# Camera 3d Re-projection

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## 1 Math behind the code

Suppose we have two cameras 1 and 2 positioned in different places, the position of camera 1 plane can be described with $R, T$, the rotation and translation matrices. The cameras can be described by their intrinsic matrices $K_1, K_2$. Now, to re-project a point from camera plane 1 to camera plane 2. We need the depth of the point itself $z_1$ and the coordinates of the point in pixel coordinates $u_1, v_1$. The formulas to obtain the re-projection (as in fig.1) are:

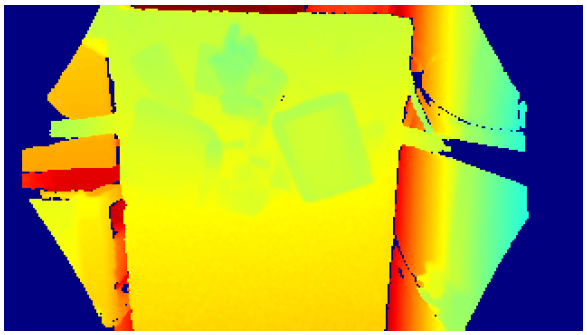
$$\begin{bmatrix} x_1 \\ y_1 \\ z_1 \end{bmatrix} = K_1^{-1} \begin{bmatrix} \frac{u_1}{z_1} \\ \frac{v_1}{z_1} \\ z_1 \end{bmatrix} \text{ This is the 3d point in camera 1 coordinates}$$

Now we need to project to the second camera coordinate frame

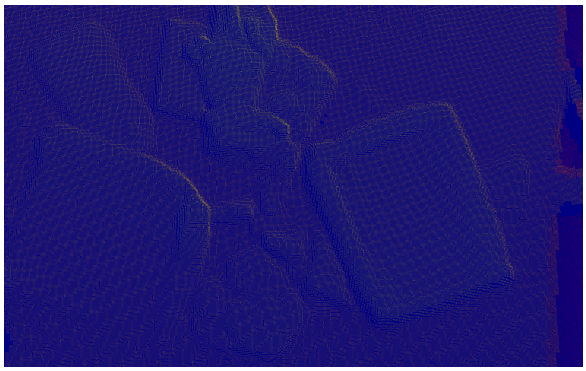
$$\begin{bmatrix} x_2 \\ y_2 \\ z_2 \end{bmatrix} = R \begin{bmatrix} x_1 \\ y_1 \\ z_1 \end{bmatrix} + T \text{ This is the 3d point in camera 2 coordinates}$$

Finally, we need to project the point in camera 2 coordinates

$$\begin{bmatrix} u_2 \\ v_2 \\ z_2 \end{bmatrix} = K_2 \begin{bmatrix} \frac{x_2}{z_2} \\ \frac{y_2}{z_2} \\ z_2 \end{bmatrix} = \text{ This is the pixel coordinates point in camera 2 image plane}$$



(a) Original depth map obtained with a Kinect camera



(b) Depth map visualization in camera 2 image plane

Figure 1: Re-projection from camera 1 to camera 2 of the depth map. Blue points indicate 0 distance from the camera. In the second image, the number of blue points is much larger since camera 2 is closer to the objects and the dimension of the image is 2x times the dimension of the first image.