

# Control of a Biped Rolling Robot

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## Introduction;

Biped robots are humanoid mechanisms designed to simulate the human walking. Unlike other mobile robots, bipeds possess the potential to maneuver in areas containing obstacle such as ladders, stairs, and uneven surfaces. In general, a bipedal locomotion system consists of several links which are interconnected with actuated joints.

In this project, a 3-DOF biped rolling robot will be studied. As shown in Figure (1) the robot consists of three links and each link has a straight element connected rigidly to a circular arc. It is assumed that all arcs are parts of a circle of radius  $R$ . Two motors apply the controlled torques to drive links 2 and 3 with respect to link 1 which is passive. Link 3 provides the required moment for motion and links 1 and 2 are the robot's legs supposed to move the biped forward by rolling on the ground. At any instant time, only one leg is rolling while the other leg moves in such a way that two legs stay symmetric with respect to the vertical line.

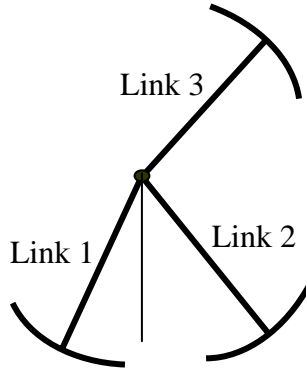


Figure (1): 3-DOF Biped rolling robot

## Dynamic Model

Figure (2) shows a configuration of the robot with angle  $\theta$  measured from the vertical line and angles  $\phi_1, \phi_2$  measured relative to link 1. Symmetry of two legs is guaranteed by;

$$\phi_1 = -2\theta \quad (1)$$

Imposing symmetry constraint in Eq. (1), the biped robot will be reduced to a 2-DOF system. Dynamic equations of motion are obtained from Lagrange's method and can be written in the following matrix form;

$$M(q)\ddot{q} + N(q, \dot{q}) = T \quad (2)$$

Where  $q = (\theta, \phi_2)^T$  is the vector of generalized coordinates,  $M(q)$  is the inertial matrix,  $N(q, \dot{q})$  includes centrifugal, gravitational and other terms and  $T = (0, \tau_2)$  is the controlled input torque. It should be noted that the effects of friction have been ignored in deriving these equations.

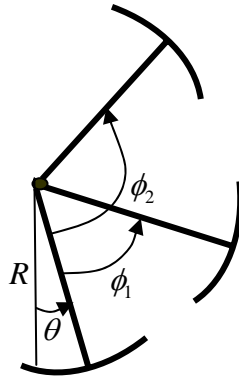


Figure (2): Angular positions of the robot links

### Objective

Since rolling moment is provided by link 3, Motion of the biped can be regulated by controlling the angular position of link 3. The main goal of the project is to design a controller to make the biped robot follow a desired acceleration trajectory.