Study of Availability and Extensibility of Theo Jansen Mechanism Following a Holistic Approach and Implementing in Wide Range of Applications in Terrain Region by the use of Ball Bearings and Round Surface

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Abstract— On this Earth's landmass wheeled and tracked vehicles exists. But people and animals using their legs can go almost anywhere. The main aim of the walking mechanism is to develop rough terrain robots by capturing mobility autonomy and simulation of living creatures. Such robots can travel like living creatures in stepped stairways household clutters limit the utility of wheeled vehicles. Machines consist of a number of mechanisms for their successful operation and to give the desired output. Mechanisms like four-bar mechanism, single slider crank mechanism, double slider crank mechanism, etc, are used for transmitting motion, force, torque etc. The analytical data can be used for reference purpose to design a walking robot to attain better design qualities. There are many types of walking mechanisms but there are two major mechanisms implemented to their best. They are THEO JANSON's mechanism and KLANN linkage. The first mechanism which I came across for purpose of smooth walking on terrain region was Klann mechanism which actually mimics the motion of the biological organism i.e., crab. Observing keenly I found that there were lot of drawbacks within the mechanism, the drawbacks being jerky motion and difficulty in the turning of the vehicle. The next step to be taken was to find a better mechanism which had a smooth walking pattern on any given terrain and could easily function as per requirements. The most flexible mechanism which I settled with is THEO-JANSEN MECHANISM (STRANDBEEST). My final contribution would be to do holistic analysis to determine the smooth working of the mechanism thereby walking lightly and swiftly and how to refrain from jamming. Finally, all vehicles must be controlled - by a human or other means. Therefore investigation is necessary in controlling such vehicles.

Keywords: Theo Jansen Mechanism, Ball Bearings, Klann Mechanism, Walking Robots

I. INTRODUCTION

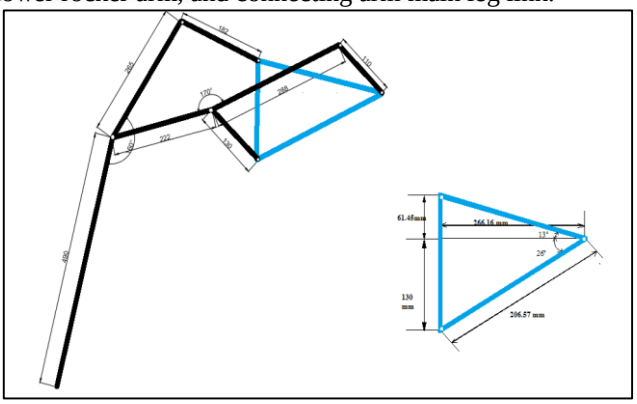
Engineering Design is one of the core courses of mechanical engineering, which introduces fundamentals in kinematic design of the mechanism and application of dynamics to the design of machine elements. The best of the two mechanisms are described as under:

The Klann linkage was developed by Joe Klann in 1994 as an expansion of Burmester curves which are used to develop four-bar double-rocker linkages such as harbour crane. This Klann mechanism is a planar mechanism converts the rotary motion of the crank to linear movement of the foot for one-half rotation of the crank and raises the foot for the second half, returning it to the starting point. Two of these linkages, 180 degrees out of phase, will function as a wheel replacement. It was designed to simulate the gait of legged animal like spider and function as a wheel replacement. Here the wheels can be replaced by either four legs or six legs sometimes eight legs is also possible to design a terrain robot. The Kann linkage consists of the frame, a crank, two grounded rockers, and two couplers all connected by pivot joints. It has 6 links per leg.

There is also another popular mechanism is also there that is Theo Jansen's mechanism. Which designed by Theo Jansen to simulate a smooth walking motion. Jansen has used his mechanism in a variety of kinetic sculptures which are known as Strandbeests. Jansen's linkage bears artistic as well as a mechanical merit for its simulation of organic walking motion using a simple rotary input. There are many types of leg mechanisms are there such as Eight-bar leg mechanism, Strandbeests (applied Jansen linkage), Tokyo Institute of Technology walking chair, Ghassaei Linkage Tchebyshevs plant grade machine. But out of them, Klann mechanism and Jansen mechanism are most popular and best in design.

A. Klann Mechanism

Klann mechanism is a planar mechanism converts the rotary motion of the crank to linear movement of the foot for one-half rotation of the crank. There are six links in Klann mechanism they are fixed frame, crank, upper rocker arm, lower rocker arm, and connecting arm main leg link.



B. Theo Jansen Mechanism

Theo Jansen devices, which resemble skeletons of animals and are able to walk by the wind, are built by the Dutch artist and kinetic sculptor, Theo Jansen. The basic Theo Jansen device is a 13-bar tie system that 'walks' when a crank is turned. The 'Strandbeest', one of Theo Jansen's most famous models, is basically a collection of many of the basic devices and it is these devices that offer walking mobility that wheels may struggle with. The central 'crank' link moves in circles as it is actuated by a rotary actuator such as an electric motor. All other links and pin joints are unactuated and move because of the motion imparted by the crank. Their positions

and orientations are uniquely defined by specifying the crank angle and hence the mechanism has only one ((degree of freedom. The kinematics and dynamics of the Jansen mechanism have been exhaustively modeled using circle intersection method and bond graphs (Newton–Euler mechanics). These models can be used to rate the actuator torque and in design of the hardware and controller for such a system.

C. Walking Mechanism

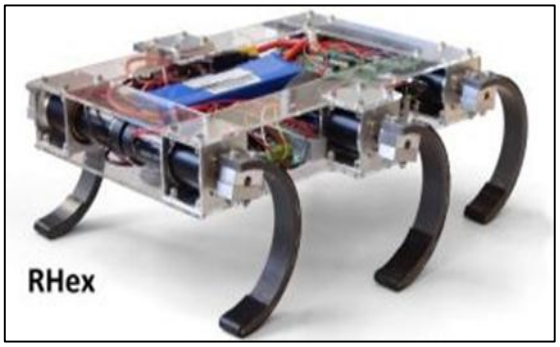
A leg mechanism (walking mechanism) is a mechanical system designed to provide a propulsive force by intermittent frictional contact with the ground. This is in contrast with wheels or continuous tracks which are intended to maintain continuous frictional contact with the ground. Mechanical legs are linkages that can have one or more actuators, and can perform simple planar or complex motion. Compared to a wheel, a leg mechanism is potentially better fitted to uneven terrain, as it can step over obstacles.

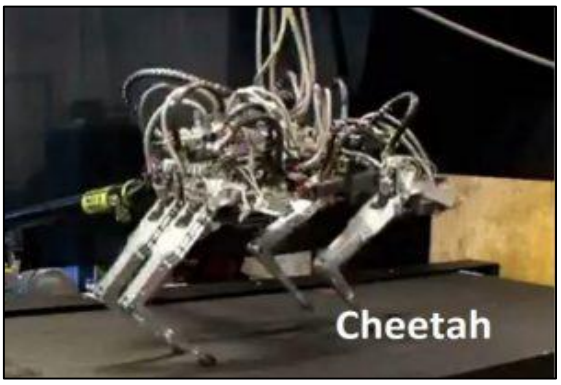
An early design for a leg mechanism called the Plantigrade Machine by Pafnuty Chebyshev was shown at the Exposition Universelle (1878). The original engravings for this leg mechanism are available. The design of the leg mechanism for the Ohio State Adaptive Suspension Vehicle (ASV) is presented in the 1988 book Machines that Walk. In 1996, W-B. Shieh presented a design methodology for leg mechanisms.

The artwork of Theo Jansen, see Jansen's linkage, has been particularly inspiring for the design of leg mechanisms, as well as the Klann patent, which is the basis for the leg mechanism of the Mondo Spider.

D. Walking Robots

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 a large number 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. This project 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 a mechanical spider. It would perform very well as a platform with the ability to handle stairs and other obstacles to wheeled or tracked vehicles.





II. LITERATURE SURVEY

On a rough terrain legs have advantage over tyres so I came on Klann Mechanism. After researching through this mechanism on internet and going though few reports and watching its motion in the YouTube videos, I found that Klann Mechanism has its own demerits which include steering and stability. After analysing the Klann Mechanism I stumbled onto Theo Jansen Mechanism. This mechanism gave me the smoothest motion and is able to carry loads without much high forces applied to it. With the inspiration from Jansen's walking mechanisms, I began searching for various applications of the Jansen leg mechanism. I found several images and videos on the Internet showing different applications of this design large and small that helped me identify what I wanted my design to look like. The appropriation of the Jansen mechanism has ranged from tiny motorized robots to large multi-legged two-seater vehicles. This mechanism is very simple to build and it requires very less energy to run itself. But there are certain drawbacks which can be mitigated from the following suggestions.

III. SYSTEM ANALYSIS

On analyzing I came across several problems which can be solved by using the following points:

A. Ball Bearing

There should be use of ball bearings in between the linkage of Theo Jansen mechanism for the walk to be smooth. The eleven bar of the mechanism should be joint to each other by the help of bearings to avoid rubbing, wearing and tearing and to reduce the friction between the materials. Lot of energy is lost without such type of mechanism. Ball bearing provides easy transmission of power as well as helps in uniformly distribution of the efforts. Moreover, jamming would be

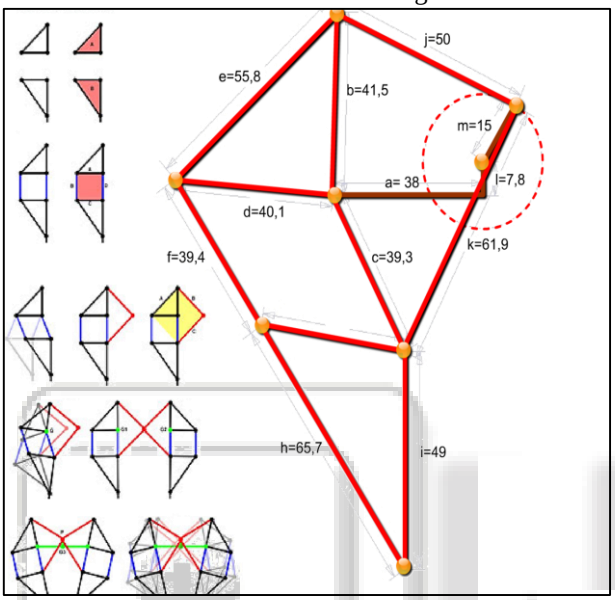
avoided which is one of the encountered problem in this mechanism.

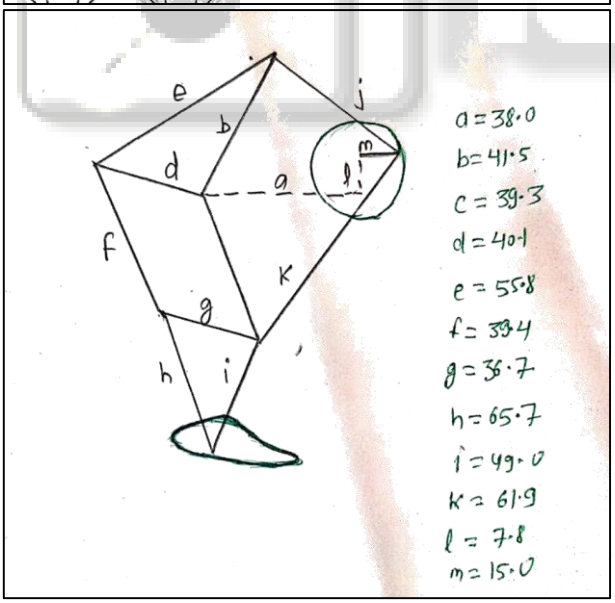
B. Weight

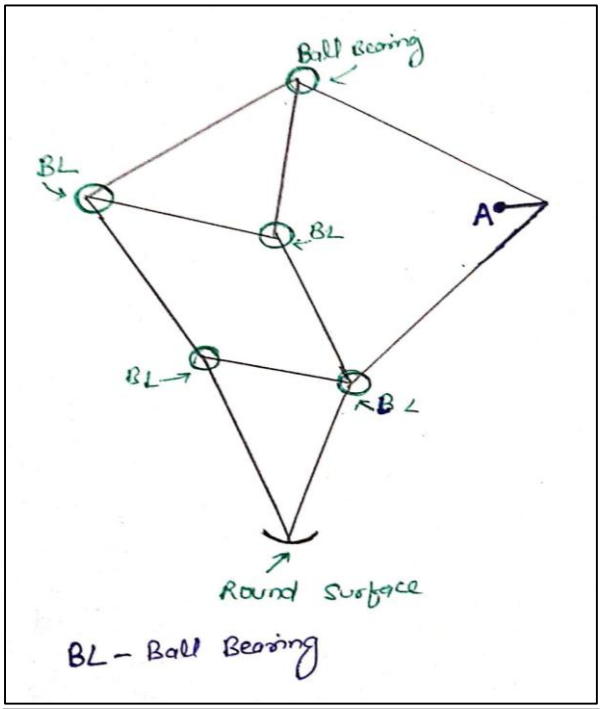
The choice of the material should be such that it is light in weight. As heavy weight overpowers the advantages of Theo Jansen. Material should be such that it neither compromises with the tensile strength nor with its weight.

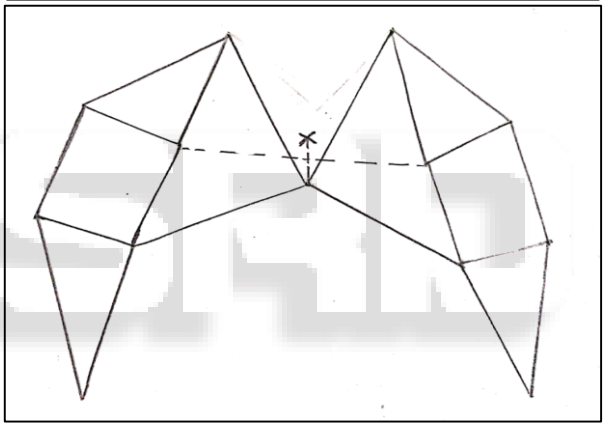
C. Round Surface

The surface which is in contact with the ground should be round as shown in the figure below in order to enlarge the area in contact between the bars and the ground.









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