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AN ASYMPTOTIC STABLE PROPORTIONAL DERIVATIVE CONTROL WITH SLIDING MODE GRAVITY COMPENSATION AND WITH A HIGH GAIN OBSERVER FOR ROBOTIC ARMS

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Abstract. *The major contributions of this paper are as follows: 1) A proportional derivative control with sliding mode for the gravity compensation for robotic arms is proposed. In the proposed control, it is not necessary to know the dynamics of the robotic arms. It is proven that the closed loop system of the proportional derivative control with sliding mode gravity compensation applied to robotic arms is asymptotic stable. 2) A high gain observer is used to estimate the joint velocities to avoid the necessity of the velocity measures. It is proven that the high gain observer applied to the robotic arms is uniformly stable. 3) A proportional derivative control with sliding mode gravity compensation that uses the high gain observer to estimate the joint velocities for robotic arms is proposed. It is proven the closed loop system of the proportional derivative control with sliding mode gravity compensation with the high gain observer applied to robotic arms is asymptotic stable. The simulations give the effectiveness of the suggested control.*

Keywords: Proportional derivative control, Sliding mode control, Asymptotic stability, Gravity compensation, Robotic arm

1. **Introduction.** It is well known that most of industrial manipulators are equipped with the simplest proportional and derivative (PD) controller. Various modified PD control schemes and their successful experimental tests have been published [19, 20]. But there exist two main weaknesses in the PD control: a) due to the existence of gravity forces, the PD control cannot guarantee that the steady state error becomes zero, i.e. the error of the PD control applied to robotic arms is not asymptotic stable [6], b) the PD controller requires measurements of both joint position and velocity. It is necessary to implement position and velocity sensors at each joint. The joint position measurement can be obtained by means of the encoder, which gives very accurate measurement, but the joint velocity is usually measured by the velocity tachometer, which is expensive and often contaminated by noise [10].

Since the friction and gravity of a robot influence the steady and dynamics properties of the PD control. Global asymptotic stability PD control was realized by pulsing gravity compensation in [9]. If the gravity is unknown, the neural networks can be applied. In [11], the author used the neural networks to approximate the whole nonlinearity of robot dynamics with a neuro feedforward compensator and a PD control, they can guarantee good track performance. The approximation errors of the neural identification for the gravitational force and friction can be eliminated by a discontinuous switching control law [24]. When the parameters in gravitational torque vector are unknown, adaptive PD control with gravity compensation was introduced by [21]. The SP-ID controller can be