Stair Climbing Robot

Mechanism used:

Hybrid (Tracked Base + Two Tyred Legs)

The robot employs a **hybrid mechanism** combining a **central tracked system** with two **articulated wheel-mounted legs**—one at the front and one at the rear. These legs operate like hydraulic arms in a **JCB backhoe loader**, providing **lift, push, and balance** to enable the robot to scale stairs, uneven terrain, or obstacles.

1. **Tracked Base** provides strong **traction and stability** on flat, inclined, or uneven surfaces. Tracks offer a larger contact area, reducing slippage while climbing stairs
2. **Articulated Legs with Tyres** allow the robot to:

⇨ Push itself up each stair (front leg lift)
⇨ Stabilize or provide assistive thrust (rear leg)
⇨ Act like outriggers to correct pitch and roll

3. This configuration replicates the **self-lifting** approach of construction machines, making it ideal for heavy-duty or rough environments.

Stability, Centre of Mass, and Power Requirements:

Stability:

- Robot uses a **tripod-like posture** during stair climbing: front leg in contact with the next stair, track base on current stair, rear leg stabilizing.
- **Wide track base** ensures lateral stability.
- Also to ensure stability during climbing **CoM** should be on the **straight line** joining front and rear leg.

Center of Mass (CoM):

- CoM is kept **low and centralized** by placing batteries and controllers in the lower chassis, close to the tracked base.

- The legs operate in a coordinated manner to shift CoM forward during ascent and backward during descent.

Power Requirements:

- **Tracked drive** uses **brushless DC motors with gear reduction** for high torque.
- **Legs** use **linear actuators** (or powerful servos) to push the robot vertically.
- Power sourced from a **Li-Po battery .**

Control Strategy and Sensors:

Sensors:

- **IMU**: Detects robot orientation, tilt, and acceleration.
- **Ultrasonic or IR sensors**: Detect step edges and stair depth.
- **Depth Camera**: Captures 3D stair geometry for adaptive planning.
- **Force/pressure sensors** on legs: Verify contact before lift.
- **Motor encoders**: Track position of legs and track speed.

Control Logic:

  - Uses **depth camera** + **ultrasonic data** to create a map of the stair.
  - **Leg control logic** executes lift, lock, and push commands in a loop per step.
  - **PID Control System** ensures smooth, balanced movement.

Real-Time Stair Detection and Adaptive Motion:

⇨ **Stair detection** by the depth camera and ultrasonic sensors.

⇨ The system calculates:

Step height and depth
Angle of approach
Distance to next step

Motion planning:

⇨ The robot **extends its front leg**, lifts the front track section, and places it on the next step.

- ⇨ Once contact is confirmed (via pressure sensors), the track climbs forward.
- ⇨ The **rear leg pushes the base** or stabilizes it based on IMU feedback.