3D Vehicle Reconstruction via Monocular Camera with Deep Learning Models and Direct Linear Transformation

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***Abstract*—Hello here goes the abstract**

I. Introduction

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II. 3D Pose Estimation

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Matrix representation of the standard projection onto the z = 1 plane.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} x \\ y \\ z \\ z \end{bmatrix} \overset{\text{div z}}{\equiv} \begin{bmatrix} \frac{x}{z} \\ \frac{y}{z} \\ 1 \end{bmatrix} \tag{1}$$

The API projection Matrix

$$M_{API} = M_O M_P = \begin{bmatrix} \frac{2}{r-l} & 0 & 0 & \frac{-(r+l)}{r-l} \\ 0 & \frac{2}{t-b} & 0 & \frac{-(t+b)}{t-b} \\ 0 & 0 & \frac{2}{f-n} & \frac{-(f+n)}{f-n} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} n & 0 & 0 & 0 \\ 0 & n & 0 & 0 \\ 0 & 0 & n+f & -nf \\ 0 & 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} c_1 & 0 & 0 & 0 \\ 0 & c_2 & 0 & 0 \\ 0 & 0 & c_3 & c_4 \\ 0 & 0 & 1 & 0 \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} -c_1x_1 & -c_1y_1 & -c_1z_1 & -c_1 & 0 & 0 & 0 & 0 & x_1x'_1 & y_1x'_1 & z_1x'_1 & x'_1 \\ 0 & 0 & 0 & 0 & -c_2x_1 & -c_2y_1 & -c_2z_1 & -c_2 & x_1y'_1 & y_1y'_1 & z_1y'_1 & y'_1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ -c_1x_n & -c_1y_n & -c_1z_n & -c_1 & 0 & 0 & 0 & 0 & x_nx'_n & y_nx'_n & z_nx'_n & x'_n \\ 0 & 0 & 0 & 0 & -c_2x_n & -c_2y_n & -c_2z_n & -c_2 & x_ny'_n & y_ny'_n & z_ny'_n & y'_n \end{bmatrix} \begin{bmatrix} a \\ b \\ \vdots \\ k \\ l \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ 0 \end{bmatrix} \tag{3}$$

To get the screen-space position of a vertex, we multiply it by its Modelview Matrix and API Projection Matrix before doing the projective division. We have all the parameters except the Model Matrix. $p' = M_{API} M_{Modelview} p$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} \overset{\text{div z}}{\equiv} \begin{bmatrix} c_1 & 0 & 0 & 0 \\ 0 & c_2 & 0 & 0 \\ 0 & 0 & c_3 & c_4 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

If we multiply that out, we get for x' and y':

$$x' = \frac{c_1ax + c_1by + c_1cz + c_1d}{ix + jy + kz + l}$$
$$y' = \frac{c_2ex + c_2fy + c_2gz + c_2h}{ix + jy + kz + l}$$

We can multiply by the denuminator and solve for 0. Since this holds for every pair of points $(p_1, p'_1), (p_2, p'_2), ..., (p_n, p'_n)$ that we track we can create the following system of equation: 3

References

[1] J.-B. Michel, Y. K. Shen, A. P. Aiden, A. Veres, M. K. Gray, T. G. B. Team, J. P. Pickett, D. Hoiberg, D. Clancy, P. Norvig, J. Orwant, S. Pinker, M. A. Nowak, and E. L. Aiden, “Quantitative analysis of culture using millions of digitized books,” *Science*, vol. 331, no. 6014, pp. 176–182, 2011. [Online]. Available: https://www.science.org/doi/abs/10.1126/science.1199644