IRO Homework 3: RGB-D to colored 3D point cloud.

Karel Zimmermann, Vlada Kubelka, Radoslav Škoviera, Ondřej Holešovský

You are given 3-channel `RGB` and 1-channel `depth` images captured by the Kinect camera. Pixel in the RGB data at coordinates (u, v) has 3 components: red $\texttt{RGB}(u, v, 1)$, green $\texttt{RGB}(u, v, 2)$, blue $\texttt{RGB}(u, v, 3)$. In the depth image, there is just one component: depth $\texttt{D}(u, v)$. Red, green, blue components have values from $[0,\ 255]$ interval, depth component is provided in meters. We have already estimated intrinsic parameters of the camera, therefore matrix `K` is available.

1. Download the `rgbd_data.npy` file, which contains a dictionary (structured NumPy array) of the recorded data. The dictionary contains RGB (*key: 'rgb'*) and depth (*key: 'depth'*) images and intrinsic camera parameters for the RGB and depth camera (*key: 'rgb_K', 'depth_K'*). The file `camera_transform.ipynb` can be opened in Jupyter Notebook (`http://jupyter.org/`). It is an interactive python notebook containing blocks of python code for loading the data and visualizing the results.

2. Derive explicit relation $(x, y, z) = f(u, v, d)$ assigning 3D world coordinates (x, y, z) to pixel (u, v) with depth $d = z = \texttt{D}(u, v)$ and camera matrix K. When deriving the function f remember that $\lambda \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = K \begin{pmatrix} x \\ y \\ z \end{pmatrix}$. Filter out points for which the depth information is missing.

3. Use the function f to convert the depth image to a point cloud. Rotate the point cloud so that the z-axis is pointing up and the x-axis is pointing forwards. The origin of the new coordinate system is located at the same position as the coordinate system of the camera.

4. Filter out potentially noisy points and points from objects that cannot collide with the robot (e.g. keep only points 30cm above and below the camera). Remove points that are outside the reliable range of the sensor (closer than 20cm or further than 3m). Finally, flatten the point cloud by projecting the points onto the XY plane.

5. Visualize the flattened point cloud along with the origin of the coordinate system.