AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHATRONICS ENGINEERING DEPARTMENT

Concepts for Tunable Springs in Robots

A Thesis submitted in partial fulfillment of the requirements of the Master of Science degree in Mechatronics Engineering

By

Omar Amr Hassan Nassar

B.Sc. Mechanical Engineering
Ain Shams University, 2011

Supervised by:

Prof. Farid A. Tolbah

Prof. Magdy M. Abdelhameed

Prof. Hartmut Witte

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FG BIOMECHATRONIK

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EXAMINERS COMMITTEE

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Statement

This thesis is submitted in the partial fulfillment of M.Sc. degree in Mechanical Engineering –Mechatronics Engineering Major-, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other scientific entity.

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Abstract

The wheg-driven robots are kind of robots that use rimless wheels to have the advantages of both wheels “fast constant speed” and legs “ability to overcome obstacle with non-uniform shapes”. The wheg-driven robots are useful in many fields such as security, exploration, surveillance… etc.. The whegs robots have the disadvantage of the vertical alternation of the robot’s body in the direction perpendicular to the direction of motion due to rimless wheel. Based on the mechatronics design methodology, a new approach for a wheg-module driven robot is introduced. The wheg module with electromagnetic spokes is a wheg appendage with actively controlled spokes, to enhance the wheg performance by decreasing the vibration of the robot during motion over smooth terrains (alternation in the direction perpendicular to the direction of motion), increasing its ability to overcome obstacles without the need to change the design. The wheg was studied using mathematical model. Simulations using the multi-body simulation tool ADAMS View® were done to help improving the concept. Based on the results from the mathematical model and simulations, a prototype for the wheg module with electromagnetic spokes was manufactured, and experiments were done to evaluate the concept. Through the thesis a complete mathematical model for the wheg-module kinematics is introduced to help in the future studies for making the robot applicable to be used as a transportation tool. The simulations show the effect of the different parameters on the vertical alternation of a single wheg-module and a half robot model.

Keywords:

Whegs, bio-inspired robotics, locomotion, rimless wheels, leg-wheel robot, tunable springs in robots.

Summary

The objective of this work is to introduce a new mechatronics solution to the wheg-driven robots in order to increase its robustness “decrease the alternation of the robot’s body in the direction perpendicular to the direction of motion” with increasing its ability to overcome obstacle. This is done by introducing the wheg-module with electromagnetic spokes where the angles between the spokes are controlled in an active way through magnets and electromagnets which act as a spring with tunable stiffness. The thesis consists of five chapters and the summary of each chapter is as follow.

Chapter one consists of introduction to the thesis, a background about the wheg-driven robot, a survey of the published papers for solutions introduced to enhance the performance of the whegs robots and ended this chapter with the problem statement and description of the introduced solution.

Chapter two contains a mathematical study for a single wheg-module and half robot model with driving the required equation for proving the concept of the introduced solution.

Chapter three contains the simulation study for a single wheg-module and half robot model using multi-body simulation tool ADAMS View® 2012 showing the effects of the different parameters on the stability of the wheg-driven robots.

Chapter four contains a proof for the concept of the proposed solution of the wheg-module with electromagnetic spokes using the mathematical study from chapter two and simulation model from chapter three, also it contains the design and manufacture of the experiment platform which is a prototype for the wheg-module with electromagnetic spokes and laboratory experiments are provided showing the advantages of the proposed solution.

Finally, chapter five contains conclusions and future work.