The Offset Model of a Hexapod Robot and the Effect of the Offset Parameter

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ABSTRACT

Generally, it is claimed that hexapod walking robots are superior to others. However, in some conditions hexapod suffers from stability problems. To solve the problem of stability, this paper proposes a new gait model of hexapod robot named offset model and also investigates the effects of morphological factor of hexapod robots on their locomotion. A comparison between the offset model and general model of hexapod robot is also included. The stability margin and error margin are used to indicate the stability of a hexapod robot, as it walks with different gaits in arbitrary directions. Two hexapod gaits are compared, which are the diametrical gait and the paired metachronal gait. The former is an artificial gait and the latter is a natural gait. The authors conclude that that the stability of a hexapod robot with the diametrical gait can be enhanced by increasing the offset parameter.

Keywords: Diametrical Gait, Error Margin, Hexapods, Offset Model, Paired Metachronal Gait, Stability Margin

INTRODUCTION

Legged robots have greater flexibility in crossing barriers and adapting to the terrain. Wheels can perform better on prepared surfaces, but unable where terrain is uneven. However, the design, control and gait planning of legged robots depend on several areas of engineering and science. A robot designer has to know which gait is the best for a specific use of the hexapod (Erden & Leblebicioglu, 2007; Starke, Robilliard, Weller, Wilson, & Pfau, 2009; Mostafa, Her, & Her, 2011).

Among all legged robots, advantages of the hexapod configuration are satisfactory walking efficiency and at the same time static stability. Hexapod gaits are much diversified, i.e., having a larger number of patterns than biped, quadruped or even myriapod gaits. For the development of artificial gaits, Bessonov and Umnov (1973) proposed the free gait for a hexapod robot to move in a straight line. Regarding crossing an uneven terrain, McGhee and Iswandhi (1979) presented the adaptive gait...
to improve the performance of the free gait. Ozguner and Tsai (1984) then inventoried the FTL (Follow-the-leader) gait. Yang and Kim (1998) investigated a fault tolerant gait for a hexapod robot to be stable and functional even when one leg is broken. Afterward, Yang (2009) combined the adaptive gait and the FTL gait to improve the fault tolerant gait. One of the gaits mentioned in this paper (the diametrical gait) is extended from the fault tolerant gait. The robot swings a pair of legs at the same time in this gait, as shown in Figure 1(a). Readers interested in more details about diametrical and paired metachronal gait can find them in Mostafa et al. (2011).

Wilson (1966) observed gaits of the hexapod for the slow wave gait, the ripple gait, and the tripod gait. The paired metachronal gait discussed in this research is the ripple gait. The hexapod robot swings a pair of legs at a time during the movement with the paired metachronal gait. The group of legs is shown in Figure 1(b). McGhee and Frank (1987) proposed the slow wave gait of the quadruped robot moving along the straight line. They divided the leaving and contact of legs to the ground into two states and discussed the best swinging sequence of the legs, the control of gait, and the algorithm for the stability of gait.

The main focus of this study is to develop an offset model of hexapod robot and assess the effect of offset parameter. We investigate two offset models hexapod gait (diametrical gait and paired metachronal gait) and their stability margin.

The Offset Model of Hexapod Robots

Before delving into details, an explanation of the six-legged robot model is appropriate. More details about hexapod robot of this study can be found in Mostafã et al. (2010) and Mostafã et al. (2011). Figure 1 illustrates the offset model of hexapod robots used in this paper. The general model which means $D=0$ in Figure 1 has been used frequently in the research and analysis of the hexapod robot gait. $P$ and $Q$ define the size of the allocated reachable region of a leg, and $U$ is the width of the body. In this paper, we simply let $P=Q=U=1$. The mass of the legs is small, and the CG (denoted as a star) is at the centroid of the body.

Yang and Kim (1998) proposed the fault tolerant gait with this model and indicated that
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