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Research Article

Mechanical Spider Using Klann Mechanism

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Abstract: Since the wheel was invented back in the Stone Age, it was the primary component used in all forms of mechanical transportation. Even today it is the component of choice for almost any type of moving machine like cars. However, the wheel has always had a major disadvantage with short instant elevation changes like stairs. For most uses, climbing stairs or steep jagged rock piles is not a problem which is why the wheel is still almost always used. For the other applications, people looked at animal and human legs which are already proven to work effectively on this type of terrain. The two most effective leg mechanisms are currently Joe Klann's mechanism which resembles a spider leg and Theo Jansen's mechanism which resembles a human leg. We have chosen Joe Klann mechanism which has more advantage than Jansen mechanism. The main objective of our paper is to replace the function of wheel with an alternative in order to overcome the difficulty of travelling in uneven terrain. This paper is useful in hazardous material handling, clearing minefields or secures an area without putting anyone at risk.
Keywords: Joe Klann's Mechanism, Theo Jansen's Mechanism, Steep Jagged Rock piles, Material Handling.

INTRODUCTION

The main objective of our paper is to replace the function of wheel in order to overcome the difficulty of travelling in uneven terrain. In this mechanism links are connected by pivot joints and convert the rotating motion of the crank into the movement of foot similar to that of animal walking. The proportions of each of the links in the mechanism are defined to optimize the linearity of the foot for one-half of the rotation of the crank. The remaining rotation of the crank allows the foot to be raised to a predetermined height before returning to the starting position and repeating the cycle. Two of these linkages coupled together at the crank and one-half cycle out of phase with each other will allow the frame of a vehicle to travel parallel to the ground.

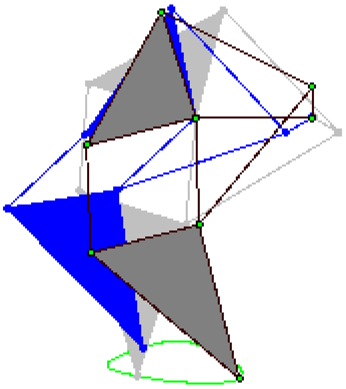
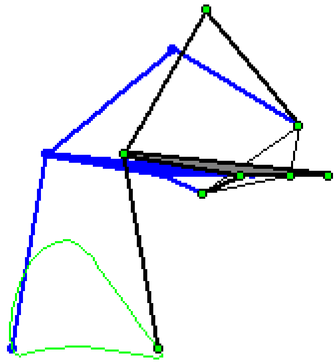
It has been a hobby for a number of years to develop a bicycle without wheels that could walk. It would move on legs and resemble a large insect. A linkage was developed that satisfied the design criteria and several small-scale prototypes were built that demonstrated the concept. Applications for the linkage go beyond human-powered machines. The links are connected by pivot joints and convert the rotating motion of the crank into the movement of a foot similar to that of an animal walking. Two of these legs coupled together at the crank can act as a wheel replacement and provide vehicles with a greater ability to handle obstacles and travel across uneven terrain while providing a smooth even ride. Initially it was called the Spider Bike but the applications for this linkage have expanded well beyond the initial design purpose of a human-powered walking machine. This linkage could be utilized almost anywhere a wheel is employed from small wind-up toys to large vehicles capable of transporting people. The relationships for the linkage have been established and are covered by several patents. The simplicity and scalability of the walking device, along with a little imaginative engineering, lead to numerous possibilities[1].

Jansen's linkage mechanism designed by the kinetic sculptor, Theo Jansen to simulate a smooth walking motion. Jansen has used his mechanism in a variety of kinetic sculptures which are known as Strand beests. Jansen's linkage bears artistic as well as mechanical merit for its ingenious simulation of walking motion using a simple rotary input.

The Klann linkage mechanism provides many of the benefits of more advanced walking vehicles without some of their limitations. It can step over curbs, climb stairs, or travel into areas that are currently not accessible with wheels but do not require microprocessor control or multitudes of inefficient actuator mechanisms. It fits into the technological void between these walking devices and axel-driven wheels [2].

The step height, stride length, ground clearance, overall size, and maximum incline, as well as the ratios of these factors, are obvious ways to compare the two linkages. Both linkages can be proportioned differently based on the inputs in the relationships. The center of gravity coincided with the center of the crank in the comparison of these linkages' ability to handle an incline but could be significantly different depending on a wide range of factors. [3]

Table1: Comparison between Jansen and Klann mechanism

Jansen Linkage (existing method)	Klann Linkage (proposed method)
 Jansen Linkage	 Klann Linkage
8 links per leg 120 degrees of crank rotation per stride. 3 legs will replace a wheel. Counterclockwise rotation of the crank.	6 links per leg 180 degrees of crank rotation per stride. 2 legs will replace a wheel. Clockwise rotation of the crank.
Step height is primarily achieved by a parallel linkage in the leg that is folded during the cycle angling the lower portion of the leg.	Step height is achieved by rotating the connecting arm which is attached to the crank on one end and the middle of the leg on the other. It pivots on a grounded rocker.
The eight-bar Jansen linkage evolved through iterations of a computer program.	The six-bar Klann linkage is an expansion of the four-bar Burmester linkage developed in 1888 for harbor cranes.
Can walk only on even surfaces and terrain.	Can walk on uneven surfaces and terrains.
The number of links in the Jansen mechanism is more when compared to that in the Klann mechanism. It is costly.	The number of links in the Klann mechanism is less when compared to that in the Jansen mechanism. It is less costly.

PROPOSED METHODOLOGY

KLANN MECHANISM

As the wheels are ineffective on rough and rocky areas, therefore robot with legs provided with Klann mechanism is beneficial for advanced walking vehicles. It can step over curbs, climb stairs or travel areas that are currently not accessible with wheels. The most important benefit of this mechanism is that, it does not require microprocessor control or large amount of actuator mechanisms.

This paper is useful in hazardous material handling, clearing minefields, or secures an area without putting anyone at risk. The military, law enforcement, explosive ordinance disposal units, and private security firms could also benefit from applications of mechanical spider. It would perform very well as a platform with the ability to handle stairs and other obstacles to wheeled or tracked vehicles

THEORETICAL DISCUSSIONS

Legged motion systems have been effective in numerous robotic missions and such locomotion is especially useful for providing better mobility over irregular landscapes. However locomotion capabilities of robots are often constrained by a limited range of gaits and associated energy efficiency. This journal presents the design of a novel reconfigurable Klann mechanism capable of producing a variety of useful gait cycle. Such approach opens up new research avenues, opportunities and applications.

The position analysis problem that arise when dealing with reconfigurable Klann mechanism was solved here using a bilateration method, which is distance base formation by changing the linkage configuration. Our aim was to generate a set of useful gaits for a legged robotic platform. In this study three gait patterns of interest were identified, analyzed and discussed that validates the feasibility of our approach and considerably extends the capabilities of the original design[3]

ADVANTAGE OF KLANN MECHANISM

Simplicity in design: The design of the Klann mechanism is simple and has a less complicated when compared to the other mechanism.

Compatibility: The design of the Klann mechanism is very compactable and portable with lesser linkage for movement.

Reliability: This mechanism consists of linkages which can move on uneven and rough terrains or surface thereby has the ability to endure giving it a good reliability.

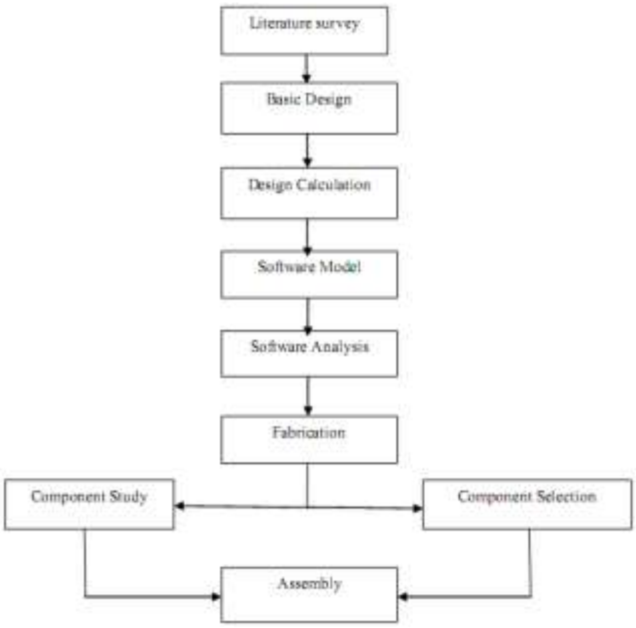


Fig. 1: Design Flow Chart of Proposed Mechanical Spider

CONSTRUCTION OF MECHANICAL SPIDER

The cranking link is also axially mounted to the frame in operative association with a power source and operatively linked to at least one connecting rod so as to provide locomotion to the interconnected linkages of the walking assembly. The walking assembly includes a reciprocating leg equipped at one leg end with a foot and a hip joint at an opposite leg at one end. The hip joint is axially coupled to an opposite rocker arm end from the axial mount of one rocker arm end to the frame. The first rocker arm limits locomotion of the hip joint about an acute arced path as the first rocker arm and upper extremity of the leg reciprocates about the path when placed under locomotion by the power source [2].

The spider mechanism works on the principle of the Klann mechanism that deals with six leg linkage [1] with three linkages equally spaced on each side of the frame. These six linkages are connected to two cranks shafts, with three cranks on each shaft. Here a connecting rod connects the linkages with their respective cranks and the connecting rod is supported by a rocker at its center forming a crank-rocker mechanism. Step height is achieved by rotating the connecting arm which is attached to the crank on one end and the middle of the leg on the other. It pivots on a grounded rocker.180 degrees of crank rotation per stride.

The 4-Channel Relay Driver Module [4] makes it simple and convenient to drive loads such as 12V relays from simple 5V digital outputs of your remote compatible board or other microcontroller. You can use any of the control channels independently, so simply leave any unused channels disconnected.

Gear motors are complete motive force systems consisting of an electric motor and a reduction gear train integrated into one easy-to-mount and –configure package. This greatly reduces the complexity and cost of designing and constructing power tools, machines and appliances calling for high torque at relatively low shaft speed or RPM.

WORK METHODOLOGY ADOPTED

The most important benefit of this mechanism is that, it does not require microprocessor control or large amount of actuator mechanisms. In this mechanism links are connected by pivot joints and convert the rotating motion of the crank into the movement of foot similar to that of animal walking. The proportions of each of the links in the mechanism are defined to optimize the linearity of the foot for one-half of the rotation of the crank. The remaining rotation of the crank allows the foot to be raised to a predetermined height before returning to the starting position and repeating the cycle. Two of these linkages coupled together at the crank and one-half cycle out of phase with each other will allow the frame of a vehicle to travel parallel to the ground.

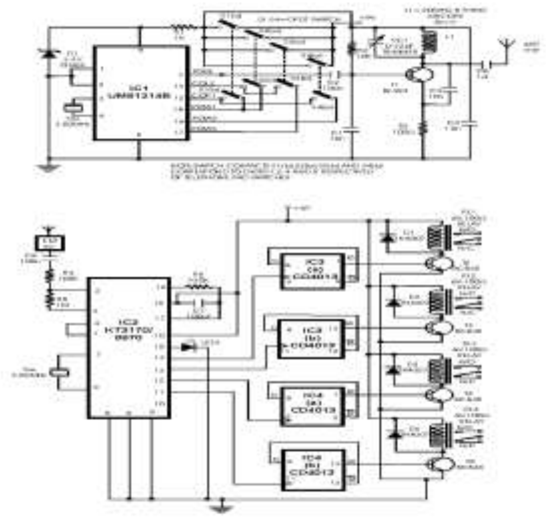


Fig. 2: Circuit Diagram of Spider LEG

Fig. 3 Leg

SOFTWARE USED

SOLID WORKS

Solid Works [5] is a solid modeler, and utilizes a parametric feature-based approach to create models and assemblies. The software is written on Parasolid-kernel. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lm lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

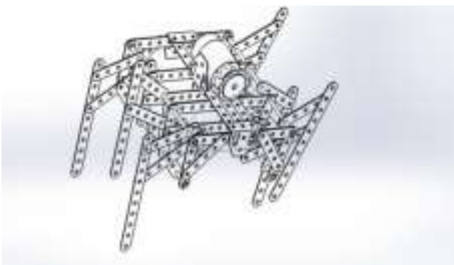


Fig. 4: Solid Work Assembly

Fig. 5: Photograph of mechanical spider

CONCLUSION

The most forceful motivation for studying legged robots is to give access to places that are inaccessible or too dangerous for human beings. Legged robots can be used for rescue work after earthquakes and in hazardous places such as the inside of a nuclear reactor, giving biologically inspired autonomous legged robots great potential. Thus in our paper we have proposed a method to replace the function of wheel in order to overcome the difficulty of travelling in uneven terrain. The most important benefit of this mechanism is that, it does not require microprocessor control or large amount of actuator mechanisms.

FUTURE SCOPE

Though the idea is pretty old, the future scope could be many making it useful in hazardous material handling, clearing minefields, or secures an area without putting anyone at risk. The military, law enforcement, explosive ordinance disposal units, and private security firms could also benefit from applications of mechanical spider. It would perform very well as a platform with the ability to handle stairs and other obstacles to wheeled or tracked vehicles.

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