# *Towards the design of a leg-wheel walking hexapod*

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*Abstract*— **Hexapod walking robots have been widely addressed in literature. Their design requires to manage a very large number of design variables and design solutions. Thus, this paper proposes a procedure in order to systematically design a hexapod walking robot. A design case of study is described in order to show the effectiveness and feasibility of the proposed procedure. As results the design concept and mechanical configuration of a novel hybrid leg-wheel hexapod walking robot is presented. The proposed robot is composed of six legs having a modular anthropomorphic architecture with omni-wheels as feet at its extremity**.

**Keywords— Leg-wheel walking hexapod, design procedure, preliminary design.**

## I. INTRODUCTION

Walking hexapod robots are programmable robots with six legs that are attached to the robot body. The legs are controlled with a degree of autonomy so that the robot can move within its environments, to perform intended tasks [1].
Legged robots possess clear advantages over wheeled robots like obstacle climbing capability, omnidirectional motion, variable geometry, good stability, access to uneven terrain, fault tolerant locomotion. Despite the above mentioned aspects, many challenges remain before hexapod walking robots can foresee a widespread use. Some of their current disadvantages include relatively low energy efficiency and low speed [2]. Other key factors that restricted a pervasive application of hexapod are high complexity and costs. In fact hexapod walking robots are usually expensive machines, consisting of many actuators, sensors, transmissions and supporting hardware.
A very reach literature can be found on hexapod walking robots, while each hexapod robot design is almost unique. For example, some ones are equipped with biologically inspired legs. This type of walking machines can be slow and more difficult to design and operate, on the other hand it can overcome obstacles that are comparable with the size of its legs [3]. There is also a further type of hexapod robots that is called "hybrid" since it has legs and wheels at the same time. This type of walking machines may range from wheeled devices to true walking machines with a set of legs to overcome particularly difficult obstacles, or wheels to enhance the speed when moving on flat terrain.
This paper focused on a preliminary design procedure in order to systematically approach the design of hexapod walking robot and identifying the most convenient design characteristics. A design concept of a hybrid leg-wheel hexapod walking robot is presented in order to show the effectiveness and feasibility of the proposed procedure.

## II. THE ATTACHED PROBLEM

A very wide range of possibilities exist to design a hexapod. Some milestones in the early design solutions have been for example Masha, OSU Hexapod, Odex I, Aquarobot, ASV, Genghis and Ambler. Remarkable hexapod robots in recent design solutions have been for example, Hamlet, Boadicea, Rhex, Athlete, Lemur, Comet, Lauron, Rise and a series of bio inspired hexapods of Case Western Reserve University. The evolution of hexapod robots design was outlined in [4]; an overview of the state of art of hexapod robot was given also in [5]. However, each prototype shows specific design solutions and its design can be considered unique.
Considering the wide literature on the topic designers must take several decisions which influence the operation and technical features of a hexapod robot. Most important engineering requirements can be outlined as:

- body architecture;
- legs type setting;
- actuators and drive mechanisms.

In order to systematize the complex design process of a walking hexapod robot in this paper we propose a two steps design procedure. At first stage we propose a preliminary design in order to identify the key features and design requirements of the robot. Examples of key features in hexapod walking robots design can be walking speed, cost, load carrying capacity, autonomy, climbing obstacle capability, walking gait. A preliminary design is often a trade-off solution between design requirements and key features, but in literature it is lacking a systematic design procedure for hexapod robot as referring to specific functional requirements. On this matter some authors propose a Quality Function Deployment [6] in order to define the relationship between the design configuration and the robot capabilities or requirements. In this paper a simplified approach is proposed to relate and prioritize key features through numerical ranking as a tool for identifying a preliminary design solution. Then, design refinements are outlined by referring to the engineering requirements that have been identified at the previous stage.

## III. DESIGN PROCEDURE

The proposed design procedure has been described in Fig. 1. Two main stages have been addressed: preliminary architecture