Walking Mechanism of Robot

Mr. Prashant Chavan[1] Mr. Suraj Nalawade[2] Mr. Mayur Kadlag[3] Mr. Sachin Lahane[4] Abhijeet Chavan[5]
[1,2,3,4]Student [5]Assistant Professor
[1,2,3,4,5]Universal College of Engineering and Research, Sasewadi, Pune

Abstract— 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. 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 mechanical spider. It would perform very well as a platform with the ability to handle stairs and other obstacles to wheeled or tracked vehicle.

Key words: Klann mechanism, walking robot, planar mechanisms

I. Introduction

In comparison with the industrial manipulators, the task of building an adaptable, autonomous walking machine is more difficult. Walking machines have more active degrees of freedom (DOF) than industrial robots. To enlarge the work-space of the legend, and thus enhance the machine's ability to adapt to the terrain, each leg should have at least 3 DOF, which results in a total of 12 DOF for a quadruped or 18 DOF for a hexapod. All those joints must be controlled adequately in real time. This also means that the hardware and software systems must meet more critical requirements than those formulated for industrial robot controllers. Moreover, fully autonomous vehicles use only on-board controllers and so those controllers have to be miniaturized to an utmost extent. Mechanical structure of a walking machine should not only imitate the leg structure of living creatures (e.g., insects, spiders), but should also take into account the actuating systems properties (e.g., size, weight and power of the motors) and constraints (e.g., size of the body and the leg work-space). The need for a general solution to the problem of robot legs design that can be used either by two-, four- or six-legged or eight leg vehicles, is clear.

However the ability to meet this need has been hampered by the lack of adequate joint mechanisms and controls. Joint technology is a key problem in the development of such vehicles, because hip and ankle joints require, at a minimum, pitch and yaw motion about a common center with remote location of actuation sources analogous to our muscles and joints. The lack of simple, compact, cost-effective and reliable actuator packages has also been a major stumbling block in current designs. Ineffective joint design leads to unwieldy vehicles that compensate for the instability of their simple joints by means of additional legs. Following subjects are found important to study the leg mechanism.

1) Effectiveness of leg joints relating to the walking.
2) Locations of leg joints.
3) Movable extent of leg joints.
4) Dimension, weight and center of gravity of a leg.
5) Torque placed on leg joints during the walking.
6) Sensors relating to the walking.
7) Grounding impact on leg joints during the walking.

II. Literature Review

A. 1878-'Edward Muybridge'

The scientific study of legged locomotion began just very a century ago when Leland Stanford, then governor of California, commissioned Edward Muybridge to find out whether or not a trotting horse left the ground with all four feet at the same time. Stanford had wagered that it never did. After Muybridge proved him wrong with a set of stop motion photographs that appeared in Scientific American in 1878, Muybridge went on to document the walking and running behavior of over 40 mammals, including humans. His photographic data are still of considerable value and survive as a landmark in locomotion research. The study of machines that walk also had its origin in Muybridge's time. An early walking model appeared in about. It used a linkage to move the body along a straight horizontal path while the feet moved up and down to exchange support during stepping

B. 1950-'Chebyshev'

The linkage was originally designed by the famous Russian mathematician Chebyshev some years earlier. During the 80 or 90 years that followed, workers viewed the task of building walking machines as the task of designing linkages that would generate suitable stepping motions when driven by a source of power. Many designs were proposed but the performance of such machines was limited by their fixed patterns of motion, since they could not adjust to variations in the terrain by placing the feet on the best footholds. By the late 1950‟s, it had become clear that linkages providing fixed motion would not suffice and that useful walking machines would need control.

C. 1960-'Ralph Mosher'

By the late 1950‟s, it had become clear that linkages providing fixed motion would not suffice and that useful walking machines would need control. One approach to control was to harness a human. Ralph Mosher used this approach in building a four-legged walking truck at General Electric in the mid-1960s.The project was part of a decade-long campaign to build advanced operators, capable of providing better dexterity through high-fidelity force feedback. The machine Mosher built stood 11 feet tall, weighed 3000 pounds, and was powered hydraulically. Each of the driver's limbs was connected to a handle or pedal that controlled one of the truck's four legs. Whenever the driver caused a truck leg to push against an obstacle, force feedback let the driver feel the obstacle as though it were his or her own arm or leg doing the pushing. After about 20 hours of training, Mosher was able to handle the machine with surprising agility. Films of the machine operating under his control show it ambling along at about 5 MPH, climbing a stack of railroad ties, pushing a foundered jeep out of the mud, and maneuvering a large drum onto some hooks. Despite its dependence on a well-trained human for control, this walking machine was a landmark in legged technology.

D. 1970-'Robert McGhee'

Computer control became an alternative to human control of legged vehicles in the 1970s. Robert McGhee's group at the Ohio State University was the first to use this approach successfully. In 1977 they built an insect like hexapod that could walk with a number of standard gaits, turn, walk sideways, and negotiate simple obstacles. The computer's primary task was to solve kinematic equations in order to coordinate the 18 electric motors driving the legs. This coordination ensured that the machine's center of mass stayed over the polygon of support provided by the feet while allowing the legs to sequence through a gait. The machine traveled quite slowly, covering several yards per minute. Force and visual sensing provide a measure of terrain accommodation in later developments. The hexapod provided McGhee with an excellent opportunity to pursue his earlier theoretical findings on the combinatorics and selection of gait .The group at Ohio State is currently building a much larger hexapod (about 3 tons), which is intended to operate on rough terrain with a high degree of autonomy . Garfunkel and his co-workers in the USSR built a machine with characteristics and performance quite similar to McGhee's at about the same time .It used a hybrid computer for control, with heavy use of analog computation for low-level functions. Hirose realized that linkage design and computer control were not mutually exclusive. His experience with clever and unusual mechanisms he had built seven kinds of mechanical snakes-led to a special leg that simplified the control of locomotion and could improve efficiency. The leg was a three dimensional pantograph that translated the motion of each actuator into a pure Cartesian translation of the foot. With the ability to generate x, y, and z translations of each foot by merely choosing an actuator, the control computer was freed from the arduous task of performing kinematic solutions. The mechanical linkage was actually helping to perform the calculations needed for locomotion. The linkage was efficient because the actuators performed only positive work in moving the body forward. Hirose used this leg design to build a small quadruped, about one yard long.

It was equipped with touch sensors on each foot and an oil-damped pendulum attached to the body. Simple algorithms used the sensors to control the actions of the feet. For cleared the obstacle, the cycle would repeat. The use instance, if a touch sensor indicated contact while of several simple algorithms like this one permitted the foot was moving forward, the leg would move Heroes' machine to climb up and down stairs and to backward a little bit, move upward a little bit, then negotiate other obstacles without human intervention resume its forward motion, if the foot had motion. Each differs in the details of construction and in the computing technology used for control, but shares a common approach to balance and stability. Enough feet are kept on the ground to guarantee a broad base of support at all times, and the body and legs move to keep the center of mass over this broad support base. The forward velocity is kept sufficiently low so that stored energy need not be figured into the stability calculation. Each of these machines has been used to study rough terrain locomotion in the laboratory through experiments on terrain sensing, gait selection and selection of foothold sequences.

III. OBJECTIVE

The final design of this new walking machine is intended for transport service across rough terrain. It should be large enough to carry a significant payload, of some tons. It should be capable of operating without roads, and should be self-sufficient with respect to motive power. The envisaged operating environment would be somewhat flat land, such as open bush country, or light forest. It should be capable of ascending and descending slopes of up to 400, and should be sufficiently maneuverable to avoid large obstacles. It should be able to move at reasonable walking speeds, up to 50 kilometers per hour and have a useable range of several hundred kilometers before refueling. It should be robust, simple and easy to maintain. Complex parts that cannot be repaired in the field should be minimized. The two legs in Klann linkage coupled together at the crank can act as a wheel replacement and provide vehicles with greater ability to handle obstacles and travel across uneven terrain while providing a smooth ride This linkage could be utilized almost anywhere a wheel is employed from small wind-up toys to large vehicles capable of transporting people. Initially the linkage was called spider bike but applications for this linkage have expanded well beyond the initial design purpose of a human-powered walking machine.

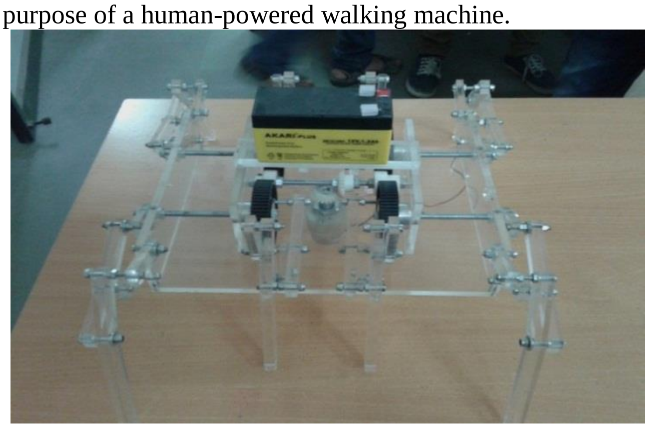

Fig. 1: Eight leg mechanism of walking robot

IV. METHODOLOGY

A. Walking Mechanism

Nature has always chosen legs as the best mode of locomotion so using linkages we tried to mimic nature and come up with certain walking mechanism which will suite all terrain. After reviewing certain mechanisms we came across two of them which proved to be more efficient.

B. Klann Mechanism

The Klann linkage was developed by Joe Klann in 1994.This mechanism is a planar mechanism designed in such a way that it mimics the walking of a crab and acts as a replacement for modern day wheels. The linkage consists of a fixed frame, a crank and 2 rockers all connected using pivot joints. The linkage provides many benefits over standard locomotive vehicles. Below is the pictorial representation of the Klann mechanism.

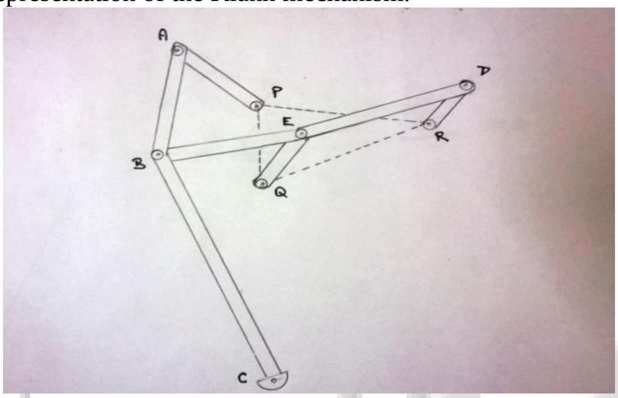

Fig. 2: klann mechanism

C. The Jansen Mechanism

Using eleven small rods, Dutch kinetic sculptor Theo Jansen has created a planar mechanism that, when used in tandem with many others identical to it, can walk in a smooth forward motion. The resulting device has a very organic look, much like a creeping animal. His "beasts" have been made to be wind powered, using a combination of wind sails and empty plastic bottles that can be pumped up to high pressures.

Fig. 3:Jasen Mechanism

V. WORKING

The Klann linkage is a planar mechanism designed to simulate the gait of legged animal and function as a wheel replacement. The linkage consists of the frame, a crank, two grounded rockers, and two couplers all connected by pivot joints.

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.

The Klann linkage 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 actuator mechanisms. It fits into the technological space between these walking devices and axle-driven wheels.

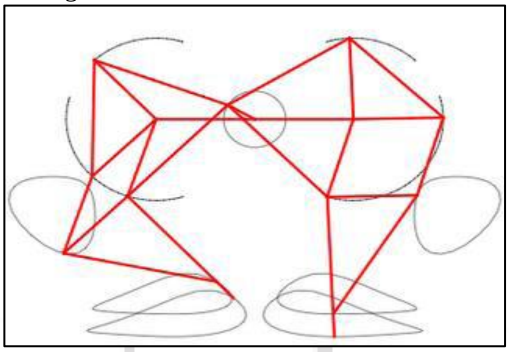

Fig. 5: Planer Mechanism

VI. MANUFACTURING PROCESS

We first find a specific motor for this project & collect its specification. The motor is main part of machine. The legs &wheels are connect to the motor shaft. In this project motor is is used 1.2v, 30rpm.

1) The motor fitted in between middle of Klann with spure gear. This spure gear is connected to another spure gear. the another spure gear is mounted on shaft with nut fitting. the shaft is nut and both side of nut are attached to acrylic body.
2) Before attaching to acrylic body 2 spure gear are attached on both side & this gear are connect with two side wheels.
3) The middle leg front and back side are connect to the one side of wheel and body. the other four legs are connect to the middle of wheel and body.

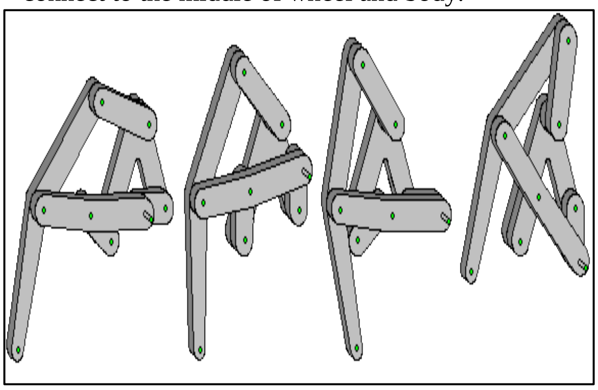

Fig. 6: Mechanical linkage

These figures show a single linkage in the fully extended, mid-stride, retracted, and lifted positions of the walking cycle. These four figures show the crank (rightmost link in the first figure on the left with the extended pin) in the 0, 90, 180, and 270 degree positions. My inspiration for this project is that we have wanted to make a machine that would move with legs instead of wheels for a very long time. With this final fab lab project we finally got the chance to do that. Our first efforts to create this were to find out the right dimensions for the legs of the robot. We did this by searching on Google for Klann Linkage dimensions. This is the pictures that we used throughout our project to create the linkage.

our first step was to laser cut out on acrylic material of each leg and creates a very rough test of the leg to make sure that the dimensions we had were correct and to make sure it seemed like this was possible. We used fevistick to hold each piece in place when we made our acrylic model of the leg. It looked like this.

we wanted to print off the legs on the 3D printer so that they would be more solid and more likely to stay together than the acrylic model we had made before. The problem was we had to design tabs on each piece of the leg so that the pieces would be able to be connected, but still allowed to freely rotate. On each piece we used the exact same dimensions for the tabs as the dimensions below. For each hole we used the exact same dimensions as below as well. On a few pieces there was slight deviation from the dimensions below, but we will state them when they come up. This is the dimensions of the tabs. we put either a tab or a hole at the exact corrects lengths in the original drawing we took our dimensions from, and then built around those pieces to make each piece functional. This is the dimensions for the tab and the hole that goes around the tab. we created each piece separately and then assembled them all together as an assembly in solid works and made an .STL file from there. Here are the dimensions of each piece.

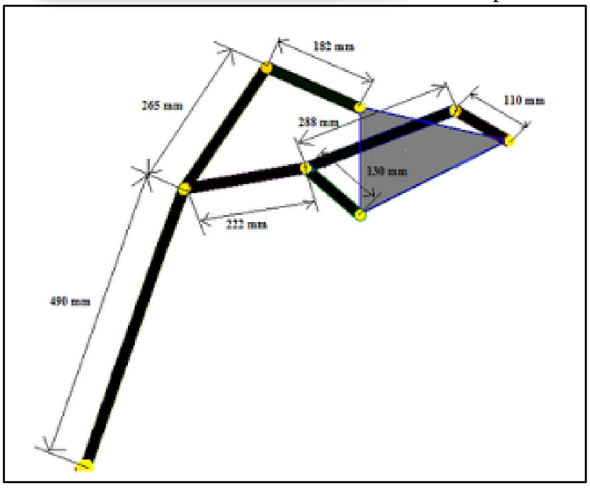

Fig. 7: Linkage Dimensions

The length of each piece is scaled down by a factor of 10 from the dimensions found above. This was because if I followed the dimensions exactly above the whole leg would be too big to be able to print inside the 3D printer.

We also had to make the triangle base that the pieces would connect to. It is very important that this triangle is exactly how the dimensions as stated in the above picture for the triangle, otherwise the whole leg will not function properly.

The only hole in that piece is there because wear going to make an axle that slides through that hole and connects it to the 11mm piece that is supposed to spin on the leg. This is the only way we could come up with so that we could spin two legs completely in sync, and still be able to print the legs separately from the body of my machine.

The first run through making the legs we made the piece that was 11mm long a circle because that is the piece that needs to spin in a circle for the leg to walk properly. However after printing out the leg we realized that we could not use a circle because its shape makes it interfere with other pieces of the leg and the leg couldn't walk. So we went back into Solid works and made the 11mm piece the way that it should be so it would not interfere. Here is what the leg with the circle looks like.

Fig. 8: Connecting linkages

After printing off the leg again and finding out we had a functioning leg. we made the body of the machine. we made 4 slots on the side of the body that were the same shape as the triangle base, but a little bigger so all 4 legs could fit in place where they needed to be so, we would not have a problem gluing them in later. We also made an even larger hole at the same spot where the smaller hole is in the triangle base. This large hole is so the axle of my machine can spin freely, but will not be able to be slid out. We will explain more with the dimensions of my axle below.

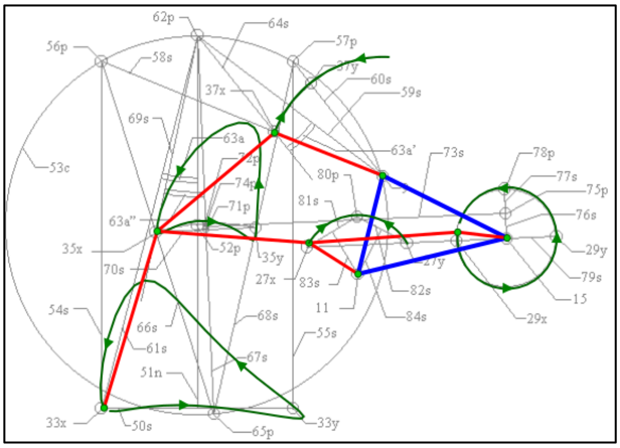

Fig. 9: motion of wheel

VII. CONCLUSION

In the present work we have consider a one-degree-of-freedom six-bar linkage Klann linkage. The optimum link length for the desired locus is calculated using genetic algorithm is also reported. The objective function namely path error i.e. offset to all the precision points is specified and tabulated.

From the above results the following conclusions are made

1) This thesis has succeeded in its objective of path synthesis of Klann mechanism.
2) This thesis explains how the optimized link lengths of Klann mechanism are derived using Genetic Algorithm for certain step length and step height.
3) Even though we obtained the locus with optimized link lengths there is a deviation of obtained locus from the desired locus due to non-consideration of some of the constraints like mechanical advantage of the linkage and flexibility effects can be also considered to get the accuracy.

VIII. FUTURE SCOPE

As in hybrid synthesis approach the same linkage may be adopted for both path synthesis and synthesis applications. The objective function should be modified so as to get a different optimum link dimensions. Finally, fabrication of the proto-type of linkage may be done to know the difference between theoretically obtained end point co-ordinates and actual values achieved A leg mechanical spider can be applicable for making of robots. It has a wide range of applications in the manufacturing of robots. A large version could use existing surveillance technology. By placing bomb detectors in the machines we can easily detect the bomb without harmful to humans. The objective of the Project is two make robots to step over curbs, climbs, stairs or travel into the areas which are currently not accessible with wheels.

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