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Hydraulic levelling control system technology of bricklaying robot

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Abstract: The article presents a hydraulic control system for the auto-levelling of a mobile bricklaying robot platform. To stabilize the position of the robotic bricklaying system, four extendable hydraulic supporting legs were used. For the correct operation of the robot, its horizontal position is important. To control the self-levelling process, the system uses a two-axis tilt sensor and proportional directional control valves. After the target practical test, the results show that this method is a simple and reliable adjustment and perfectly realizes the precise and fast levelling of the hydraulic platform of the bricklaying robot. It can also be used for other multi-point automatic levelling systems.

Keywords: self-levelling system, bricklaying robot, hydraulic control

1. Introduction

Masonry works are one of the very early human craftsmanship. However, this discipline has not achieved a high degree of automation. Several attempts were made to develop mobile construction works, the most advanced of which were the projects [1], [2], [3]. During capturing and laying bricks, the robot should avoid collisions with obstacles. For such a dynamic area as a construction site, obstacles detection requires active motion planning techniques based on real-time sensory data. In addition, the bricklaying machine must be "aware" of the progress of wall evolution.

2. Dynamic model

Mobile Hydraulic Module (MHM) is a support platform for further development of devices used in cooperating construction works, such as: construction manipulator, material warehouse or lifting platform. Both of these tasks are significantly influenced by the dynamic behaviour of the mobile module itself and the mechanisms mounted on it. Fig. 1 shows the model of the Mobile Hydraulic Module (MHM).

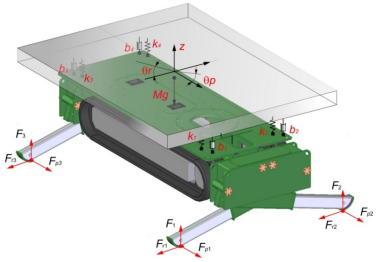

Fig. 1. Mobile Hydraulic Module (MHM)

3. Levelling

To obtain the relationship between the slope and displacement angles of hydraulic cylinders, it was assumed that the angle θ_p (pitch) is measured from the X axis and the angle θ_r (roll) from the Y axis in the direction of the Z axis. The purpose of levelling is to set the surface of the robot platform so that these angles are zero. The determined coordinate system is shown in Fig. 2.

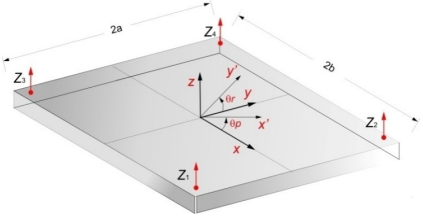

Fig.2. The coordinate system for the mobile hydraulic module

For this coordinate system, we can write rotation matrices:

$$R_x(\theta_r)=\begin{bmatrix}1 & 0 & 0\\ 0 & \cos\theta_r & \sin\theta_r\\ 0 & -\sin\theta_r & \cos\theta_r\end{bmatrix},\ R_y(\theta_p)=\begin{bmatrix}\cos\theta_p & 0 & \sin\theta_p\\ 0 & 1 & 0\\ -\sin\theta_p & 0 & \cos\theta_p\end{bmatrix} \tag{1}$$

In fact, during the levelling process, the deviation in the platform level is small. With this assumption, we can determine the following relationships: $\cos\theta_r=\cos\theta_p=1$ and $\sin\theta_r=\theta_r$, $\sin\theta_p=\theta_p$.

3. Concluding Remarks

A technical solution was presented to the lifting and levelling system of the mobile hydraulic module (MHM) unit, where electro-hydraulic control and drive systems were used. A model of platform MHM dynamics was presented along with a model of hydraulic drives. A control system diagram was developed. Simulation tests were carried out to test the accepted scheme of the bricklaying robot. The presented MHM control system uses feedback from platform bracket position errors, synchronization errors and tilt angles.

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