STUDYING WALKING HEXAPODS ROBOTS

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ABSTRACT: *The paper aims to present the main features of the hexapods walking robot, the basic parameters that matter in walking and the classification of the gait for such robots. It also presents two types of regular walking, considered to be the most used at this type of robots.*

KEYWORDS: stability of robot, geometric parameters, forward wave gait, backward wave gait

1. INTRODUCTION

A hexapod robot is a mechanical and electronic device whose movement is based on the six legs. Unlike other types of robots, with two, three or four legs, the hexapod robot has superior flexibility and stability [1]. Therefore, the behavior of a hexapod robot is much more complex, especially due to the fact that not all six legs are necessary for movement; the others can be used to lift objects or to better target the robot to certain areas [2,3]. It is believed that this type of robot was created to test biological theories related to insect movement, motor control and neurobiology. Last but not least, such robots can be used in discovery or research missions, in places that are difficult for humans to access. In [4] is presented a hexapod robot equipped with a 360 ° viewing system and good stability even at an inclination of 60 ° of the surfaces, which aims to inspect areas affected by earthquakes or other natural disasters. A comparison of two types of gait: the tripod gait and the crab-inspired gait for hexapod robots is presented in [5]. A study on a hexapod robot through a maze which is detailed in [6]. An obstacle avoidance and terrain identification method is proposed in the paper [7]. An analysis of several types of gait as well as the kinematics of a hexapod robot is detailed in [8,9]. Khudher D. et al. performs in their work an operational space inverse dynamics control law to control the motion of a sixlegged robot [10]. Most of the conventional hexapod robots are either rectangular type of hexagonal type, those robots have drawbacks in the speed and stability of walking, but in the paper [11] the robot forms relatively wide supporting polygons along the walking direction, so it can walk very fast stably.

2. BASIC PARAMETERS THAT CHARACTERIZING GAIT OF ROBOT

To analyze the basic parameters that characterize hexapod walking robot is considered a schematic diagram of such a robot, number associated with each leg (Fig. 1).

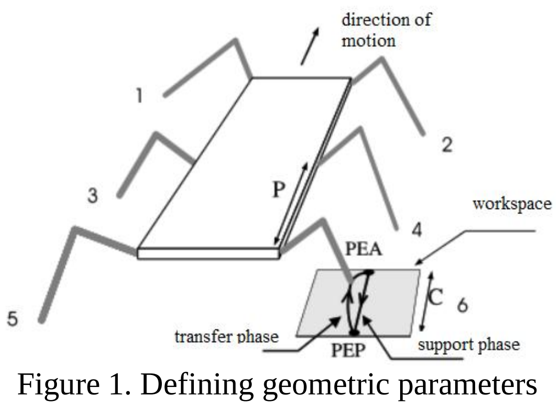

Figure 1. Defining geometric parameters

Starting from this figure, the parameters that characterize the gait are briefly presented in the following.

- The transfer phase of a foot is the time interval in which the foot is not in contact with the ground, the time corresponding to this phase is denoted by τ.
- The support phase of a foot is the time interval in which the foot is in contact with the ground, the corresponding time being denoted by s.
- The duration of a cycle, T, is the duration of a complete locomotor cycle of a leg, respectively $T = s + \tau$. Periodic walks are characterized by the same duration of the cycle for all legs.
- The extreme positions of the support phase are called:
  - an Anterior Extreme Position (AEP)
  - a Posterior Extreme Position (PEP).

In case of a uniform rectilinear movement of the robot, in the support phase the end of the foot performs a movement opposite to the walking direction. Also, in the transfer phase, the foot advances in order to find a new support point. For this reason, the final part of the transfer phase is very delicate and requires tactile information in case of rough terrain.

- The utilization factor (Duty Factor) of a leg is given by the relation $\lambda = s / T$. But $T = s + \tau$, which means $\lambda = s / s + \lambda$. Finally we can write $s / \tau = \lambda / 1- \lambda$.

Static stability requires that, permanently, at least three feet be in contact with the ground, this being the condition that imposes the minimum value of the use factor: $\lambda \geq 3 / n$, where n is the total number of legs of the robot. For hexapos robots this means: $\lambda \geq 1/2$. A walk is called regular if the usage factor has the same value: λ for each leg.

- The phase Φ_i of a foot is the fraction of the cycle that separates the beginning of the cycle of the i foot and that of the foot l, taken as a reference. A gait is symmetrical if the left-right leg pairs have movements shifted by 1/2 (half) cycle or a phase difference $\Delta\Phi = 1/2$. A walk with a constant phase increment is one in which the phase differences between successive legs on the same side of the robot are equal:

$$\Phi_3 - \Phi_1 = \Phi_5 - \Phi_3 \tag{1}$$

- Leg step L (Leg Stride) is the distance traveled by the center of mass of the robot during a locomotive cycle.
- Stroke C is the distance traveled by the leg in the support phase (distance between AEP and PEP).
- Stroke Pitch is the distance between two adjacent legs on the same side of the robot.
- The effective length of the body, L_b, of an animal or robot with n legs is the distance between the centers of rotation of the front legs, respectively behind the robot, legs located on the same side of the body. If the distances between adjacent legs are the same, you can write:

$$L_b=(n-1)\cdot L \tag{2}$$

The static stability limit for tetrapod robots requires $\lambda \geq 3/4$, which means that the maximum value of the $1- \lambda / \lambda$ ratio can be 1/3, ie the maximum speed of a hexapod robot is three times higher than that of a tetrapod robot, for the same kinematic conditions. That is why it is more preferable to use a number of six feet.

3. TYPES OF WALKING

Coordinating the movement of a robot's legs is very important for two reasons:

- keeping the robot in balance
- its movement with a certain imposed speed

This can be done using several types of walking:

• Periodic walks, characterized by the same duration of a complete locomotive cycle, for all the robot's legs. These types of gait form the basis of other coordination strategies.

• Adaptive Wave Gait, is an extension of periodic walking and is characterized by allowing the use of fixed sequences of movement in omnidirectional movements.

• Neurobiological coordination, based on a model of insect coordinating mechanisms.

• Free Gait, ensures the control of the robot according to the imposed speed and the obstacles encountered.

Given that in the case of the robot, which is the subject of the study in this paper, the control of movement is done using regular periodic types of walking (duration T of a cycle is identical for all six legs, the use factor λ is the same for each leg), some of them will be briefly presented below.

3.1 WAVE GAIT

It is so called because the transfer phases propagate from one foot to another like waves. This type of walking is characterized by:

$$\Phi_3 = \lambda \, , \; \Phi_5 = 2 \cdot \lambda - 1 \tag{3}$$

Depending on the direction of propagation in time of the transfer phases, we can have:

- Forward Wave Gait - Fig 2. a, b, when the transfer phases propagate starting with foot 5, up to foot 2.
- Backward Wave Gait - Fig. 3 a, b, when the transfer phases propagate from foot 2 to foot 5.

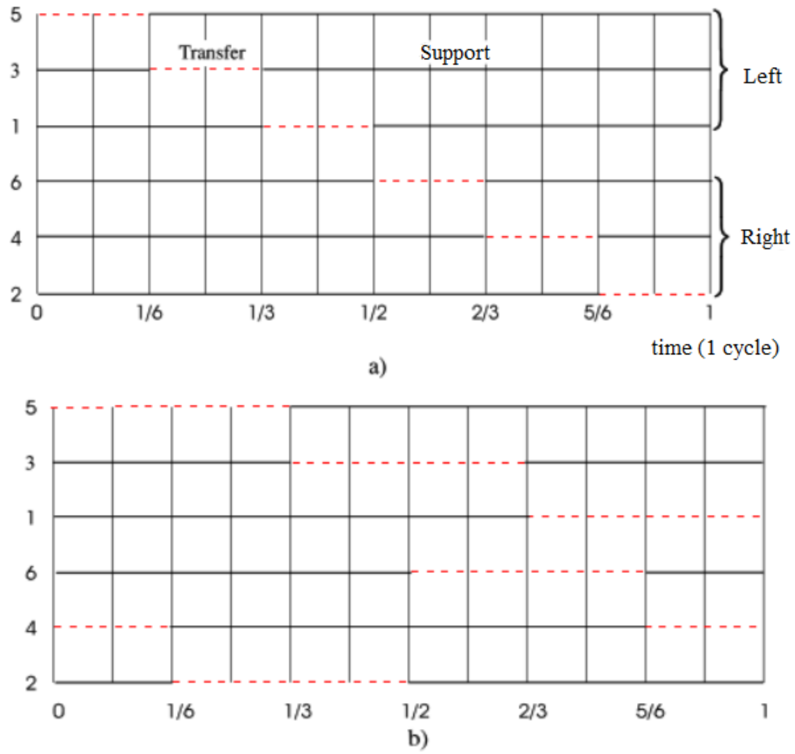

Figure 2. Forward Wave Gait : a) $\lambda = 5/6$; b) $\lambda = 2/3$

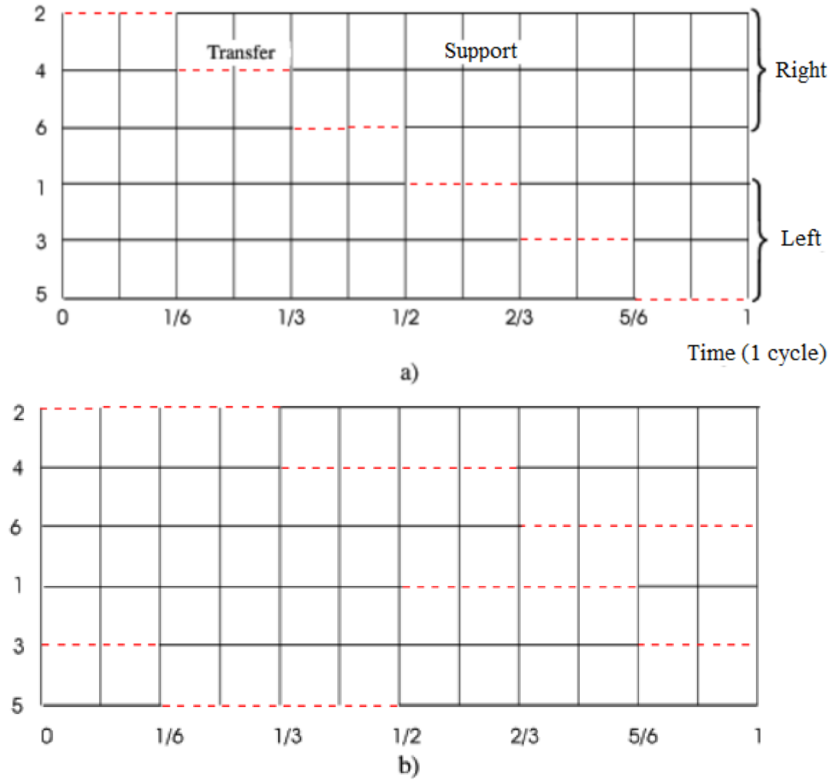

Figure 3. Backward Wave Gait : a) $\lambda = 5/6$; b) $\lambda = 2/3$

3.2 ALTERNATING TRIPOD GAIT

This type of walking is characterized by λ = 1/2, Φ_3 = 1/2, Φ_5, = 0 on the ground being permanently three feet. The diagram of the alternating tripod gait is shown in figure 4.

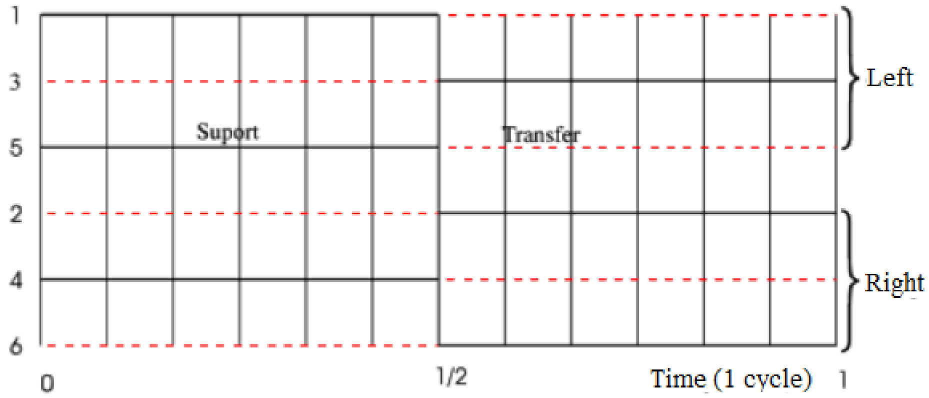

Figure 4. Alternating tripod gait λ=1/2

4. CONCLUSIONS

The most important advantages of passing robots are the following: they can move on difficult terrain (soft, rugged), allows omni-directional movement, isolated contact (intermittent) with the ground, optimizing the support polygon and traction force, the trajectory of the robot body can be decoupled from the trajectories of the extremities of the legs, the position of the transported load is not influenced by terrain irregularities, a stepping robot can cross obstacles, climb or descend stairs, can walk without being influenced by terrain irregularities, can ensure a smooth movement on rough terrain, varying lengths actual footwork depending on terrain irregularities (active suspension), construction of stepping robots depends on advances in a number of areas of engineering and science, less destruction of the terrain on which it moves, behavior while moving is interesting both in terms of of mechanical engineering, drive, system sensory or calculations required, have a natural, biological appearance, Are appropriate to the human environment, have better energy performance, have fewer blocking problems.

Disadvantages include: complex design (because it has a complex mechanical system), high energy consumption, control algorithms of increased complexity, low speed on rough terrain, the need to synchronize the movement of a large number of kinematic couplings.

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