Design & Development of Legged Quadruped Robots for Uneven Surface Locomotion (DESOBOTS)

Khalid Siddiqui1 Umang P. Joshi2 Aniket K. Randeria3 Vishal U. Tiwari4 Rahul R. Tiwari5

1Professor 2,3,4,5Student

1,2,3,4,5Department of Mechanical Engineering

Shankersinh Vaghela Bapu Institute of Technology, Vasan, Gandhinagar, Gujarat, India

Abstract—Since the ancient era, humans are using circular wheels for land locomotion. However, this mode of transportation seems inefficient on uneven surfaces and loose grounds like deserts. Though, advancements have helped to increase the feasibility but not up to a great extent. This paper depicts the designing of an innovative approach to vehicles that may easily maneuver on the abnormal terrains. For instance, we focused on ‘Desert lands’. The core objective of the Desobot is to provide comfortable and cheap ferry for travelers. Aside of this basic function, it may also serve as a tourist attraction; an asset for tourist agencies. The Gradual design iterations are also contained in the paper. Advanced CAD tool like PTC Creo and linkage 2.0 are used to enhance the visual and dimensional aesthetics.

Key words: Klann’s Linkage, Desert Movers, Legged Vehicles, Stability Configuration, Desert Locomotion

I. INTRODUCTION

World’s more than 20% land area is covered in sands. For desert travelers, Explorers, desert traders the biggest obstacle for travelling is the medium of transportation. Usually, they prefer camels because roads vehicles are not reliable for desert locomotion. But camels can travel for 30 to 40 km per day which consumes more time and also results in severe back pain. And the luggage weighing allowance is extremely limited.

The solution to this problem is our robots termed as “DESOBOTS”. Desobots are the legged robotic vehicle with linkage mechanism that can stride over uneven terrains.

Klann’s linkage is a planar mechanism designed to simulate the gait of legged animal and function as wheel replacement. It is one such mechanism which converts rotary motion into a replica of a legged animal. We have selected Klann’s Mechanism as the working linkage because it uses lower number of links and provides better strength than other similar linkages.

We modified the Klann’s linkage according to our need to attain stability. A Leg is designed with optimized dimensions using CAD software.

II. NOMENCLATURE OF KLANN’S LINKAGE

The Klann’s Linkage is a six link mechanism. It is given alias names according to their function in the mechanism just for ease.

Frame is the base that holds the pivot arm, Fulcrum arm and the Crank Gear. The main power input from the Motor is given to the Crank Gear that imparts rotary motion to the Supporting Arm.

The leg is attached with the Supporting Arm that results in the locomotion. To get the appropriate gait, Pivot arm and Fulcrum arm are provided. A foot is also attached in the bottom of the leg. All the arms (Links) are connected using pin joints. The Nomenclature is shown in Figure 1.

![Fig. 1: Nomenclature of the Klann’s Linkage](image)

The labels are as follows:
1) Frame Link
2) Crank Link
3) Supporting Link
4) Fulcrum
5) Leg (link)
6) Pivot Link

The gait is the output motion we receive from the foot of the mechanism. Consider fixing a pen on the foot and then starting the mechanism. The pen will move and draw a path. That path can be traced on a graph paper in order to get stride length and height (lift) of the leg in motion. Stride length and height or lift of the leg is shown in the figure 2.

![Fig. 2: Labeling the Gait of Mechanism](image)
III. OBJECTIVES FOR DESIGNING THE LEGS
This section lists out the design outputs of the Klann’s Linkage.
1) Maximising the Stride Length as much as possible
2) Optimizing the height or lift of the leg
3) Defining the link lengths in Linkage (2D)
4) Designing the 3D solid link shapes
5) Defining the link dimensions (3D)
6) Arranging the gait in order to get the Stabilized motion

IV. EVOLUTION OF KLANN’S LINKAGE (LEGS)
The final modified Klann’s linkage mechanism inspired legs were developed after numerous iterations. Some of the important iterations are depicted below. We used Linkage 2.0, open source software to analyze mechanical linkage system to design the linkages.

Fig. 3: Original Klann’s Mechanism
This mechanism is developed by Sir Klann for the purpose known to their time. But our application seeks different configurations. Hence, we started modifying the links using the above original linkage as the base. Figure 4 is the 1st modified Klann’s Linkage iteration.

The spotting feature in this modification is the slight symmetry attained on both the sides of maximum life. Also, the frame points are set to feasible locations. The angular displacement of the Pivot Arm is reduced. Yet the linkage needs optimization for dimensions. Figure 5 shows the modified Klann’s linkage iteration 7.2.

The frame points are changed in this linkage for aesthetic purposes. This also, resulted in increase of the displacement. Hence, the Gait is improved. But the Support Arm is inverted that results in decrease of strength. This motivated into development of the next iterations, Version 13.2 as shown in Figure 6.
when it moves. Figure 8, shows the 3D line diagram of a 4 legged (Quadruped) vehicle.

This is the reason we selected 4 equal interval points on the gait to attain tripod configuration at the base as shown in figure 9. When one leg will lift (Lifting Leg) the other three legs (Supporting Legs) will remain at the base to support the vehicle.

V. STABILITY CONFIGURATION

Our vehicle is a 4 legged vehicle. Hence, to attain stability we divided the gait into 4 points at equal interval, say A, B, C and D. The legs attain a triangular base (Tripod) at the base
VI. CAD MODEL OF DESOBOTS

![Fig. 11(a): CAD Model of One Leg of the Desobot](image1)

![Fig. 11(b): CAD Model of One Leg of the Desobot](image2)

The Computer Aided Design (CAD) model of the leg is shown in figure 11. The Crank Gear is shielded with cover to ensure safety. Also, fork suspensions are embedded in the legs to minimize the shocks and impact forces. The solid links are provided with round edges to improve its durability and ensure safety of users. Also, to imply camouflage of the vehicle with the desert it is provided with brownish tint.

VII. FUTURE SCOPE

This paper included the stability of the Klann’s linkage along with its optimization of shape and dimensions. This optimized linkage mechanism can be used as locomotion (Vehicle) in desert and semi-Arid Regions. Also, with change in the foot design this project can dig its way in the Snow locomotion and other off Road applications.

The Crank is imparted with the rotary motion from the motor gear. For non-environmental impact, we can use solar panels and other renewable sources of energy.

The Gearing arrangement is of the SPUR GEAR in this paper. For the future scope, helical gears can be used to transmit higher torque with minimal noise.

The project would be followed by a scaled prototype model.

VIII. CONCLUSION

In this research paper, we optimized the lengths of the Klann mechanism suitable for the locomotive application. First, we started with the modification of the Klann’s Linkage in order to get the best stabilized and optimally dimensioned linkage mechanism. The Gait, which is the parameter that dignifies the output of the mechanism, is also optimized with considering the Stride length and the lift of the leg. The 3D model of the linkage is also prepared keeping in mind aesthetics and overall output.

The research paper stated the stability of a quadruped (four legged) vehicle for the locomotion on uneven land forms like sands.

REFERENCES