Chapter 18
Design of Hexapod Walking Robots: Background and Challenges

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ABSTRACT

This chapter deals with hexapod walking robot design and operation. The first section gives a wide overview of the state-of-the-art on hexapod walking robots by referring both to early design solutions and to most recent achievements. Section two identifies the main design challenges that influence the technical feasibility and performance of these systems. In section three, a design procedure is proposed. In particular, the proposed design procedure takes into account mechanical structure, leg configuration, actuating and drive mechanisms, payload, motion conditions, walking gait, and control system. A case of study is carefully described as referring to previous experiences at LARM.

INTRODUCTION

Historical evidence of legged mechanisms dates back to antiquity, such as reported in (Zielinska, 04). The long history associated with the evolution of walking machines was outlined for example in (Silva and Tenreiro Machado, 2007). Early walking machines were focused on more and more complex linkage design, driven by only one source of power. The pure mechanical solution was limited and it becomes an evidence that less predictable environment requires advanced control. Walking machine researches gathered a new momentum after the Second World War due to the new findings in mechanics, electronics and control system (Nonami et al., 2014). A number of research groups started to study and build walking machines in a systematic approach from the mid-1950s. It took another decade to have early progress in robotics as an interdisciplinary area of engineering sciences. At early of 70ies the word "mechatronics" was coined. Nowadays mechatronics is a multidisciplinary field of engineering that represents a unifying

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and intelligent engineering science paradigm. Mechatronics fuses and comprehends modern engineering science and technologies to enhance machine intelligence and interactions as described for example in (Habib, 2007). Advances in the fields of robotics and mechatronics made possible the development of so-called Hexapod Walking Robots (HWR). In recent years, biological approach is bringing new perspective and is giving great potential to HWR design. Biomimetics is in fact an emerging discipline that studies and examines nature, its models, processes, structures, to take inspiration from, or emulate, nature's best biological ideas in order to solve scientific and engineering problems (Habib, 2011).

The first section of this chapter begins addressing a definition of HWR. Then an historical overview is given by referring to the milestones in the history of hexapod walking robotics developments. Section two describes the design challenges that influence the technical feasibility and performance of HWR. Discussion takes into account mechanical structure, leg configuration, actuating and drive mechanisms, payload, motion conditions, walking gait, control system. A case of study is described as referring to previous experiences at LARM in Cassino, Italy.

Background

The term Hexapod, originated from the greek *hex*, "six" plus pod, from greek *pod-* steam of pous "foot" (On-line etymology dictionary, 2014). In entomology the term hexapod refers to the class Insecta or Hexapoda, any member of the largest class of the phylum Arthropoda. Insects are distinguished from other arthropods by their body, which is divided into three major regions: the head, the three-segmented thorax, which usually has three pairs of legs (hence "Hexapoda") and the many-segmented abdomen (Encyclopedia Britannica, 2014).

A very comprehensive definition of walking robots, has been given in (Nonami et al., 2014) as: "A mobile vehicle or machine that utilizes one or more leg mechanisms as a means for propulsion and having reprogrammability features for modifying the motion control algorithm and also for imparting intelligence to it so that it can perform multiple functions and execute variety of useful tasks, within the workspace as set by its mechatronic design, can be regarded as a walking robot".

Typically HWR may be used as service robot, thus one should refer also to the ISO definitions (ISO 8373:2012) of robot and service robots:

- **Robot:** Actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environments, to perform intended task;
- **Service Robot:** Robot that performs useful task for humans or equipment excluding industrial automation application.

Based on the above definitions one can describe a HWR as "a programmable mobile platform or machine on which six legs mechanisms are attached to the robot body and controlled with a degree of autonomy that allow the robot to moving within its environments, to perform intended task". According to this definition, "a degree of autonomy" is required for service robot ranging from partial autonomy, including human robot interaction, to fully autonomy without active human robot intervention. (IFR homepage, 2014).

HWR have attracted considerable attention in last decades, but only in the recent past efficient walking machines have been conceived, designed, and built with performances that are suitable for practical applications. HWR have been widely studied for their significant advantages on rough terrain with respect