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Six-Legged WI FI Surveillance Multi-Purpose Spider Using Klann Mechanism

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ABSTRACT:

This paper presents the design and implementation of a six-legged spider robot inspired by the Klann mechanism, which mimics the locomotion of legged animals for enhanced mobility on uneven terrains. The robot employs a mechanical linkage system to convert rotary motion into walking motion, eliminating the need for complex microprocessors or actuators. The system is powered by a DC motor and integrates WiFi for remote surveillance and control, making it suitable for applications such as search and rescue, military reconnaissance, and industrial inspections. Experimental results demonstrate the robot's ability to traverse obstacles, climb stairs, and operate in hazardous environments. The project highlights the advantages of legged locomotion over wheeled systems in rough terrains and proposes future enhancements for intelligent autonomous operation.

KEYWORDS:

Klann Mechanism, Six-Legged Robot, Legge Locomotion, WiFi Surveillance, Search and Rescue, Remote Control.

1. LITERATURE SURVEY :

Swadhin Patnaik: Its comparative advantage over Wheel Based Mine Escavation system he says that I decided to implement linkage based locomotive system on standard load carrying tippers and trucks as a replacement for the conventional tyres. The first mechanism which actually mimics the motion of the biological organism Amanda Ghassae: The design and optimization of a crank-Based Leg Mechanism he says that this paper describes the design and fabrication process of a 2n-legged passive walker based on the primary focus of this paper is the design of a crank-based leg linkage Mano Raja

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Paul M : Klann's Mechanism Held Tele robot With Security Systems the PIR senses the human body the sensor transmits a triggering signal to the raspberry pi, which in turn triggers the face detection camera installed in the spider robot. Kazuma Komoda and Hiroaki Wagatsuma: A proposal of the extended mechanism for linkage to modify the walking elliptic orbit and a study of cyclic base function he says that in the present study, we proposed an extention mechanism of the linkage to generate various walking patterns. The advantage of the linkage is that the best properties of link length provides a smooth locomotive legs movement like animal gaits with a sharp-pointed elliptic orbit while the disadvantage is less flexibility to change the orbit without any change of link lengths. Legged robotics has roots in the studies of Muybridge and the engineering advancements of Hirose and McGhee. These efforts laid the foundation for robotic motion inspired by biology, emphasizing kinematics, gait planning, and control systems. The Klann linkage stands out for its simplicity and ability to generate lifelike gait patterns using minimal actuation.

1.1Muybridge and the Study of Animal Motion

The early scientific exploration of locomotion began with Eadweard Muybridge in the late 19th century. His high-speed photography work, which captured the motion of galloping horses and other animals, played a critical role in understanding how limbs move during different gaits. Muybridge's images allowed scientists and engineers to analyze real-world movement frame by frame, laying the groundwork for bio inspired robotic designs. Although he did not work directly in robotics, his studies helped define natural gait cycles that would be mimicked in mechanical walkers for decades to come.

1.2 McGhee's Hexapod and Static Stability

In 1977, Robert McGhee and his team at Ohio State University developed one of the first computer-controlled six-legged robots— known as a hexapod. This robot showcased static walking stability, where three or more legs are always in contact with the ground to prevent tipping. It incorporated complex kinematic models and algorithms to manage 18 actuators (three per leg), enabling it to move with coordinated gait sequences such as tripod, ripple, and wave gaits.

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McGhee's contributions emphasized:

- Gait planning
- Stability analysis
- Feedback-based motion control

These elements became standard in the design of legged robots moving forward. His work demonstrated how robotic systems could maintain balance and walk autonomously over variable terrain using real-time calculations.

1.3 Klann Mechanism: Mechanical Simplicity Functionality:

1994, Joe Klann introduced a game changing innovation—the Klann linkage. This mechanism is a six-bar linkage system that converts the rotary motion of a crankshaft into a walking motion. Each leg follows a trajectory that approximates that of biological limbs, enabling a robot to walk without requiring complex control systems or sensors. Unlike McGhee's or Hirose's robots, the Klann mechanism: • Requires only a single rotary input per side • Is purely mechanical, with no need for electronics • Can step over obstacles, curbs, and uneven terrain • Offers low cost, high-durability solutions for hostile environments The Klann mechanism has become popular in applications such as search-and-rescue, mine detection, and terrain exploration, where mechanical simplicity and robustness are prioritized over adaptability and learning.

2. INTRODUCTION:

The main purpose 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. A leg mechanism (walking mechanism) is an assembly of links and

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joints intended to simulate the walking motion of humans or animals. Mechanical legs 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. 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. 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 Zsame time. The 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.

The Klann mechanism is a specialized type of linkage system that replicates the motion of walking legs using only mechanical components. It combines a four-bar linkage and a crank rocker mechanism to guide each leg through a specific walking pattern. The core idea is to convert the rotational motion of a motor into a precise, repeatable stepping motion—all without using sensors or complex control algorithms. At the heart of the system is a crank, usually driven by a motor. This crank connects to several interlinked rigid bars, which form a closed mechanical loop. As the crank rotates, it moves these links in a coordinated fashion, causing the leg's foot to follow a two-phase motion path: 1. Stance Phase – The foot moves in a nearly straight, horizontal line, in contact with the ground. This is when the robot pushes itself forward. 2. Swing Phase – The foot lifts off the ground and arcs backward and upward, resetting for the next step. This mechanical motion mimics how biological legs function during walking, lifting and placing each foot with purpose and direction. In 1878 the Edward Muybridge discuss the logical

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investigation of a legged movement started simply exceptionally a century prior when Leland Stanford, at that point legislative leader of California appointed Edward Muybridge to see if or not a jogging horse left the ground with every one of the four in the meantime. 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. Since the time of commercial revolution, mining has been an important and financial base of any running industry. With growing need of manufactured products, the necessity of raw material has increased substantially.

3. OBJECTIVES:

This six-legged robot uses Klann mechanisms for locomotion and WiFi remote control for surveillance applications. The design focuses on:

- Mechanical stability through tripod gait walking
- Terrain surfaces adaptability for uneven
- Remote operation with live video feed

Key Specifications

3.1 Mechanical Implementation

3.1.1 Leg Mechanism

- Each leg uses a modified Klann linkage with:

Component	Details
Locomotion	6 Klann linkage legs (2 sets of 3 synchronized legs)
Power	12V DC motor + LiPo battery

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Control	ESP32 WiFi module for wireless communication
Payload	Onboard camera (720p) + sensors
Materials	3D-printed PLA linkages + aluminum frame

o 25cm leg length o 120° phase offset between adjacent legs o 4cm ground clearance in swing phase

• Synchronized motion through chain/sprocket drive system:

o Single motor drives all six legs o Three legs always in ground contact (tripod gait)

Chassis Design

• Hexagonal aluminum frame

• Low center of gravity for stability

• Modular design for easy maintenance

3.2 Electronic Systems

Control Architecture

Copy

```
[Smartphone App] ← WiFi → [ESP32] → [Motor
Driver] → [DC Motor] → [Camera Module]
```

Key Components

1. ESP32 Microcontroller o Manages WiFi communication o Processes control commands o Handles video streaming

2. Motor Control o L298N dual H-bridge driver o PWM speed control o Direction reversal capability

3. Surveillance System

o ESP32-CAM module o 720p resolution o Low-latency MJPG streaming

4. Software Implementation Control Interface

• Android/iOS app features:

o Joystick for direction control o Speed adjustment slider o Live video display o Manual gait adjustment

Gait Algorithm python Copy

def tripod_gait(): while True:

#Legs 1,3,5 move forward move_group_A_forward() # Legs 2,4,6

provide support hold_group_B() delay(step_time) # Alternate groups

move_group_B_forward() hold_group_A() delay(step_time)

3.3 Applications

1. Disaster Response

o Rubble navigation o Victim detection

2. Industrial Inspection

o Confined space access o Hazardous environment monitoring

3. Military Reconnaissance

o Silent operation o Night vision capability

3.4 Future Enhancements

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- Add LIDAR for autonomous navigation
- Implement solar charging

4. **METHODOLOGY:**

4.1 Hardware Design

4.1.1 Leg Linkage System

• Six-bar linkage configuration per leg (2 legs per side, 6 total) Component breakdown: Input crank: 40mm radius, connects to motor shaft

o Connecting rod: length, transfers motion to leg o Rocker arm: 80mm length, controls foot trajectory o Foot linkage: 150mm effective length with rubberized tip

• Material: Laser-cut 3mm mild steel plates

• Joint specification: o M3 shoulder bolts with nylon lock nuts o Oil-impregnated bushings o 0.1mm machining tolerance for smooth motion supply is a supply of electrical power.

4.2 Motion Transmission

• Sprocket ratio: 15T motor to 60T axle (1:4 reduction)

• Chain: #25 roller chain, 18" loop per side

• Synchronization:

o Phase difference: 120° between adjacent legs

4.3 Frame Construction

• Chassis: 2mm mild steel hexagonal frame o Dimensions: 400mm across flats o Weight: 2.3kg (without payload) o Laser-cut and MIG welded joints

• Mounting points:

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o 6x M4 tapped holes per leg mechanism o Vibration-damping neoprene pads o Modular design for quick leg replacement

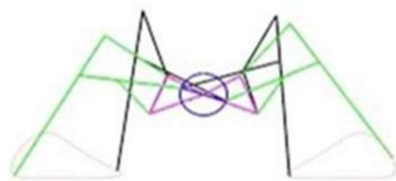

Figure 1: Planar Mechanism of Klann's Mechanism

4.4 Electronics Integration

4.4.1 WiFi Control System

• Main controller: ESP32-WROOM 32D o Dual-core 240MHz processor o Integrated 802.11 b/g/n WiFi o 16MB flash memory • Peripheral connections:

o Motor driver: L298N with heatsink o Camera: OV2640 module ESP32-CAM

o Voltage regulator: LM2596 buck converter (12V→5V)

4.4.2 Power Distribution

• Battery: 3S LiPo 5000mAh

o Main power bus: 12AWG silicone wires o Emergency cutoff switch

o Battery circuit monitoring

• Current requirements: o Motors: 3A peak o Electronics:1A continuous o Total runtime: ~2 hours

5. CONCLUSIONE:

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- The Klann's Linkage Demonstrates an Exceptional Use of a Combination of Four-bar Linkages Using One Motor to Move the Entire Leg. It is done to make the legs on 3D printer of using references of different journals on available of .stl files Firstly, installing (assembling) pieces properly and that gives real robot form with a note equilibrium of the robot Then, we creating the axis of robot that help the link to make they look similar to the one robot. In modulating the servo Motors makes them were orbiting a full 360 degrees and then was linked to main axis. After that, we connect the Bluetooth to our workshop to be able to control the robot through the mobile app. Then, we connect the wires and complete the link of components with Arduino

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