Design and Fabrication of Intelligent Autonomous Self-Lifting Stand for Two-Wheeler

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ABSTRACT
In order to increase rider convenience and safety, this study proposes the design and development of an intelligent autonomous self-lifting stand system for two-wheelers. The device autonomously deploys or retracts the side stand in response to vehicle tilt and safety circumstances using a servo motor, an Arduino Uno microprocessor, and an MPU6050 IMU sensor. By guaranteeing automated stand retraction while the vehicle is upright, the suggested technique lowers human error. For contemporary two-wheeler applications, experimental results demonstrate dependable performance, fast reaction times, and efficient automation.

Keywords — Autonomous self-lifting stand, Arduino Uno, IMU sensor, Servo motor control, Two-wheeler safety, Mechatronics system**.**

1. INTRODUCTION

Modern vehicle technology is increasingly relying on automation and intelligent control systems to improve consumer convenience, efficiency, and safety. Due to their cost and adaptability to different traffic situations, two-wheelers are frequently utilized for daily transportation, particularly in developing nations like India. Human error-related safety hazards are still a big worry, though. One frequent problem that can cause imbalance during turns and raise the danger of accidents is when riders fail to retract the side stand before driving the vehicle. The side stand on traditional two-wheelers is primarily operated manually, and while some more recent versions have warning systems, there are currently few fully automated options.

By combining embedded control and mechatronics, the suggested intelligent autonomous self-lifting stand system seeks to get over this restriction. An Arduino Uno microcontroller, a servo motor, and an MPU6050 IMU sensor are used in the system to automatically retract the stand and detect vehicle orientation. To guarantee dependable operation, other safety factors including rider presence and engine condition are taken into account. By automating the stand mechanism, the system improves safety, lessens reliance on humans, and offers a cost-effective solution that can be used with contemporary two-wheelers.

2. LITERATURE REVIEW

Through the world, two-wheelers are essential for personal mobility, particularly in emerging nations like India. However, when not used correctly, side stands and centre stands—which are necessary for stability when parked—frequently cause safety problems. Riders frequently cause accidents by failing to raise the stand before moving. Researchers have used electrical, pneumatic, and mechatronic systems to suggest a variety of automatic and semi-automatic stand mechanisms in order to solve this issue.

2.1. Review on Automated Stand Mechanism

2.1.1. Ashish Jyoti and Ajit Kumar (IJIES, 2017) designed and developed an Automatic Centre Stand for Two-Wheeler using a Linear actuator powered by the vehicle battery. Their work demonstrated a simple yet effective solution to lift heavy motorcycles with minimal human effort. They also suggested using limit switches to stop the actuator at end positions for safety.

2.1.2. Piyush Choudhary et al. (JETIR, 2020) in their paper Design and Analysis of Effortless Centre Stand for Two-Wheeler, developed a Pneumatic-powered stand system operated by a key switch. The pneumatic cylinder provided high lifting force and minimized strain on the rider. The researchers also analysed the static and dynamic stresses on the stand components using ANSYS simulation, confirming the mechanical reliability of their design.

2.1.3. Dr. T. Amuthan et al. (IRJMETS, 2025) presented an Automatic Centre Stand for Two-Wheelers that used a DC motor and gear mechanism to lift the centre stand automatically. The system reduced manual effort and improved stability on uneven surfaces. Their research highlighted the ergonomic challenges faced by riders—especially elderly and female users—in applying the centre stand, emphasizing the need for automation in motorcycle support mechanisms.

2.2. Sensor-Based Vehicle Stability and Control Studies

2.2.1. Qingyuan Zheng et al. (Actuators Journal, 2023) developed a reinforcement learning-based control system for single-track two-wheeled robots using IMU data and real-time feedback for balance control. Their work demonstrated the effectiveness of tilt-based sensing in maintaining stability on narrow terrains.

2.2.2. Feilong Jing et al. (Tsinghua University, 2025) in their paper Steady-State Drifting Equilibrium Analysis of Single-Track Two-Wheeled Robots explored the dynamic balance and control of single-track vehicles using IMU sensors and model predictive control (MPC). Their findings demonstrated how tilt angle data can be processed to maintain equilibrium — a concept closely related to our use of the IMU for detecting upright orientation before retracting the stand.

3. Proposed System and Methodology

3.1. System Overview

The proposed intelligent autonomous self-lifting stand system seeks to increase rider safety by independently controlling the two-wheeler side stand's deployment and retraction. Among the mechanical and electrical components integrated into the system are a servo motor, an Arduino Uno microcontroller, an MPU6050 IMU sensor, and input switches that signal safety circumstances. The Arduino is the core processing unit that receives real-time orientation data from the IMU sensor to determine if the vehicle is in a safe position for upright operation. The servo motor and stand are mechanically connected by a linkage mechanism for controlled movement.

3.2. Working Principle

Dependent logic control and tilt-angle detection are the foundations of the system's operation. The vehicle's orientation and tilt angle are continually monitored by the IMU sensor. The technology keeps the car in the stand position when it is parked or tilted past a certain point. The Arduino analyses the incoming signals and produces a PWM signal to turn on the servo motor once the car is upright and the necessary safety requirements are met. The platform is automatically retracted by the rotating servo motor, guaranteeing that the vehicle is prepared for safe transportation without the need for human assistance.

3.3. Control Logic

The control logic is built using embedded programming in the Arduino environment. After initializing the sensors, the system checks the input signals for rider presence and engine health. The IMU sensor's continuous angular data is contrasted with a present threshold value. If both safety inputs are activated and the tilt angle is within the safe range, the Arduino tells the servo motor to retract the stand. Otherwise, the mechanism remains inactive to prevent undesired movement. This logic ensures accurate, reliable, and safe automation of stand mechanisms.

4. Hardware Design

4.1. Arduino Uno

The central control unit of the suggested system is the Arduino Uno. It runs at 5V DC and is based on the ATmega328P microprocessor. In order to drive the servo motor, the board creates PWM output signals after processing input signals from switches and sensors. The Arduino Uno is frequently used in embedded and mechatronics applications because of its inexpensive cost, simplicity of programming, and dependable performance. By carrying out the preprogramed control logic, it serves as the primary decision-making element in this system.

4.2. IMU Sensor (MPU6050)

A three-axis accelerometer and a three-axis gyroscope are combined in the MPU6050, an inertial measurement unit. It is employed to instantly determine the two-wheeler's orientation and tilt angle. Using the I²C protocol, the sensor connects to the Arduino and delivers precise angular data that can be used to determine if the car is slanted or upright. To guarantee that the stand retracts only in safe working circumstances, this information is crucial.

4.3. Servo Motor

The actuator for the stand's actual physical movement is a servo motor. The Arduino generates PWM signals that drive the servo, which works between 0° and 180°. Automatic retraction is made possible when the servo is turned to a certain angle and pulls the linkage mechanism attached to the side stand. The servo motor offers enough torque for the necessary mechanical movement, smooth operation, and precise placement.

4.4. Push Button Inputs

The system has two push buttons to mimic safety scenarios including the presence of riders and the state of the engine. These buttons run at 5V DC and are connected to the Arduino's digital input ports. By ensuring that the stand retracts only in response to certain situations, the usage of these inputs improves safety by preventing accidental activation.

4.5. Jumper Wires

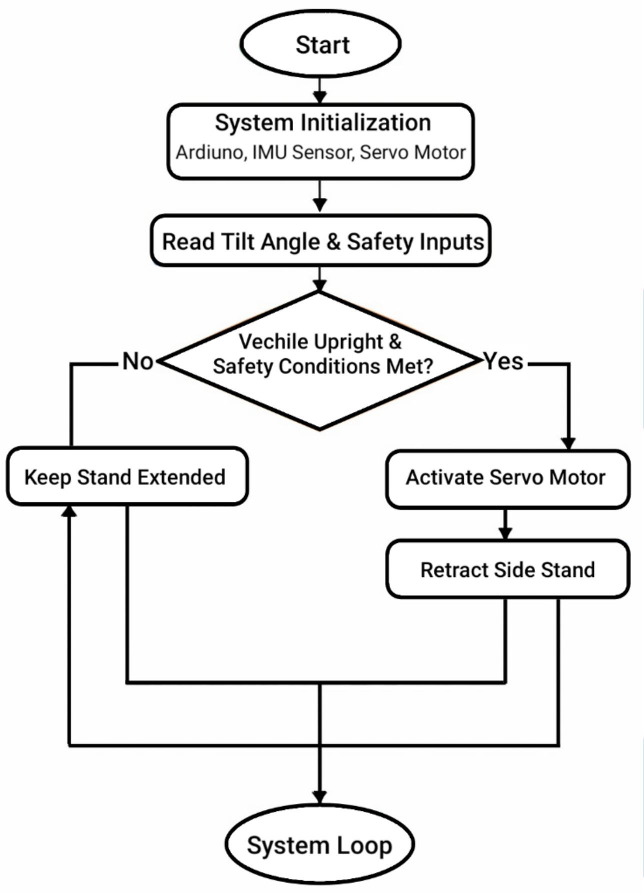
Electrical connections between the Arduino Uno and external parts such the servo motor, push buttons, and MPU6050 IMU sensor are made using jumper wires. These wires offer a dependable and adaptable way to prototype without the need for permanent soldering. Depending on the components' interface needs, several kinds of jumper wires are utilized, such as male-to-male, male-to-female, and female-to-female connections.

4.6. Power Supply

A controlled 5V DC supply is used to power the hardware parts. The Arduino, IMU sensor, and servo motor all operate steadily when the voltage is properly regulated. Accurate sensor readings and dependable actuator performance depend on a steady power source, which raises the system's overall efficiency.

5. SOFTWARE ALGORITHM

5.1. Flowchart of Operation



5.2. Arduino Programming Logic

The Arduino programming logic plays a major role in controlling the autonomous functioning of the suggested self-lifting stand system. The Arduino microcontroller is set up to continuously monitor sensor inputs, analyse decision-making scenarios, and control actuator movement based on current logic. The Arduino initializes all of the hardware, including the sensors, servo motor, and input/output ports, when the device initially powers up. To ensure accurate data, sensors such as tilt or position sensors are calibrated before entering the main execution loop.

While the vehicle is in motion, the Arduino determines its orientation and safety status using real-time sensor data. By comparing sensor data with present threshold conditions, the program decides whether the side stand should automatically retract or remain extended. If the Arduino determines that the car is upright and that all safety conditions are satisfied, it tells the servo motor to lift the stand. If not, the system maintains the status quo to prevent detrimental operations. The logic runs continuously in a loop thanks to automated control and monitoring, ensuring reliability, real-time responsiveness, and increased rider safety.

6. DESIGN OF STAND

The stand is a crucial part of the proposed autonomous self-lifting system as its design directly affects stability, reliability, and smooth operation. The stand's design provides sturdy support for the vehicle when it is stationary and enables automated withdrawal when the required safety conditions are fulfilled. The development of the mechanical structure takes into account elements like durability, balance, load distribution, and ease of mobility..

6.1. 2D Design

The basic structural organization and dimensions planning of the self-lifting mechanism are demonstrated by the stand's 2D design. The design uses front-view and side-view representations to accurately define the stand's shape, mounting location, and movement path. The 2D graphic helps see how the vehicle structure, servo motor connection, and stand align before the 3D model is created.

Fig. 6.1 shows the complex 2D arrangement of the stand mechanism, highlighting the structural dimensions and connecting locations required for proper functioning. This original concept serves as the foundation for the system's later 3D modeling and actual fabrication.

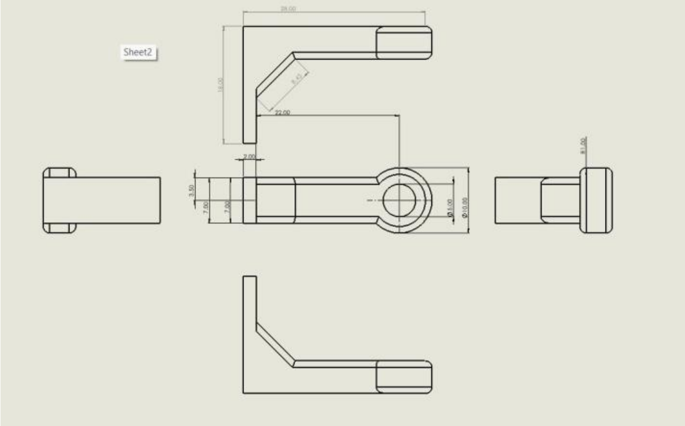
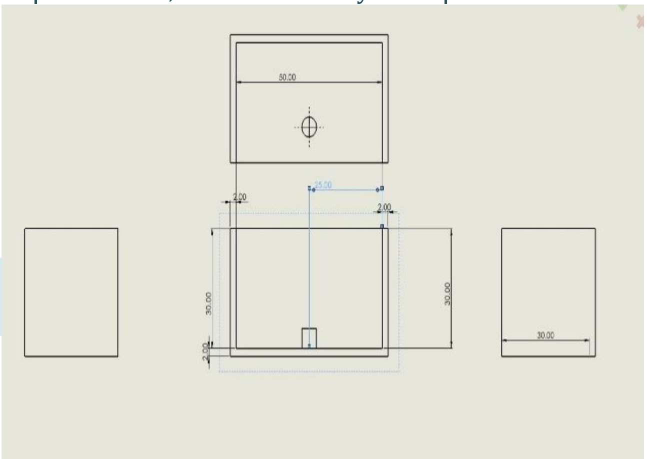



Fig.6.1

6.2. 3D Design

Using the conversion of the 2D plan into a comprehensive three-dimensional model, the stand's 3D design offers a thorough visual representation of the autonomous self-lifting mechanism. This design aids in comprehending the stand's movement dynamics, component integration, and structural arrangement within the larger system. The model enables precise depiction of the stand, servo motor, linkage system, and vehicle frame's dimensions, angles, and spatial relationships using CAD software.

The stand mechanism's whole 3D design is shown in Fig. 6.2, which also highlights the assembly structure and integration with electronic components. The suggested system can be implemented more effectively thanks to this modelling technique, which also increases design accuracy and lowers manufacturing mistakes.

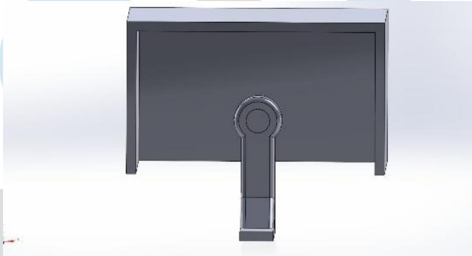


Fig.6.2

7. RESULTS AND DISCUSSION

Positive testing in a range of operating situations evaluated the autonomous self-lifting stand system's performance, reliability, and reaction time. The system correctly determined the car's orientation using the IMU sensor, and it didn't start stand retraction until the vehicle had straightened itself out. Experimental findings showed that the Arduino-based control logic accurately analysed tilt angle data and ensured that the servo motor engaged gradually without exhibiting unpredictable or sudden movements.

The system's operational status and experimental setup during testing are depicted in Fig. 7.1. The findings show that the technology enhances safety and dependability by preventing unintentional stand movement when the vehicle is unsteady. Sensors, jumper wire connections, and mechanical linkages were among the hardware components that showed reliable functioning without any noticeable lag or malfunction. All things considered, the suggested method accomplished precise automation and confirmed that tilt-based control works well for real-time stand operation.

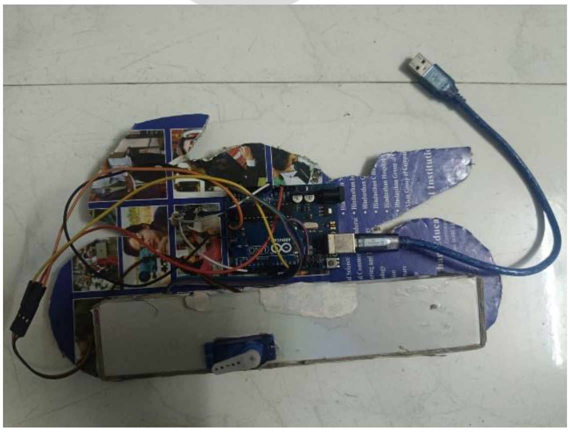


Fig.7.1

8. CONCLUSION

The suggested autonomous self-lifting stand system effectively combines sensor-based monitoring, mechanical design, and Arduino-based control logic to increase vehicle convenience and safety. Accurate orientation detection is made possible by the employment of an IMU sensor, which only permits automatic stand retraction when stable circumstances are reached. During testing, the designed system showed dependable performance, seamless operation, and successful stand movement prevention.

The viability of automating two-wheeler safety systems is confirmed by the deployment of the planned control algorithm and proposed hardware. The outcomes show increased operating efficiency, decreased manual labour, and improved stability. All things considered, the project offers an affordable and useful solution that can be further improved for real-world uses with the use of sophisticated sensors, wireless connection, and clever control schemes.

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