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KINEMATICS MODELING AND ANALYSIS OF A BIPED ROBOT

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ABSTRACT. *The purpose of this research is to investigate the kinematics behavior of a biped robot. The linkage frame system is first established to construct its mechanical structure. Then, based on Denavit-Hartenberg transformation, the relationship transferred from joint rotation angles to the position and orientation of the hip joint is obtained by forward kinematics. Moreover, once the position and orientation of the hip joint in 3-dimensional space are obtained, a nonlinear algebraic approach of each joint rotation angle will be developed by inverse kinematics. A computational algorithm is developed that the joint angles can be evaluated for the desired configuration of the biped robot and translated in terms of the motor angles to activate the robot.*
Keywords: Biped robot, Robot kinematics, Forward kinematics, Inverse kinematics

1. **Introduction.** The study of robot manipulator kinematics is concerned with the relationship of arms linkage parameters for revolute joints and prismatic joints, and the position and orientation of end-effectors. It contains both forward and inverse kinematics prior to the trajectory generation. Forward kinematics is computation of the position and orientation of robot's end effector as a function of its joint angles. The general relative position and orientation representation between joint coordinate frames are often described with Denavit-Hartenberg homogeneous transformation matrix [1]. Inverse kinematics comprises closed-form solution and numerical solution where the latter is less utilized as it requires repeated calculations [2]. The former, on the other hand, is further divided into geometric approach and algebraic approach. Obtaining a solution to a given robot configuration is the most difficult problem for most robot. In some cases, geometric intuition is required that space geometry can be divided into several plane geometry problems [3,4]. Algebraic solution is not easy to analyze the robot arm with closed-form solution systematically. Therefore, it is sometimes designed that three adjacent joints intersect at one point. Present industrial robot arms are generally solved with algebraic approach [5].

The structure for walking robots is more complicated and there is no frame fixed on the ground or the table. The past researches mainly focused on geometric approach [6], i.e., to solve the revolute and prismatic joint solutions with given positions. The process is even simplified by fixing the coordinate frames and orientation of robot sole. Nonetheless, geometric solution has to accommodate to ready-made mechanical structures and 3-D motion could not be easily analyzed. Yali [7] applied back-propagation (BP) neural network to solve the inverse kinematics of lower limbs. From the aspect of general robot kinematics, this study tends to analyze the mechanical structure of biped walking robots and further study the walking robots with forward kinematics and inverse kinematics.