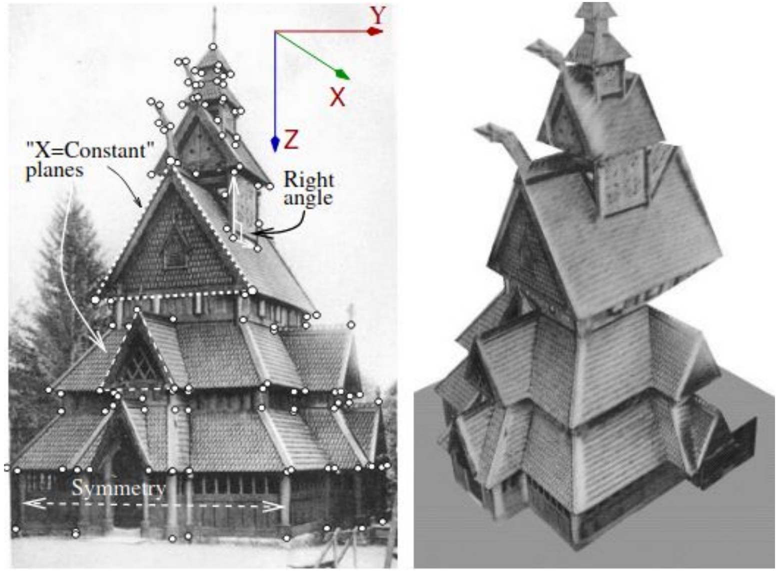
Single Image 3D Reconstruction

IBCC Proseminar

Overview

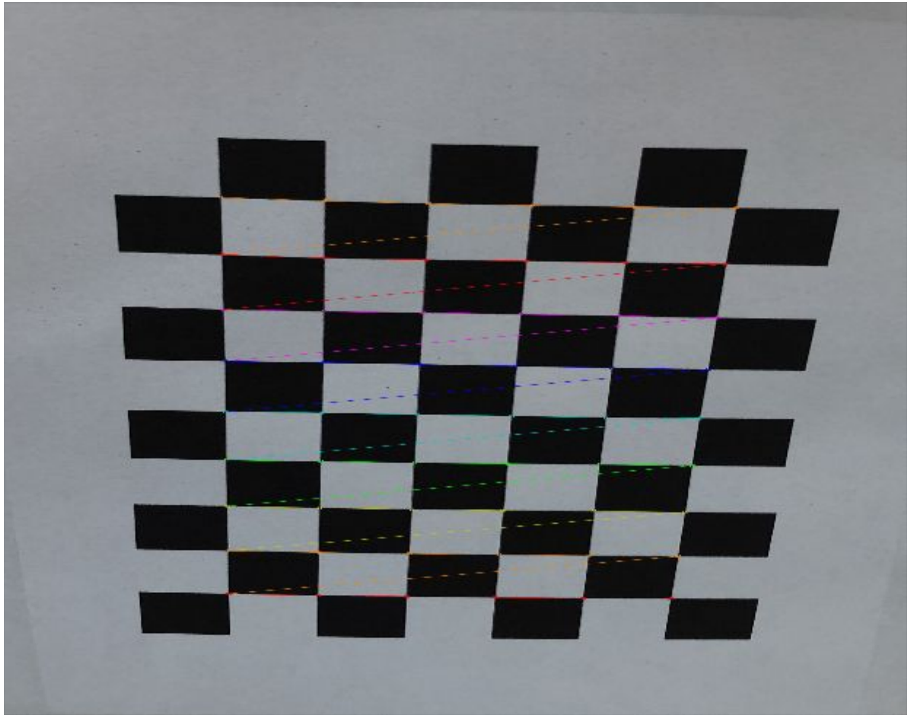
- Camera Calibration
- Classic Approach
  - Determine Vanishing Lines and Points
  - Image Transformation an 3D Object Generation
- NN Approach
  - Basic Setup
  - Training Set
  - Results



E. Grossmann, "Maximum likelihood 3D reconstruction from one or more uncalibrated views under geometric constraints," Ph.D. dissertation, INSTITUTO SUPERIOR TÉCNICO, UNIVERSIDADE TÉCNICA DE LISBOA, Portugal, 2002.

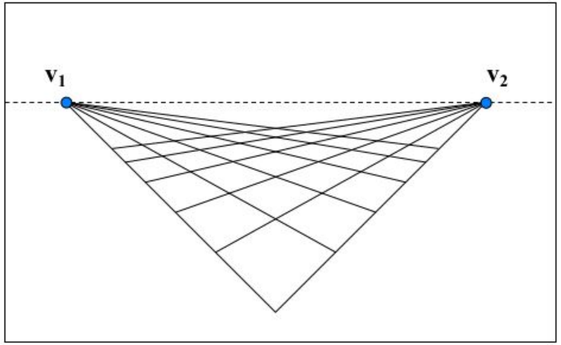
Camera Calibration

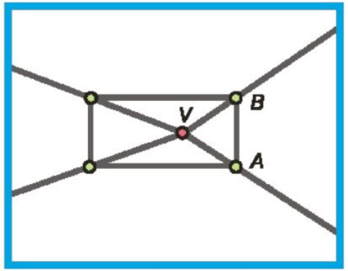
- Done with OpenCV
    - Different images (angles) of checkerboard
    - Input
        - Amount of checker
            - e.g.(6,9) => NOT 6x9 checker!!
        - Real world size of one checker
    - Output
        - Camera matrix
        - Distortion
        - Rotation Vector of each image
        - Translation Vector of each image
- Used to undistort the image

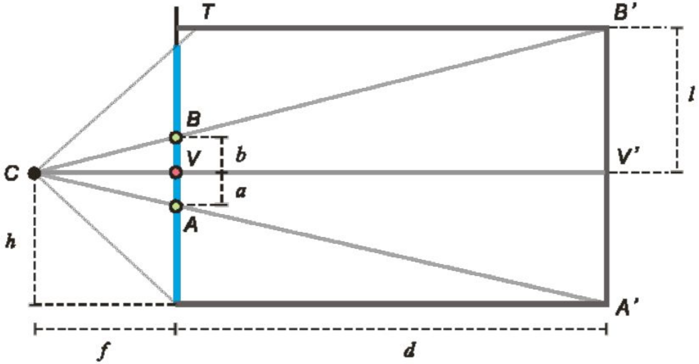


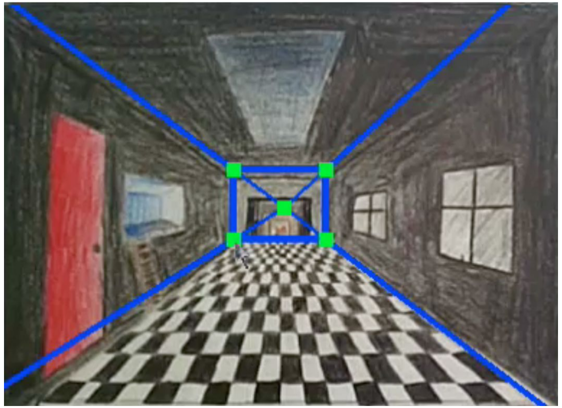
Vanishing Points And Lines

- Any set of parallel lines on the plane define a vanishing point
- The union of all vanishing points is the horizon line, also called vanishing line
- Different planes define different vanishing lines

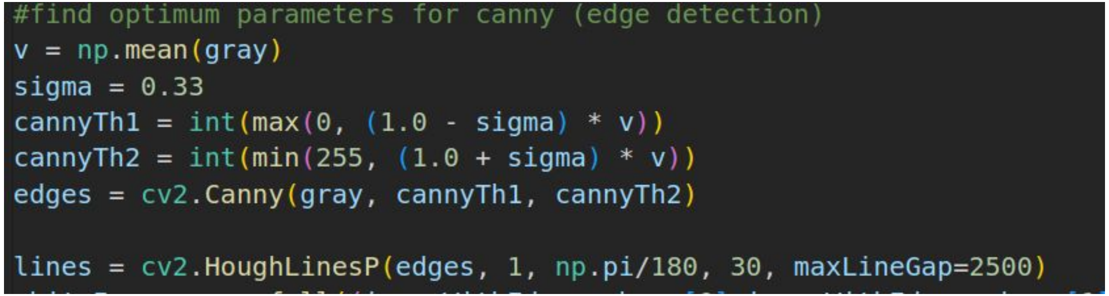




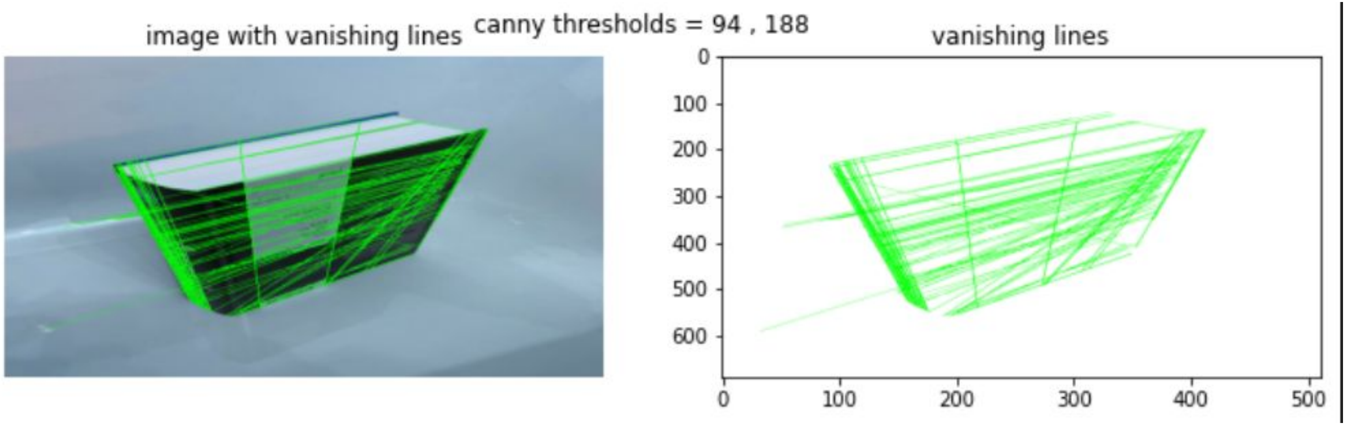




Determine Vanishing Points And Lines

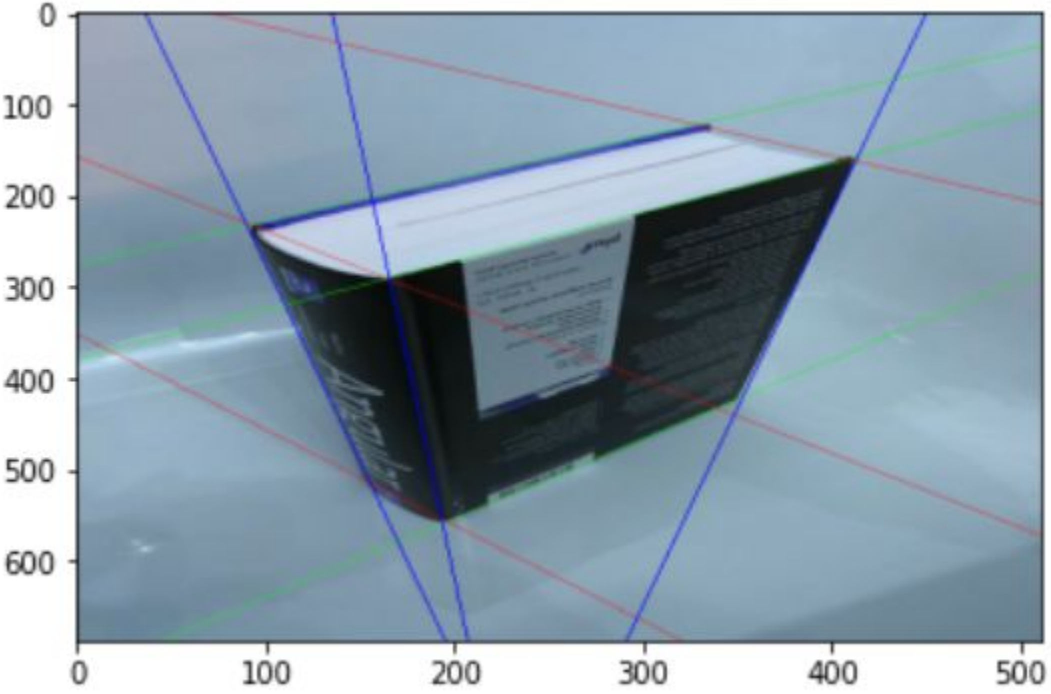


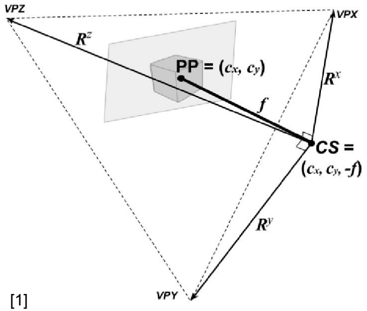
```
#find optimum parameters for canny (edge detection)
v = np.mean(gray)
sigma = 0.33
cannyTh1 = int(max(0, (1.0 - sigma) * v))
cannyTh2 = int(min(255, (1.0 + sigma) * v))
edges = cv2.Canny(gray, cannyTh1, cannyTh2)

lines = cv2.HoughLinesP(edges, 1, np.pi/180, 30, maxLineGap=2500)
```



Houghlines On Book Image

- To get for every orientation at least one line an user input is needed
- Each color shows one orientation
- In this image the vanishing points are outside, therefore the 3D projection gets hard
- Measurements from the real world are needed to solve this problem

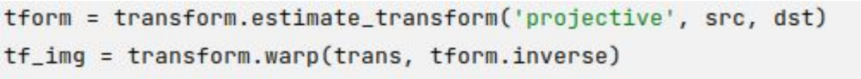




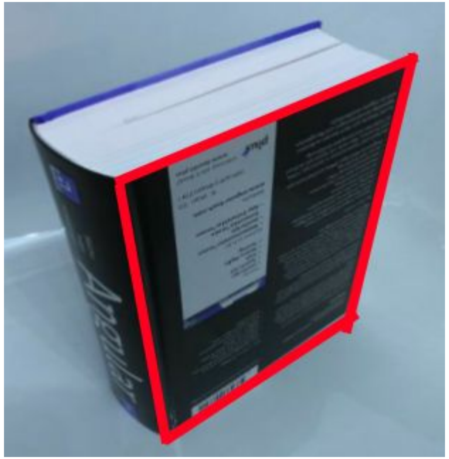
[1]

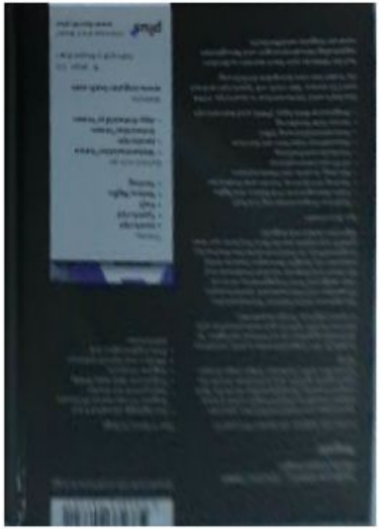
Image Transformation

- Ratios or length of object must be KNOWN
- Transforms image viewpoint
  - Determine Corner points from vanishing lines **(source)**
  - Calculate corresponding points if camera position = in front of plane **(destination)**
    - **manually**
    - **perspective pyramid**
  - Done manually with skimage.transform lib



```
tform = transform.estimate_transform('projective', src, dst)
tf_img = transform.warp(trans, tform.inverse)
```

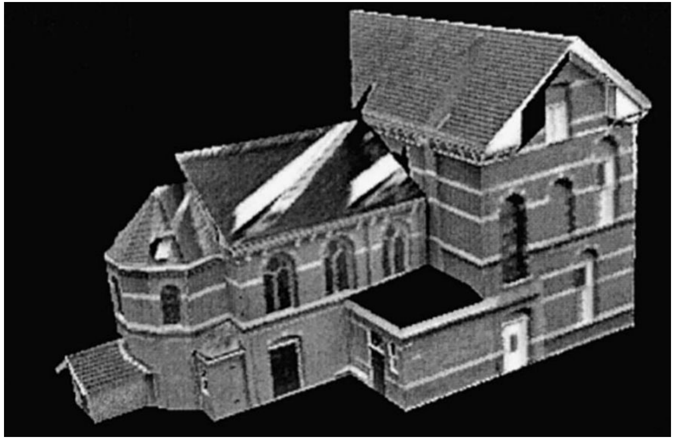




[1]R. Settergren, “RESECTION AND MONTE CARLO COVARIANCE FROM VANISHING POINTS FOR IMAGES OF UNKNOWN ORIGIN,” The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XLIII-B2-2020. Copernicus GmbH, pp. 487–494, Aug. 12, 2020. doi: 10.5194/isprs-archives-xliii-b2-2020-487-2020.

3D Object Generation

1. Generate 3D object using numpy-stl
2. Map the corresponding image to its plane with e.g. Blender



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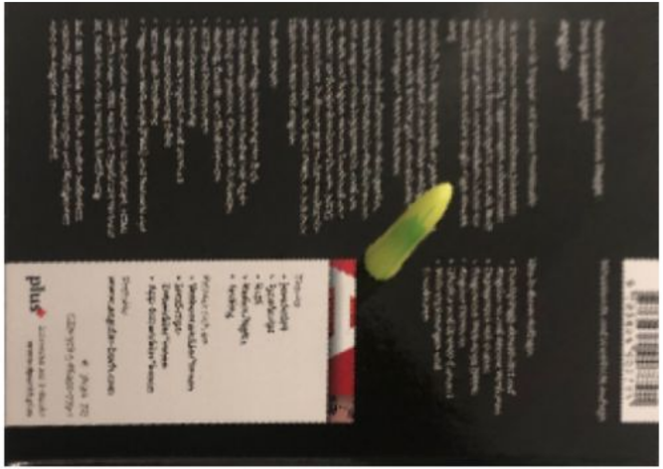


CONS

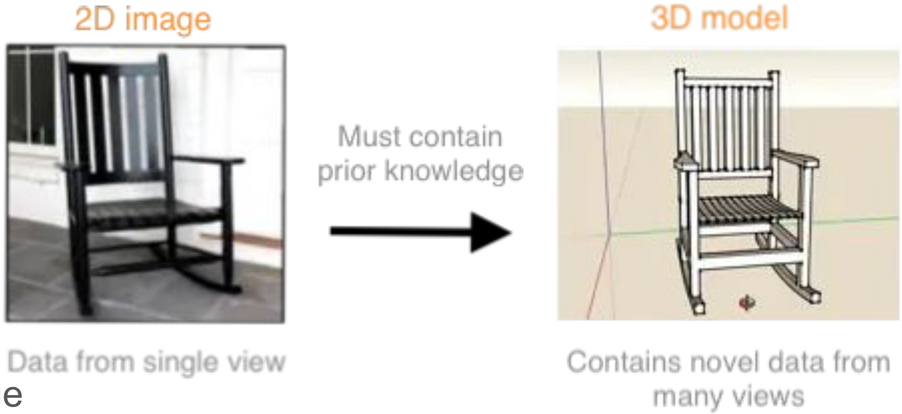
- Angles and length of object need to be known
- User Input necessary (automated just for very simple objects)
- For complex objects very complicated
- Distortions if a object lies on object

[1]F. A. van den Heuvel, “3D reconstruction from a single image using geometric constraints,” ISPRS Journal of Photogrammetry and Remote Sensing, vol. 53, no. 6. Elsevier BV, pp. 354–368, Dec. 1998. doi: 10.1016/s0924-2716(98)00019-7.

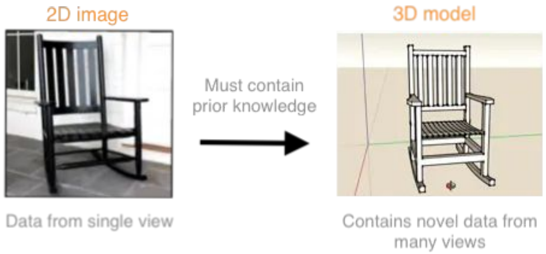
Artificial Neural Network Basic Setup

- Python
  - PyTorch
  - TensorFlow/Keras

- The Problem:
  - 2D image only a projection
  - Loss of information
  - Create a 3D Model with prior Knowledge


2D image
Data from single view
Must contain prior knowledge
3D model
Contains novel data from many views

Artificial Neural Network Basic Setup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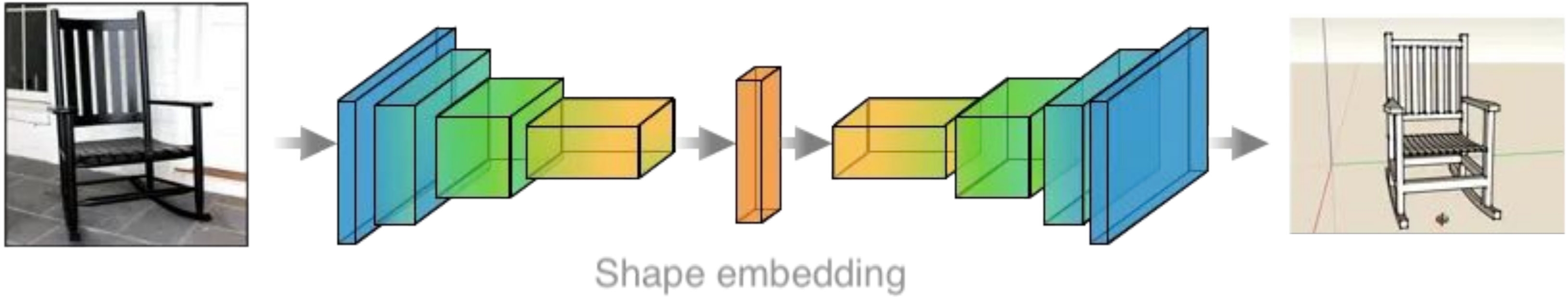
- Proposed Solution:



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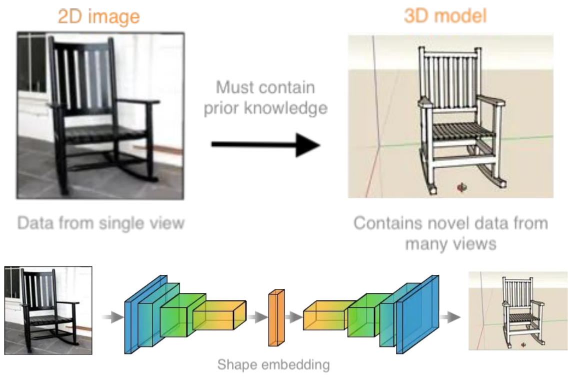
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Shape embedding

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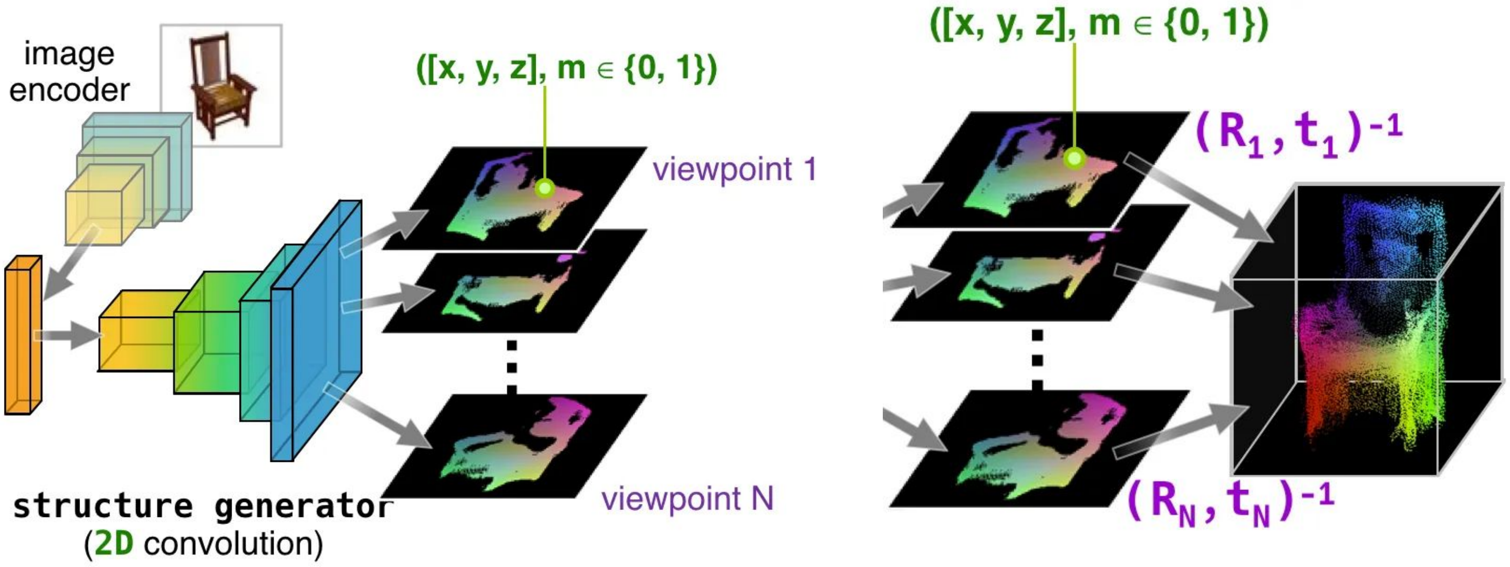
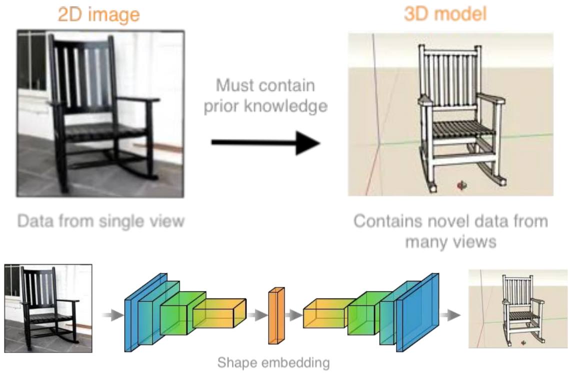


Artificial Neural Network Basic Setup

- Proposed Setup: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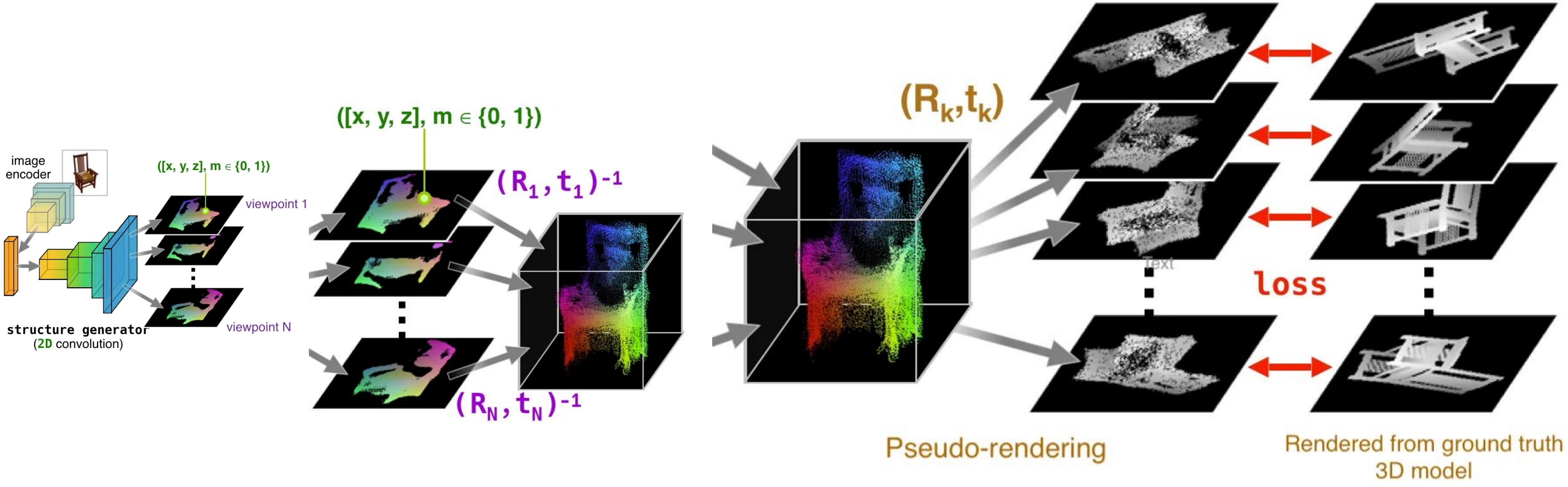
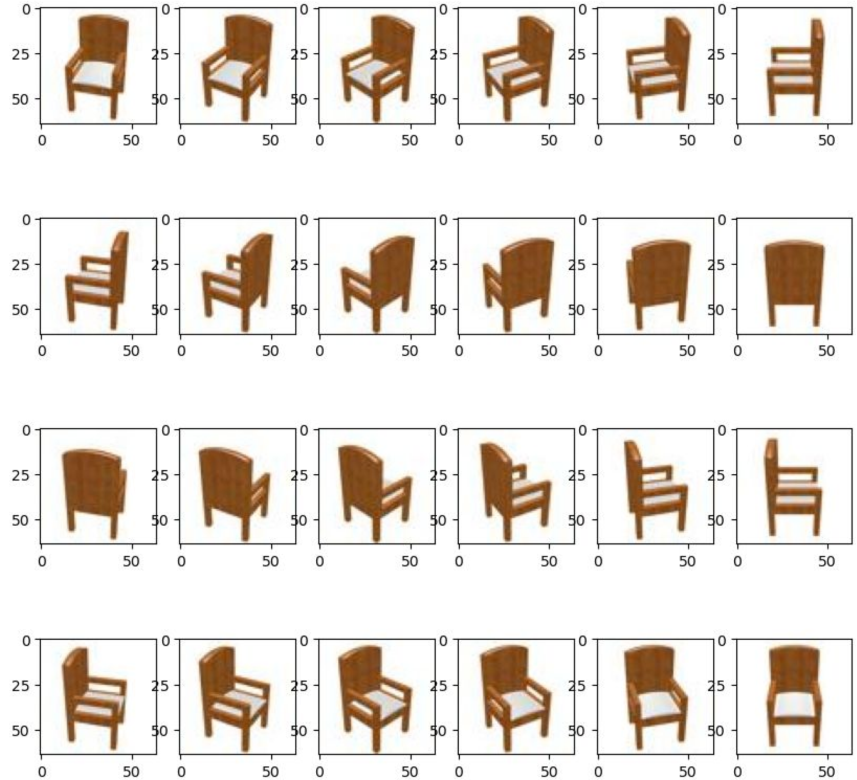
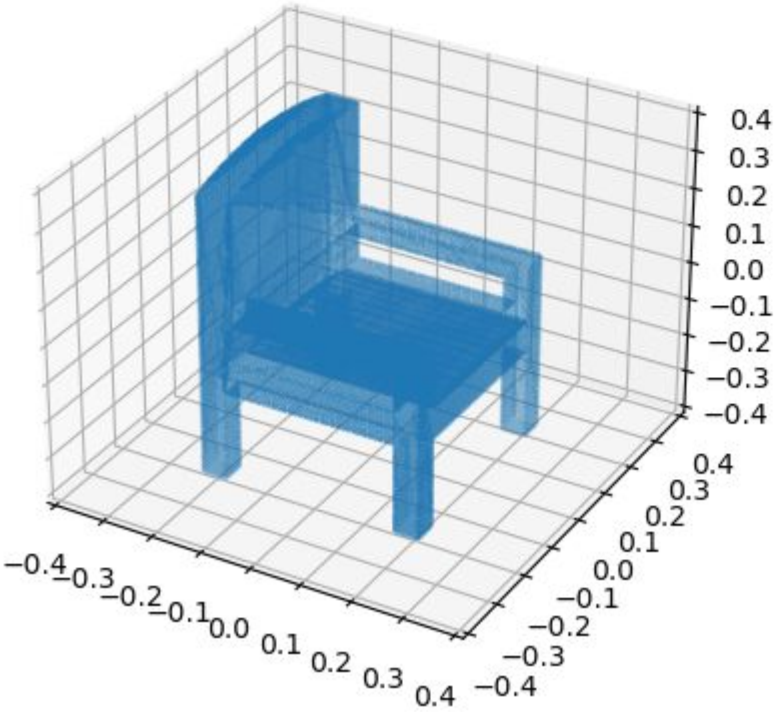


Artificial Neural Network Training Set / Results





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