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DESIGN AND ANALYSIS OF SIX PAIR LEG 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.*

I INTRODUCTION

Since time unknown, man's fascination towards super-fast mobility has been unquestionable. His never ending quest towards lightning fast travel has gained pace over the past few decades. Now, with every passing day, man is capable of covering longer distances in relatively shorter duration of time. Today's automobiles are beasts on wheels which are designed for speed and comfort. However, most of today's automobiles are limited to roads or plain terrains. Even the off-road vehicles are of no use when the land is too rough. Needless to say, no vehicle can climb mountains. This is because all automobiles depend on rubber wheels which fare better only on roads. Man, who himself depends, on legs can travel on rocky terrains and climb mountains, but such journeys are never comfortable. Thus naturally the solution can be seen as an automobile which rests on and moves with legs. Simple, it may sound but the problems in building a working model are many. The most troublesome part is powering the gait of the legs. Rotation of wheels in wheeled vehicles is powered by an engine or electric motors. Unlike wheels, legs move in an acute reciprocating movement. This is practically tough.This is where Klann Mechanism pitches in. It converts rotary action directly into linear movement of a legged animal. Vehicles using this mechanism can travel on any type of surface. Also, they do not require heavy investments in road infrastructure.

This project is useful in hazardous material handling, clearing minefields, or secures an area without putting anyone at risk .The military, Explosive Ordinance Disposal units, and security system 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.

A normal robot (or vehicle) can move only forward and backward direction. By using Klann Mechanism the vehicle can able to move in one plane along different direction. The movement of the kinematic linkage is done by the use of electric motors.

II LITERATURE SURVEY

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. 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.

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.

Normally six bar mechanism is chosen for moving leg robot because of its superior force transmission angle and bigger oscillating angle in comparison with other types such as the four-bar mechanism. Force transmission is very important for leg mechanisms, because of the point contact with the ground. The leg mechanism itself has one DOF for lifting, whilst the base of mechanism has another DOF for swinging. The body size and link dimensions are determined from the maximum swing and lift angles. Each link is created by entering its shape and reference coordinates. To mate the contact surfaces of the parts, the assembly bar of the assembly mating menu is used. Then the component is rotated around an axis, specifying the desired axis and rotation for the selected surfaces.

Gabriel Martin Nelson, in his report titled Learning about Control of Legged Locomotion using a Hexapod Robot with Compliant Pneumatic actuators; he describes efforts to get a biologically-inspired hexapod robot, Robot III, to walk. Robot III is a pneumatically actuated robot that is a scaled-up model of the Blaberus discoidalis (cockroach). It uses three-way solenoid valves, driven with Pulse-Width-Modulation, and off-theshelf pneumatic cylinders to actuate its 24 degrees of freedom. Single-turn potentiometers and strain gage load cells provide joint angle and three axis foot force sensing respectively.

Summary of Literature Review: Literature review reveals that legged robots have ability to access places which are impossible for wheeled robots. By copying to the physical structure of legged animals, it may be possible to improve the performance of the mobile robots. By implementing relevant biological concepts in the design, more stable and aster walking robots could be developed. Based on the results of literature review, an attempt is made in this project to develop a six legged mobile robot.

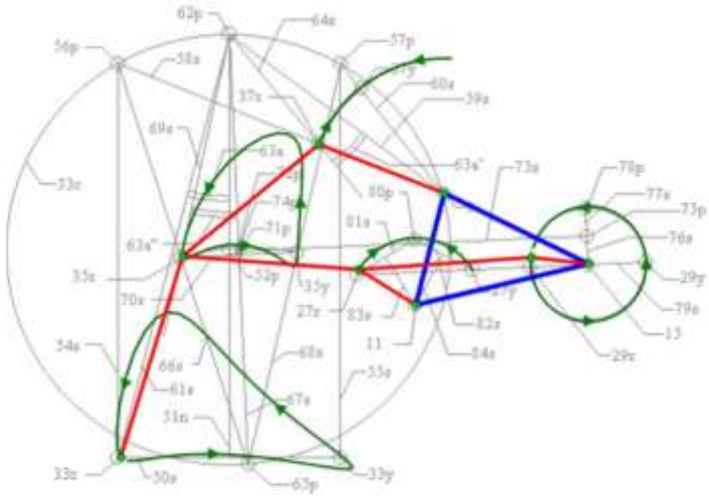
III OBJECTIVE & METHODOLOGY

Our project, “Design and Fabrication of Mechanical Mover using Klann Mechanism”, is to demonstrate the working of Klann Mechanism through a simple walking robot. A normal robot (or vehicle) can move only forward and backward direction. By using Klann Mechanism the vehicle can able to move in one plane along different direction. The movement of the kinematic linkage is done by the use of electric motors.

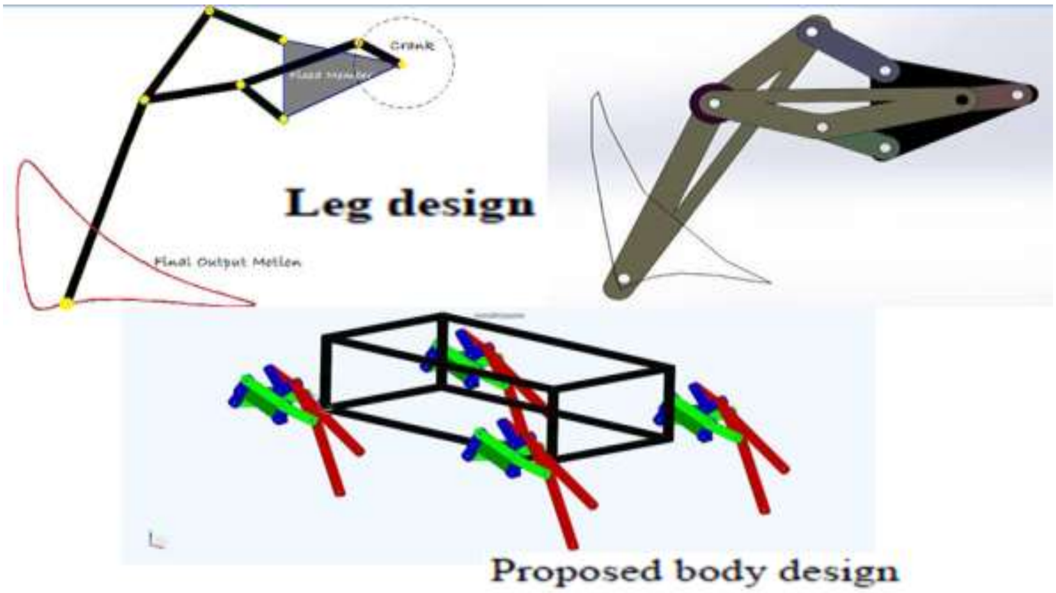
Literature review reveals that the main concern with the moving leg mechanism is the number of links involved in the design of the structure, since the numbers of links are more it is very tedious to design and operate. For the machine to move in a smooth manner the dimensions of the pieces should precise. More priority should be given to the position of the holes to be drilled since the movement depends on the amount of power or motion which is transferred to the locomotive parts respective to the position of the drills. The key to success for this mechanism is for the designer to make it locomotive even in the roughest of terrains thus the legs form an integral part and should be designed more cautiously. An objective is set to develop a six- legged mobile robot in this project.

IV DESIGN AND CALCULATION

Klann Mechanism has a patented procedure for calculation. The procedure is a complex graphical method. The process for geometrically determining the positions necessary to construct a single leg includes 6 input variables. This process is described as follows:



The length of the stride is selected as one unit and is represented by a horizontal line segment 50s. The left endpoint 33x of this line segment represents the foot 33 when the device is fully extended in the grounded stride position. The remaining endpoint 33y represents the foot 33 at the end of the grounded gait position. A line 51n is drawn perpendicular to and centred on line 50s. Point 52p is located on this line a given distance above 50s (input 1). A circle 53c is drawn centred at 52p. The radius of the circle is greater than one half of the stride length. This radius is input 2. Point 62p is located at the intersection of line 51n and circle 53c. A vertical line 54s is drawn from point 33x. Another vertical line 55s is drawn from point 33y. The intersections of these two lines and the upper half of circle 53c form the points 56p and 57p, respectively.



V ANALYSIS OF POSITION, VELOCITY, ACCELERATION

The optimized Klann linkage mechanism and numbering system are shown in the figure below. The linkage lengths were taken directly from Klann's book The Great Pretender. The black squares at points 0 ,1 and 2 in the diagram indicate to location of fixed points in the linkage. Point 0 is the crank axis and maintains a constant relative position to point 4 throughout the locomotive cycle. In this analysis I will point 0 at the origin .

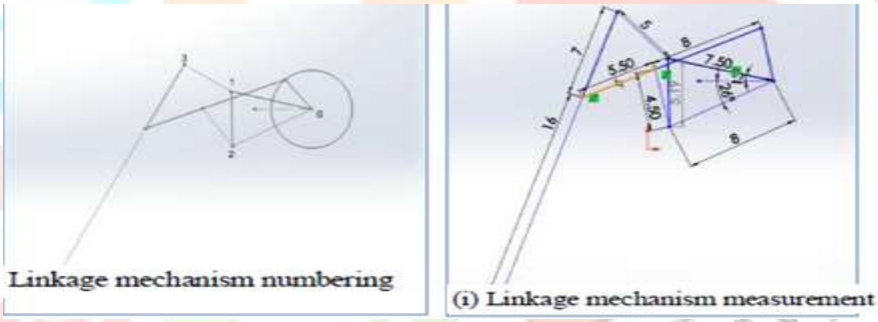


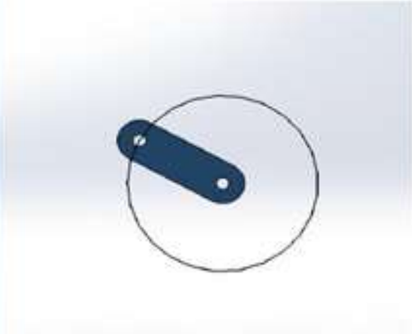
Diagram of Klann linkage mechanism showing numbering system and optimized linkage lengths to be used later in this analysis. In this paper hinge 0 may be called "the crank" and hinge 3 may be called "the foot." Hinges 0 , 1 and 2 have fixed positions relative to each other for the entire locomotive cycle; the convention in this analysis will be fix hinge 0 at the origin and hinge 1 and 2.

The position of hinges 0, 1, 2, and 3 equally spaced time intervals spanning an entire locomotive cycle hinges 0,1 and 2 were omitted because they have fixed positions in this reference frame. Since I have used equally spaced time steps to plot the position of the hinges, you can identify periods of relatively high and relatively low velocities by noticing the spacing between adjacent points in the plot. By inspection, you can see that the angular velocity of the crank is constant; this will be the convention throughout this analysis. You can also see in the "Position of foot" plot that the support phase of the Klann linkage mechanism has near constant velocity; this will be evaluated further later on in this analysis.


(ii) Position of rocker


(iii) Position of connecting rod


(iv) Position of leg


(v) Position of crank

VI CONCLUSION

This project can step over curbs, climb stairs, or travel into an area that are currently not accessible with wheels but does not require microprocessor control or multitudes of actuator mechanisms. It would be difficult to compete with the efficiency of a wheel on smooth hard surfaces but as conditions increase rolling friction, this linkage becomes more viable and wheels of similar size cannot handle obstacles that this linkage is capable of. Pivoting suspension arms could be used to optimize, Thus, all the principles and mechanisms involved in a walking robot using are studied and the practical difficulties in fabrication of a working model are understood. If implemented properly, automobiles moving on legs using Klann Mechanism have the potential to change mobility as we know it.

Future scope: This mechanism can be made more flexible by using different link lengths for front, middle and hind legs. Intelligence can be induced by introducing Sensors and vision to improve the effectiveness of this robot in future. Ranges of motion and moments available at each joint are the greatest concern as it is important for achieving stance and insect like walking.

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