Control of Omni-Directional Mobile Platform with Four Driving Wheels

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Abstract

Mobile manipulators consisting of a manipulator placed on a moving platform have wide moving range and can perform dexterous tasks. As a moving platform, omni-directional type mechanism is preferable because of its high mobility. There are several types of omni-directional mobile robots, but most of them are complicated. Therefore, a simple mechanism for mobile platforms is developed and two control methods are proposed.

Figure 1 shows the developed mobile manipulator. There are two ways to control the square-shaped mobile platform with four actuators placed on each edge of a square plate. The relationship between the small displacement of the platform and the small motion of the wheels is expressed as Eq. (1),

$$\Delta\boldsymbol{\theta} = \mathbf{J}\Delta\mathbf{x}\,, \tag{1}$$

where

$$\Delta\boldsymbol{\theta} = \begin{bmatrix}\Delta\theta_1 & \Delta\theta_2 & \Delta\theta_3 & \Delta\theta_4\end{bmatrix}^T$$
$$\Delta\mathbf{x} = \begin{bmatrix}\Delta x & \Delta y & \Delta\phi\end{bmatrix}^T .$$

J *is a Jacobian matrix of the platform and* $\mathbf{J} \in R^{4\times 3}$. *From Eq.*(1), *the motion of each wheel is determined by the desired motion of the platform. It is easy to install into control system because this algorithm is based on popular position controllers. However, if some of the wheels have rotational errors, slippages occur inevitably. As a result, positioning accuracy of the platform becomes worse.*

On the other hand, the relationship between the wheel torques and the driving forces of the platform is expressed as Eq.(2).

$$\Delta\mathbf{f} = \mathbf{J}^T\Delta\boldsymbol{\tau} \tag{2}$$

From Eq.(2), *the torques* $\Delta\tau$ *realizing* Δf_d *becomes as Eq.*(3).

$$\Delta\boldsymbol{\tau} = \mathbf{J}^{+T}\Delta\mathbf{f}_d + (\mathbf{I} - \mathbf{J}^{+T}\mathbf{J}^T)\mathbf{z} \tag{3}$$

J^{+T} *is the pseudo-inverse of* J^T *and* z *is an arbitrary vector. The second term of the right side of Eq.*(3) *expresses a redundant term, and the control performance of the platform can be improved by using this term. If the Eq.*(3) *is used for control, slippage does not occur even if the wheels have torque errors. Moreover, by changing the torque distribution ratio to the four wheels by using the redundant term, slippages of wheels can be avoided due to the change of friction coefficients on the ground.*

Some fundamental expreiments are done to test the control performances of the above algorithms.

Fig.1 *Mobile Manipulator*