Robot based on walking Jansen mechanism

R Tomović[1], V Vujošević[2] , M Mumović[3] and A Tomović[4]

[1]University of Montenegro, Faculty of Mechanical Engineering, Džordža Vašingtona bb, 81000 Podgorica, Montenegro

E-mail: radoslav@ac.me, vukvujosevic7@gmail.com, markomumovic@gmail.com, aleksandartomovic23@gmail.com

Abstract. In this paper are presented analysis of the walking mechanisms, advantages of a walking mechanisms in comparison with classical wheeled machines, as well as the effect of certain parameters on its performances.

1. Introduction

The machine is a set of elements that can be mobile or immobile, and serves to convert energy from one form to another. While the mechanisms serve to transmit the movement, that is, the force and torque of the drive member to the driven one. Mechanisms are divided into planar and spatial, manipulators. According to its purpose and design characteristics, it works on:

- Articulated with levers - members have levers that are interconnected by joints. An example of this mechanism is an articulated quadrilateral.
- Curved mechanisms - have a very wide application in various technological processes. Transfer is done by touching a drive and driven member.
- Mechanisms for the transfer of rotational motion - these are the most common gears, pulleys, etc.

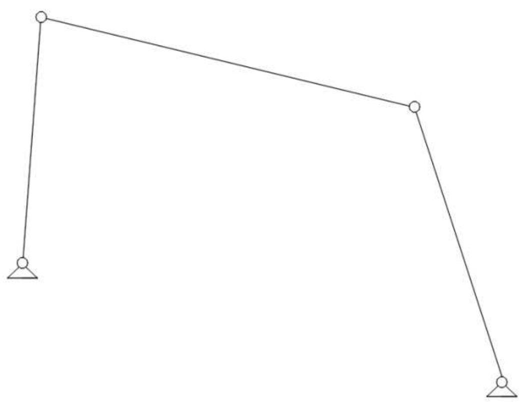

Figure 1. Mechanim - articulated quadrilateral.

2. Walking mechanisms

Walking mechanisms are suitable for applications that require movement on rough terrains, especially if compared to conventional wheels.

2.1. Flaws of walking mechanisms

The shortcomings of the walking mechanisms are as follows:

- A driving member rotates in a unequal speed to obtain a unique speed of robots, or vehicles that are driven by a walking mechanism.
- The length and height of the steps are fixed.
- Inertial moments and forces cannot be balanced in a satisfied way.

2.2. Advantages of walking mechanisms

When it comes to the advantages of walking mechanisms, first of all, it is necessary to mention the movement on rough terrain. If we compare this mechanism with a common wheel, it is obvious that the walking mechanism will overcome an obstacle much by just crossing it.

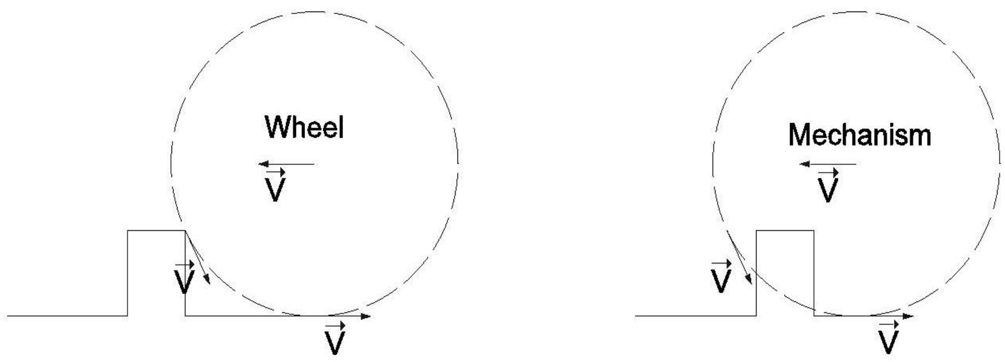

Figure 2.1. Wheel and foot crossing over obstacle . The arrows indicate the direction of movement of the wheel and the leg.

Consider a moving wheel with a constant angular velocity ω, each point on the circumference of the circle will have a velocity v, in the direction of the tangent to the circle. The picture shows that the wheel cannot overtake the obstacle. Now we observe a walking mechanism moving at a constant velocity v, the leg would describe a similar path as for a point. It is clear that the leg will have an advantage over the wheel, because it will be easier to overcome the obstacle. This way you can reduce the consumed energy.

Often, in practice, you can find an obstacle that cannot be overlooked, such as stairs. When the wheel comes into contact with the edge of the obstacle, the speed will be sharply reduced. The picture shows that the horizontal component of the speed is small. With the walking mechanism, the horizontal speed is also, but the advantage is that the foot can slide on the surface. It can still be seen from the picture that vertical displacement is required, which is an additional energy consumption.

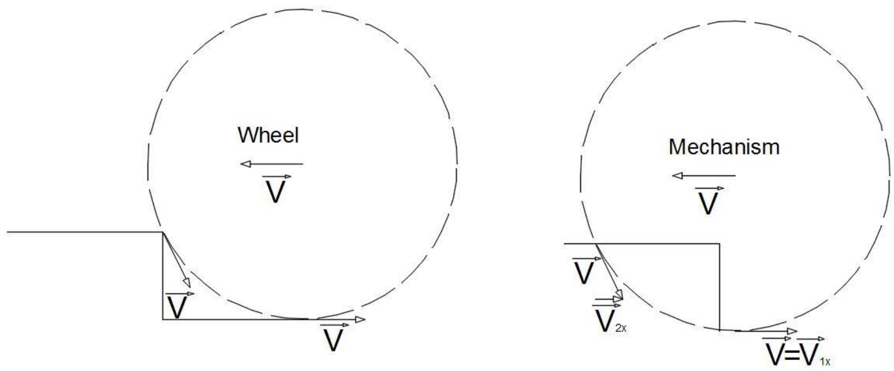

Figure 2.2 Wheel and leg crossing over an obstacle that cannot be overrun.

3. Locus

When walking, a leg generates a curved line. This line is called the locus, and it contains all the points through which the leg passes at the rotation of the driving member. The way to get this is to look at the terrain, which moves in the opposite direction relative to the movement of the robot at the same speed.

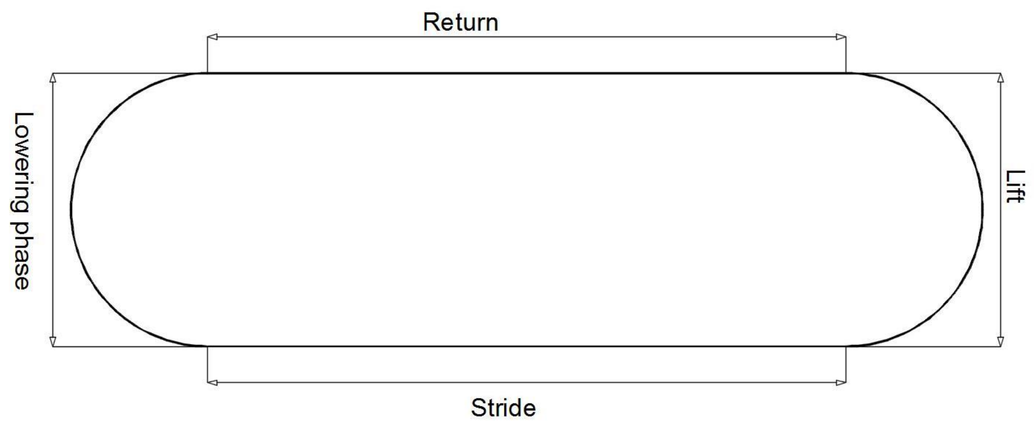

Figure 3. Locus.

Locus has 4 stages:

- Stride - that is the step of the locus when the foot is in contact with the terrain. At this stage, the speed is consFtant.
- Lift - during this phase, the leg is lifted to the maximum height.
- Return - the leg moves in the opposite direction in relation to the stride, and is at the maximum height.
- Lower stages - the leg is lowered until it comes into contact with the terrain. The curve, which is generated during the lifting and the lowering stage, holds the information on how the foot contacts the terrain.

3.1. Shapes of locus

The picture shows five theoretical forms of the locus.

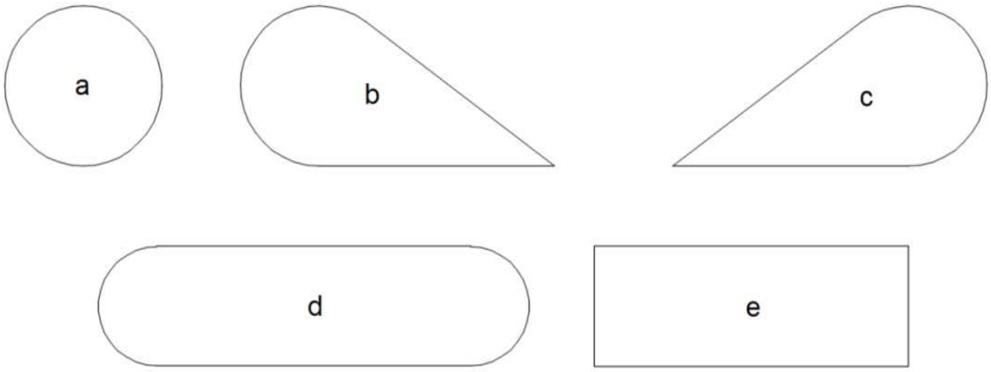

Figure 3.1. Theoretical shapes of the locus.

Locus a has the lifting and lowering stages as well as the wheel. This mechanism is not effective because it has a low-drag phase.

Locus b and c can cause unsatisfied performance due to high acceleration at pointed ends, as well as the way they come into contact with the terrain.

Locus e is rectangular and offers many advantages. However, the problem occurs when it comes into contact with the terrain during the lower stage, then the mechanism may be blocked or slipping may occur. Similarly, for the mechanism to reach constant speed in the stride phase, it will require infinite acceleration at the beginning and end of the same phase.

Locus d is theoretically ideal, and represents a compromise between circular and rectangular. It has a long stride phase. The lifting and lowering stages are the same as for the wheel and have the same acceleration characteristics as the circural locus. It is possible to balance the inertial forces by properly phasing a number of mechanisms on the terrain.

4. Motion of the foot

The foot speed in relation to the robot and the backbone could be written as follows

$$V_{ft} = V_{fr} + V_{rt} \tag{1}$$

Where:

V_{ft} - foot speed relative to the terrain.

V_{fr} - speed of the foot relative to the robot.

V_{rt} - speed of the robot relative to terrain.

From this formula it can be seen that the velocity of the leg relative to the terrain is equal to the sum of the robot velocities relative to terrain and the leg relative to the robot. In the stride phase of the mechanism, when there is no slipping, the leg velocity with respect to the base is equal to zero, It follows that:

$$V_{fr} = -V_{rt}$$

What tells us that the speed of the leg relative to the robot is the same by the intensity as the robot in relation to the terrain. This can be graphically displayed as follows.

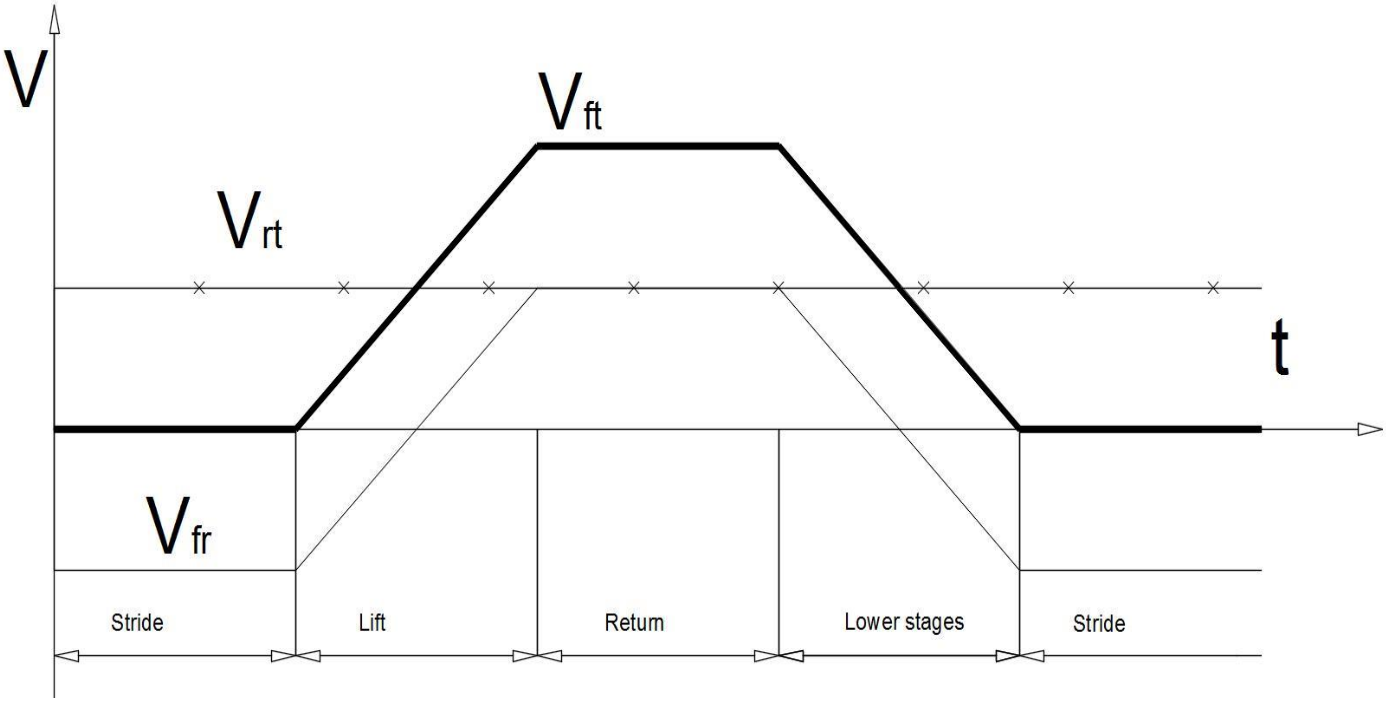

Figure 4. Velocity diagram.

It is seen that the velocity of the robot relative to the terrain is constant during each phase. During the stride phase, we see that the foot speed relative to the terrain is twice as high as the speed of the robot relative to the surface. We also see that in the half of the lift phase and the lower phase, the speed of foot relative to robot is equal to zero and that at the beginning of the lift phase the speed of leg is lower than the speed of the robot. This means that if the foot was still in contact with the terrain at this moment, if an obstacle was encountered, the robot would drag the foot over the surface, or obstacle. The same happens at the end of the lower phase.

5. Jansen mechanism

Jansen's walking mechanism belongs to a group of planar mechanisms. Designed by Theo Jansen, after which he was named. One leg of the mechanism contains 7 members, 2 triangle elements, 4 levers and one drive member.

In the following figure a schematic sketch of one leg of the jansen mechanism is drawn.

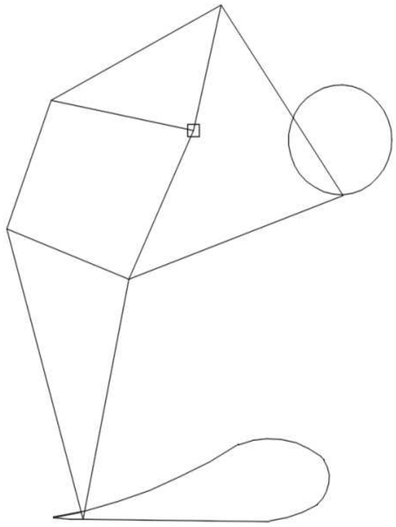

Figure 5.1. A schematic view of one leg of the jansen mechanism and the locus.

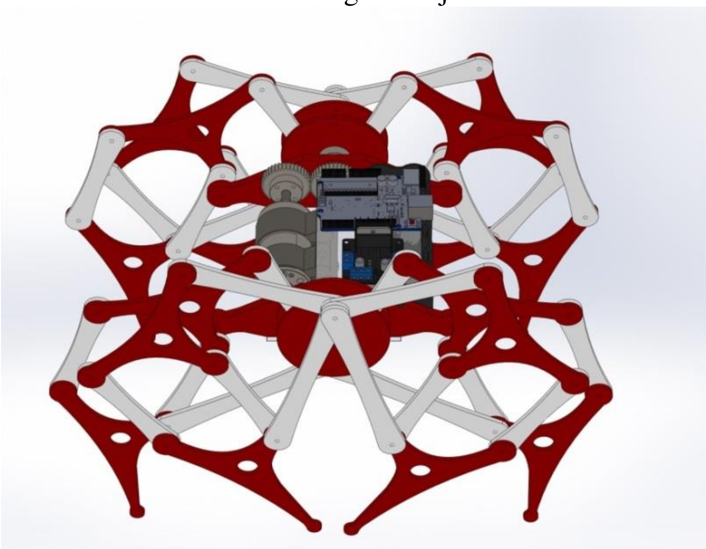

Figure 5.2. 3d robot model.

6. References

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