Layout and Proportionality Calculations for Rectilinear Effect Sensors in 6DOF Manipulator

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1 Background

RepRapPro recently shared a concept for a 6DOF manipulator using three pairs of hall effect sensor arranged at 120 degrees around a circular base. The kinematics of this map the six sensors to the 6 degrees of freedom of the controller. Given my preference for more simple software mapping between sensors and intended input, I propose the following rectilinear sensor layout.

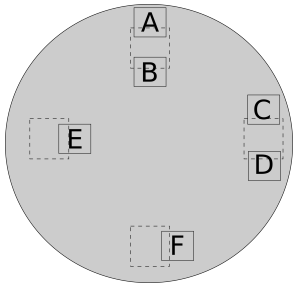

Figure 1: Proposed 6-sensor rectilinear layout.

2 Proposed Design

The proposed design uses 6 sensors arranged in pairs or alone at the cardinal points of the control puck base. Dashed lines indicate location of the magnet in the upper moving component. Sensors E and F do not have paired sensors, as the analysis below demonstrates their redundancy.

The mapping of sensor inputs to translation (T) and rotation (R) is given by the following proportionality matrix.

$$\begin{bmatrix} T_x \\ T_y \\ T_z \\ R_x \\ R_y \\ R_z \end{bmatrix} = \begin{bmatrix} -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & 1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & 0 & 0 & -1 \\ 0 & 0 & 1 & 1 & -1 & 0 \\ -1 & -1 & 1 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \\ D \\ E \\ F \end{bmatrix}$$

This conversion would just provide the relative proportions of each motion. Scaling to reasonable inputs can be done after this step.

3 First Draft Design and Analysis

The initial design used eight sensors, using pairs at the cardinal points of the circle. The intent was that for both x and y axes, there was a pair of sensors to detect translation and rotation. I assumed that the two additional sensors could be incorporated into the analysis for noise reduction.

To map sensor inputs to desired output, I considered the effect of each direction separately on each sensors response, creating a linear set of equations, shown below. For a given

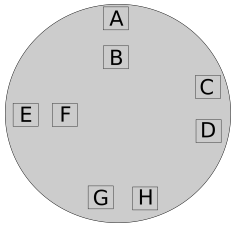

Figure 2: Version 1 of the rectilinear layout concept using 8 sensors.

$$\begin{cases} Translate_x = -A - B - C - D - E + F - G + H \\ Translate_y = A - B + C - D - E - F - G - H \\ Translate_z = -A - B - C - D - E - F - G - H \\ Rotate_x = A + B + 0 \cdot C + \cdot D + 0 \cdot E + 0 \cdot F - G - H \\ Rotate_y = 0 \cdot A + 0 \cdot B + 0 \cdot C - E - F + G + H \\ Rotate_z = -A - B + C - D - E - F - G + H \end{cases}$$

This system of equations converts nicely into a linear algebra conversion, as given below.

$$\begin{bmatrix} T_x \\ T_y \\ T_z \\ R_x \\ R_y \\ R_z \end{bmatrix} = \begin{bmatrix} -1 & -1 & -1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & 1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & 1 & 1 & -1 & -1 & 0 & 0 \\ -1 & -1 & 1 & -1 & -1 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \\ D \\ E \\ F \\ G \\ H \end{bmatrix}$$

This simplification shows that both inputs E and G are constantly -1 or is not used. From this it follows that they are redundant sensors and not needed for full 6DOF manipulation.