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Design and Fabrication of Eight-Legged Spider Using KLANN Mechanism

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Abstract: *In the present paper, an attempt has been made to carry out Design and fabrication of eight-legged spider using klann mechanism. A four-revolute (4R) kinematic chain has been chosen for each leg mechanism in order to mimic the leg structure of an insect. Denavit–Hartenberg (D-H) conventions are used to perform kinematic analysis of the eight-legged spider. The direct and inverse kinematic analysis for each leg has been considered in order to develop an overall kinematic model of an eight-legged spider, when it follows a straight path. The problems related to trajectory generation of legs have been solved for both the swing and support phases of the robot. It is important to mention that trajectory generation problem during the support phase has been formulated as an optimization problem and solved using the least squared method. Lagrange-Euler formulation has been utilized to determine the joint torques. The developed kinematic and dynamic models have been examined for tripod gait generation of the eight-legged spider using klann mechanism.*

Keywords: Joe Klann's Mechanism, Material handling, steep jagged rock piles

I. INTRODUCTION

A multi-legged spider possesses a tremendous potential for manoeuvrability over rough terrain, particularly in comparison to conventional wheeled or tracked mobile spider. It introduces more flexibility and terrain adaptability at the cost of low speed and increased control complexity. In order to develop dynamic model and control algorithm of legged spiders, it is important to have good models describing the kinematic behaviour of the complex multi-legged spider mechanism. The mechanism of a legged spider can be considered as a partially parallel mechanism. Waldron et al. analysed the kinematics of a hybrid series–parallel manipulation system. Although the work on parallel mechanisms forms a basis for legged-spider kinematic analysis, legged walking spiders differ from parallel mechanisms in some important respects. As Lee and Song pointed out, the kinematics of a walking machine is complicated due to its many degrees of freedom. Usually legs of walking machines, during walking are lifted and placed according to a gait, so that the topology of a walking machine mechanism changes. Further, the control problem of a walking machine is significantly more complex than that of a parallel mechanism because a walking machine usually possesses more driven joints than that of a parallel manipulator. Howard discusses the kinematics of a walking machine using vector and screw algebra. Barreto developed the free-body diagram method for kinematic and dynamic modelling of an eight-legged machine. Erden investigated the dynamics of a hexapod walking spider in a level tripod gait based on Newton-Euler formulation. Koo and Yoon obtained a mathematical model for quadruped walking spider to investigate the dynamics after considering all the inertial effects in the system. A dynamic model of walking machine was derived by Lin and Song to study the dynamic stability and energy efficiency during walking. Pfeiffer investigated the dynamics of a stick insect walking on flat terrain. Freeman and Orin developed an efficient dynamic simulation of a quadruped using a decoupled tree-structure approach. Due to the complexity of a realistic walking spider, it is not an easy task to include the inertial terms in the modelling. The most of the works on walking dynamics were conducted with a simplified model of legs and body. But, in order to have a better understanding of walking, dynamics and other important issues of walking, such as dynamic stability, energy efficiency and online control, kinematic and dynamic models based on a realistic walking spider design are necessary. Here, an attempt has been made to carry out kinematic and dynamic analysis of a real eight-legged spider.

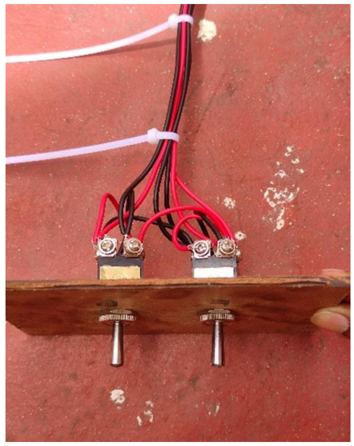

Figure 1: Circuit board of the joystick

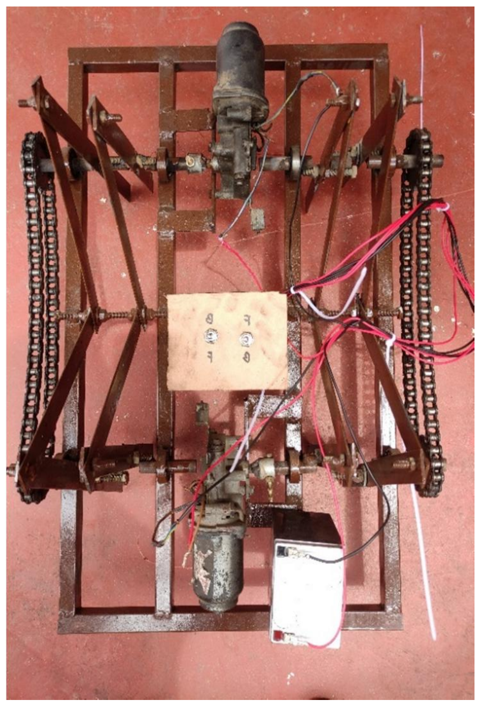

Figure 2: Top view of the project

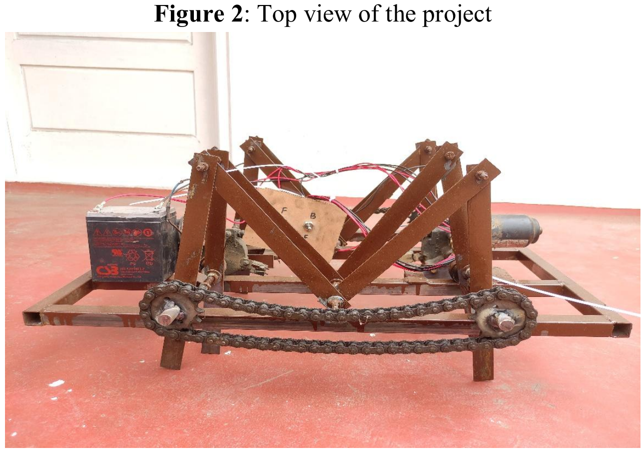

Figure 3: Eight-Legged Spider

II. CONCLUSION

Both the kinematic as well as dynamic analyses of an eight-legged spider have been carried out in the present study. The direct and inverse kinematic analysis for each leg has been conducted in order to develop the overall kinematic model of an eight-legged spider. The problems related to trajectory generation of legs have been solved for both the swing and support phases of the spider. It is important to mention that trajectory planning problem during the support phase has been solved using the least squared method. An attempt has been made in present study to obtain optimal distributions of feet forces. It has been observed that the middle legs are subjected to more force than corner legs. Joint torques have been calculated using Lagrange-Euler formulation of the rigid multi-body system. The developed kinematic and dynamic models have been examined for tripod gait generation of the eight-legged spider. This work can be extended to tackle the problems related to tetrapod and non-periodic gait of the walking spider.

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