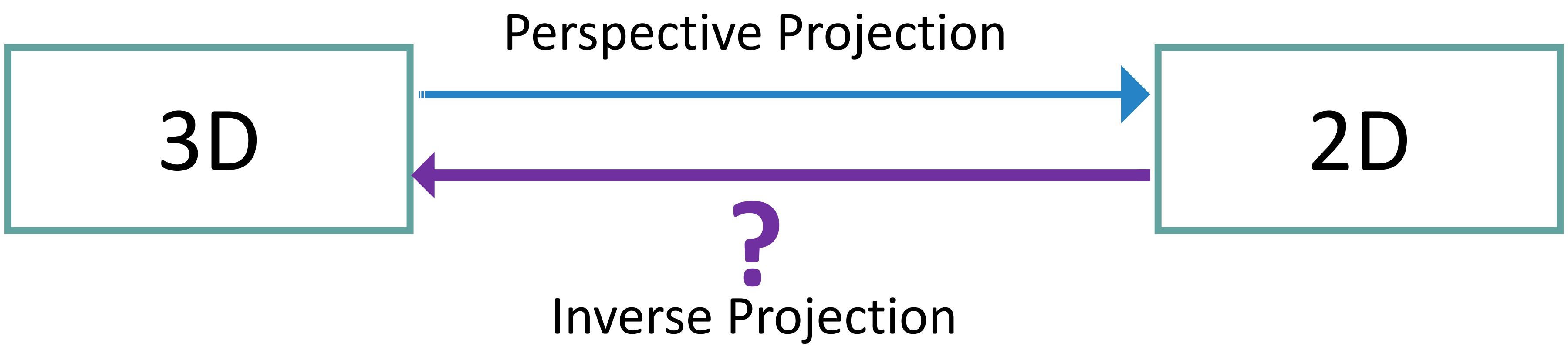
Inverse Projection

Computer Graphics Course, Fall 2023

Presenter: Hanh Le

Inverse Projection



Why Inverse Projection?

3D Reconstruction from Images

Augmented Reality

Gesture Recognition

Depth Sensing in Consumer Electronics

Surveillance and Security

Camera Calibration

Object Tracking

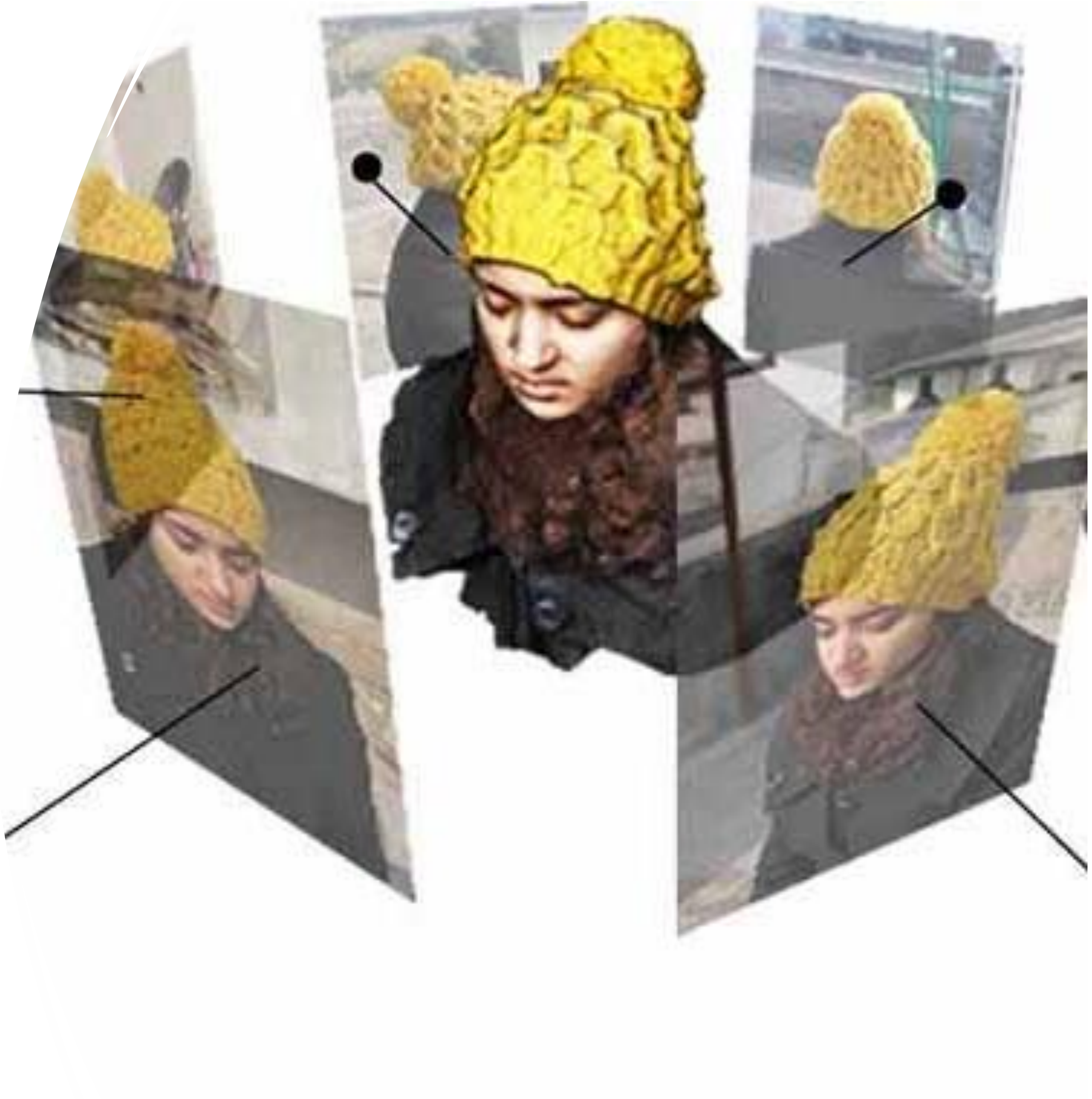
Simulations and Virtual Environments

Robotics

Medical Imaging

3D Reconstruction from Images

Using inverse projection to reconstruct three-dimensional scenes from two-dimensional images.

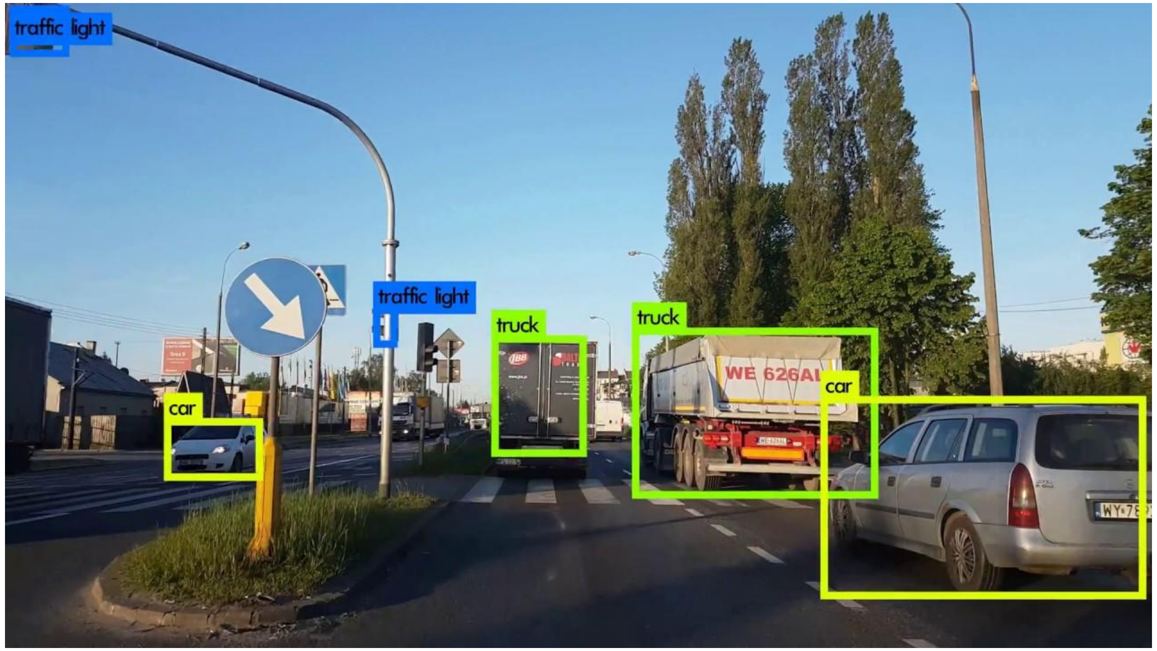


Augmented Reality

Using inverse projection to place virtual objects accurately in the real-world environment.

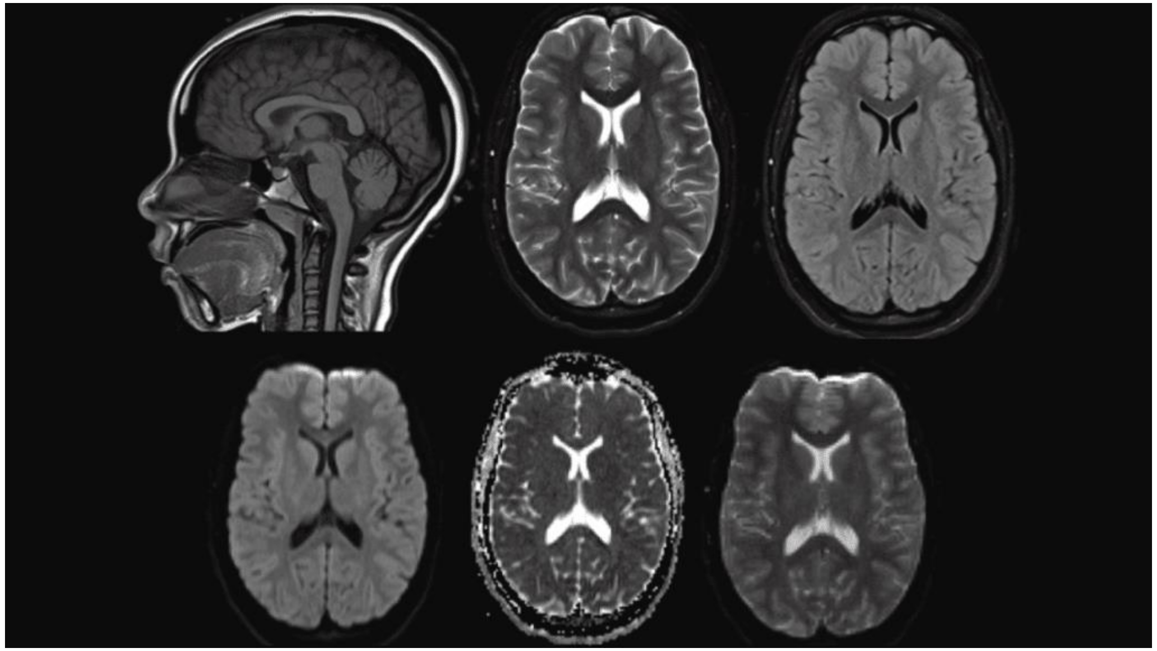
Object Tracking

Using inverse projection to track the movement of objects in a video sequence.



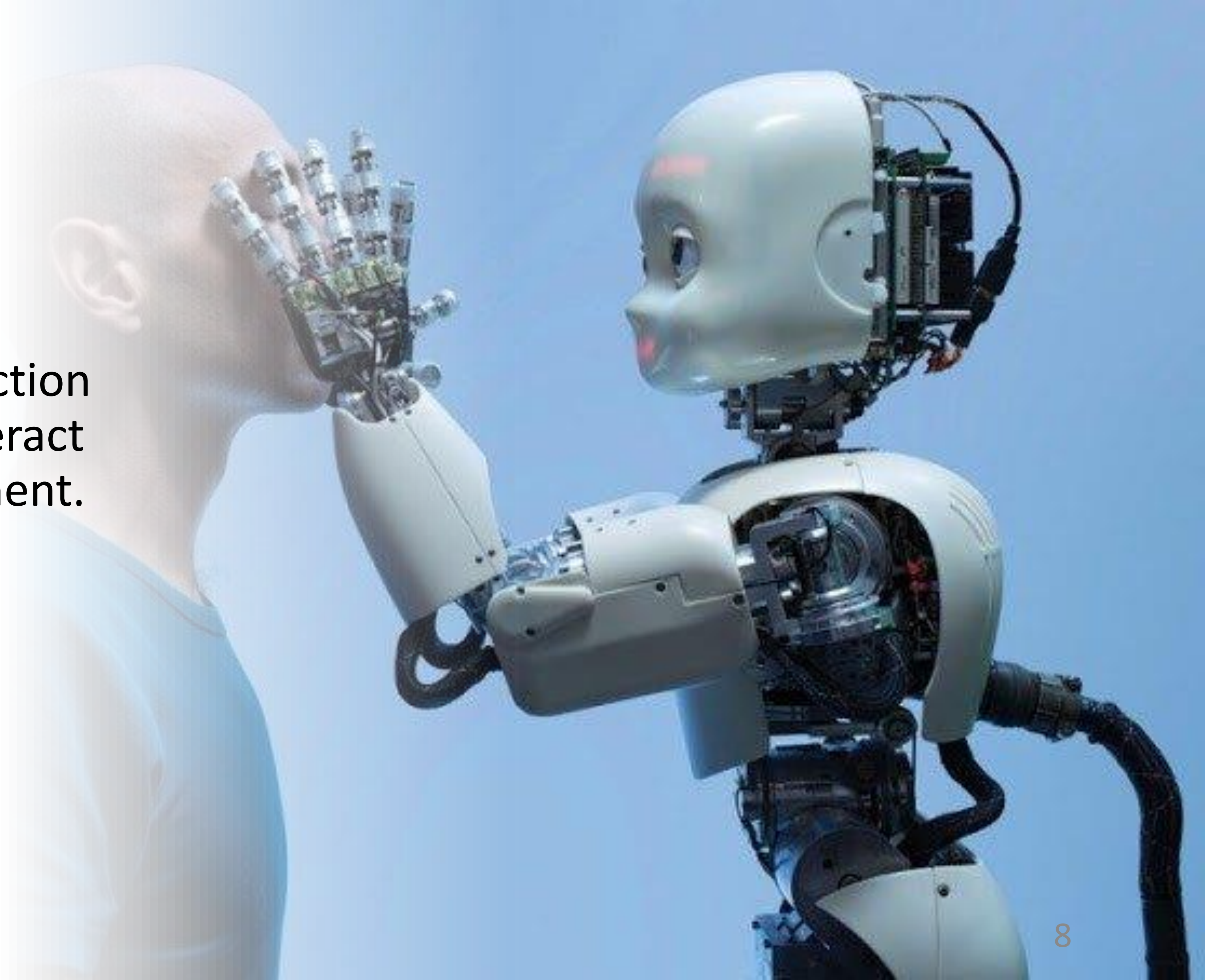
Medical Imaging

Using inverse projection to reconstruct three-dimensional images of internal structures from a series of 2D slices.

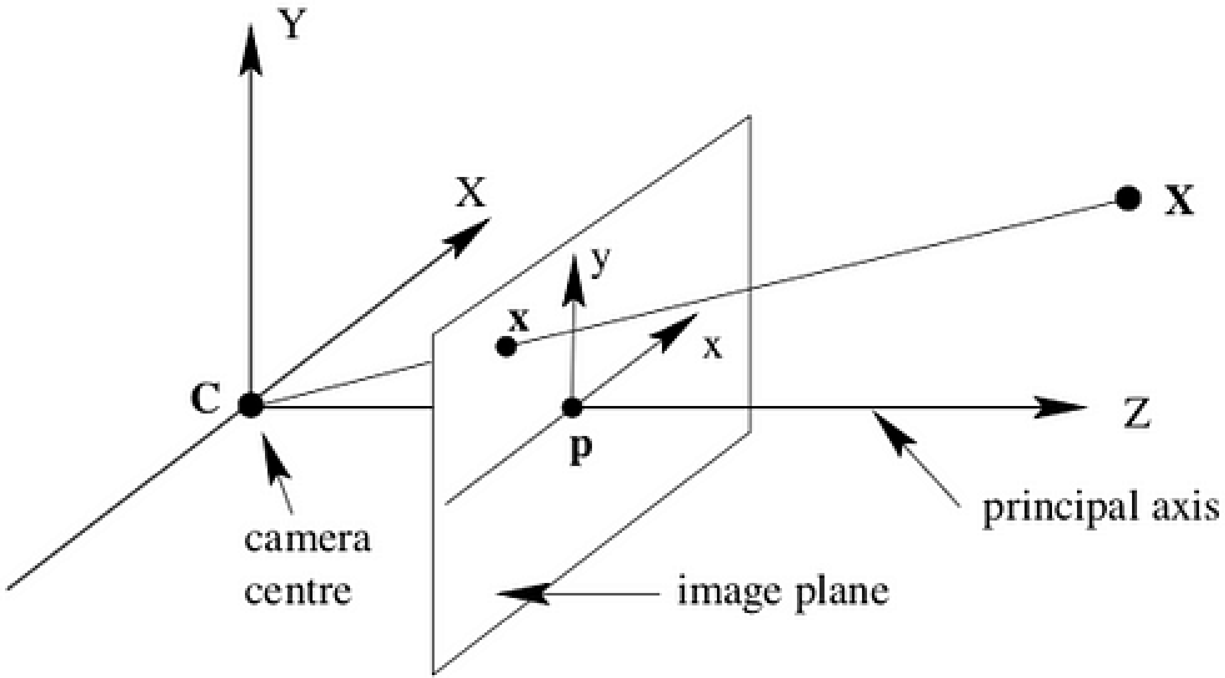


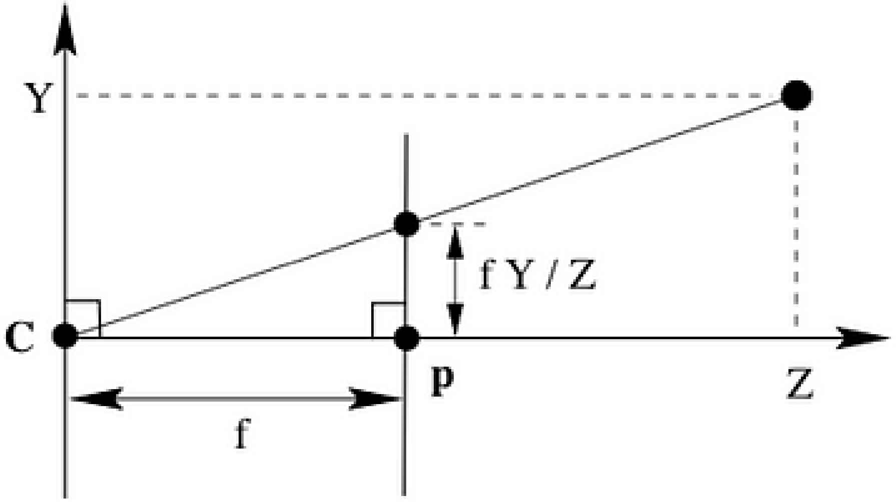
Robotics

Using inverse projection to perceive and interact with their environment.



Inverse Projection





Inverse Projection Transformation

Photo credited by Daryl Tan

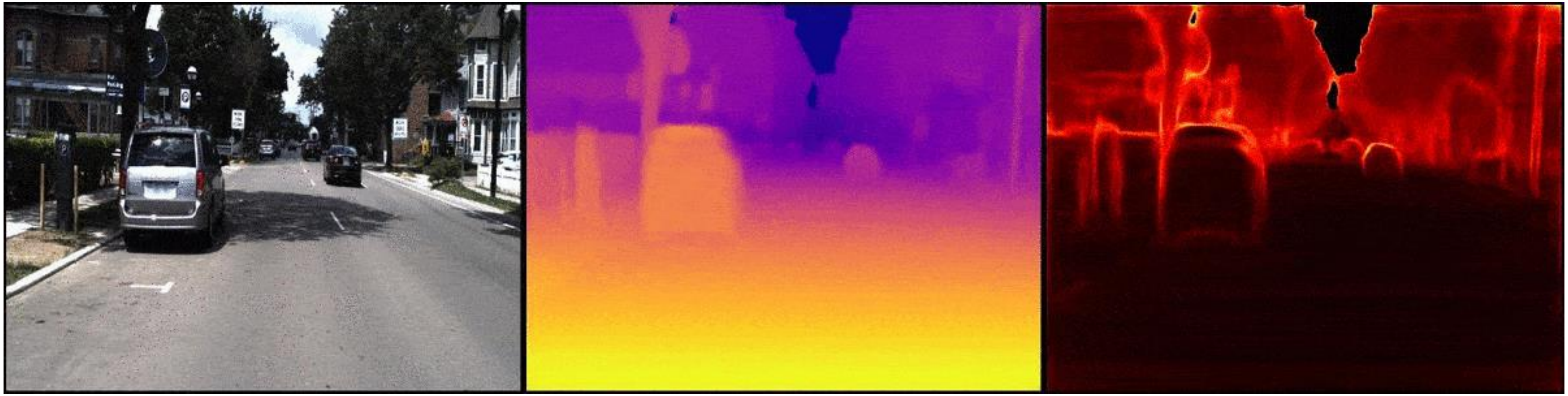
Inverse Projection Transformation

RGB image

Depth map

Photo credited by Daryl Tan

Depth map



Data from DDAD Dataset. Left: Image. Middle: Disparity. Right: Uncertainty

Depth estimation - Classical technique

Stereo vision

Depth estimation - Classical technique

Stereo vision

- Stereo Setup
- Correspondence Matching
- Disparity Calculation
- Depth Calculation

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$$\text{Depth} = \frac{\text{Baseline} \times \text{Focal Length}}{\text{Disparity}}$$

Depth Estimation – Deep learning methods

MiDaS

Structure from Motion

Depth from Focus

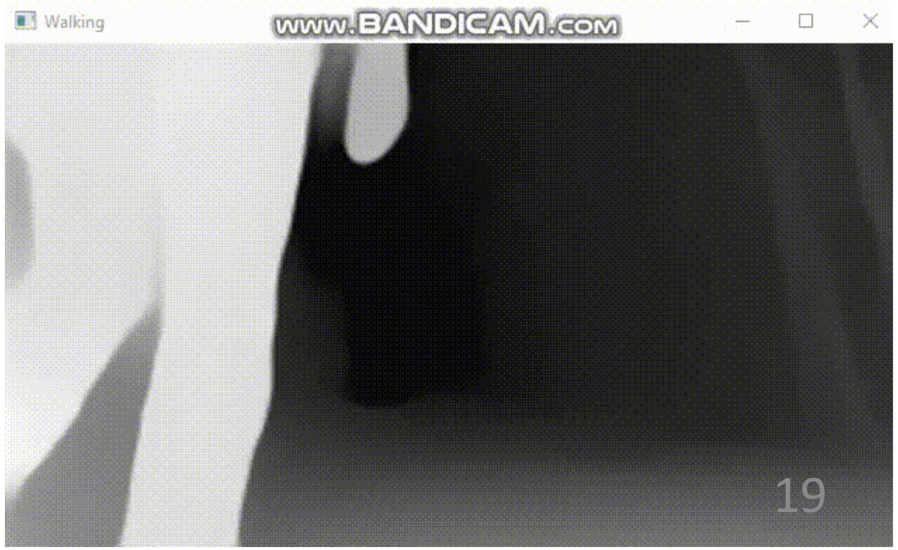


Photo credited by Nabeel Khan

Inverse Projection

Photo credited by Daryl Tan

Inverse Projection

Pixel coordinate

(x, y)

z

Depth value

$\Rightarrow \begin{bmatrix} x \\ y \\ z \end{bmatrix} \Rightarrow$

4D homogeneous vector

$$v_H = \begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix}$$

Scaling factor

Inverse Projection

$$P = \begin{bmatrix} \frac{n}{r} & 0 & 0 & 0 \\ 0 & \frac{n}{t} & 0 & 0 \\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2fn}{f-n} \\ 0 & 0 & -1 & 0 \end{bmatrix} \Rightarrow P^{-1} = \begin{bmatrix} \frac{r}{n} & 0 & 0 & 0 \\ 0 & \frac{t}{n} & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & \frac{f-n}{-2fn} & \frac{f+n}{2n} \end{bmatrix}$$

- n is the near clipping plane.
- f is the far clipping plane.
- r and t are the right and top frustum values.

Inverse Projection

$$\begin{bmatrix} x_r \\ y_r \\ z_r \\ w_r \end{bmatrix} = \begin{bmatrix} \frac{n}{r} & 0 & 0 & 0 \\ 0 & \frac{t}{n} & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & \frac{f-n}{-2fn} & \frac{f+n}{2n} \end{bmatrix} * \begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix}$$

Inverse of perspective projection matrix

4D homogeneous vector

Inverse Projection

$$\begin{bmatrix} x_r \\ y_r \\ z_r \\ w_r \end{bmatrix} = \begin{bmatrix} \frac{n}{r} & 0 & 0 & 0 \\ 0 & \frac{t}{n} & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 0 & 0 & \frac{f-n}{-2fn} & \frac{f+n}{2n} \end{bmatrix} * \begin{bmatrix} x \\ y \\ z \\ w \end{bmatrix}$$

Inverse of perspective projection matrix

4D homogeneous vector

$$\begin{bmatrix} x_r \\ y_r \\ z_r \end{bmatrix} = \frac{1}{w_r} \begin{bmatrix} x_r \\ y_r \\ z_r \end{bmatrix}$$

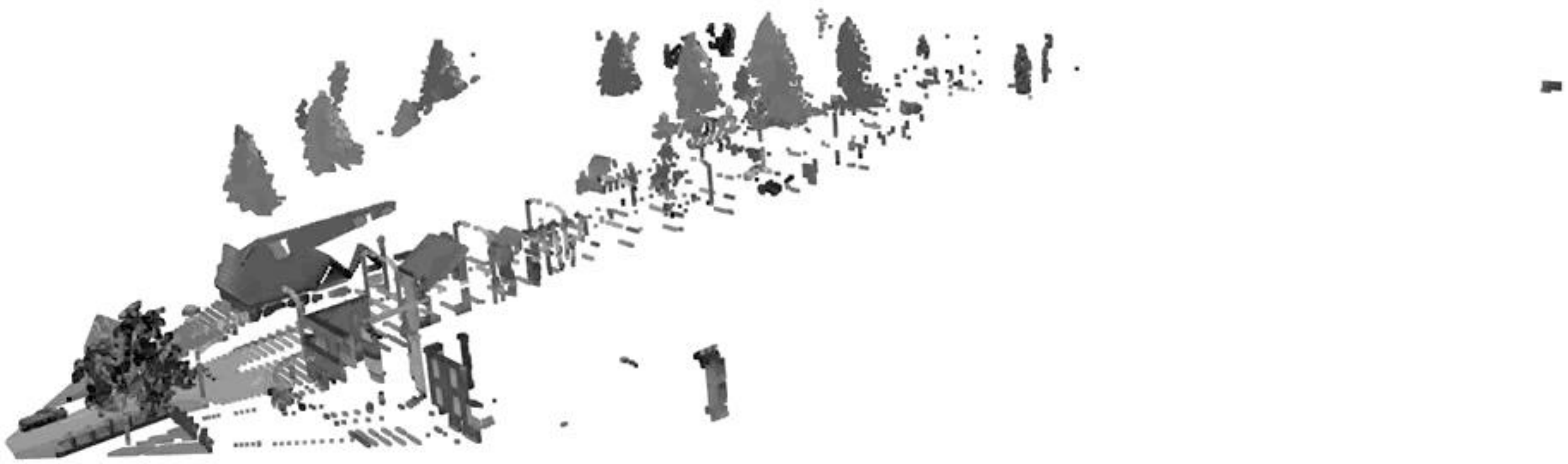
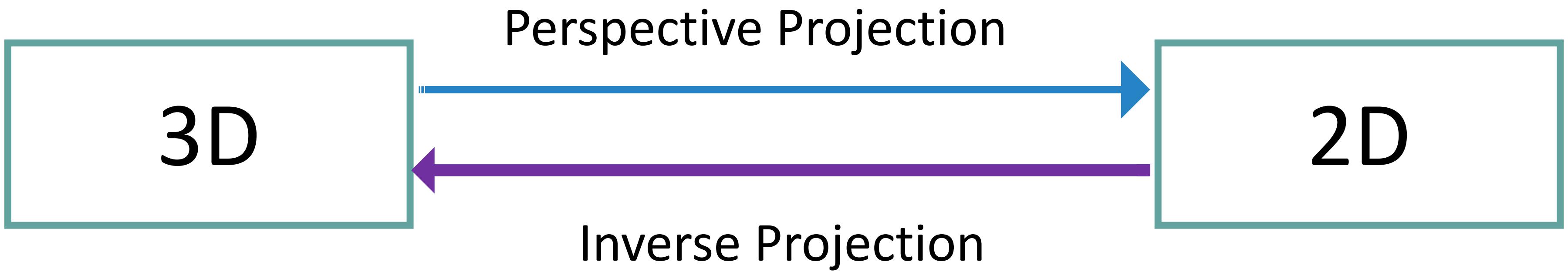


Photo credited by Daryl Tan

Inverse Projection



End.

Hope you enjoy!