Modified Sewing Machine for Disabled People - An IOT and Arduino-Based Approach: Review

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Abstract: Locomotor disabilities significantly limit access to industrial employment, especially in sectors reliant on foot-operated machinery such as textile manufacturing. Traditional sewing machines, which require continuous lower limb movement, pose a major barrier to individuals with such impairments. This study presents an inclusive, Arduino-based solution that replaces foot pedal operation with hand-controlled and sensor-driven mechanisms. Two assistive systems were developed: one using electromechanical load cell sensors integrated with clutch and servo motors, and another employing dual infrared (IR) sensors for fabric detection and automated actuation. Comparative analysis revealed that the servo motor configuration offered greater versatility and ease of use. Additionally, a reverse lever actuator was designed to enable autonomous back-tack operations. Performance metrics—including sewing cycle time, energy efficiency, and operator comfort—were evaluated through experimental trials and ANOVA statistical analysis. Results confirmed that trained disabled operators could match the productivity of conventional users. The modified system demonstrated reliable, safe, and ergonomic operation, empowering locomotor-disabled individuals with technical independence and opening pathways to employment and economic inclusion in the garment industry.

Keywords : Assistive Technology, Industrial Automation, Arduino, IoT, Sewing Machine, Textile Industry, Disability Inclusion

1. Introduction

Despite being one of the major job sectors globally, many people with locomotor disabilities are still unable to access the garment and textile industry. The foot pedal mechanisms of traditional sewing machines necessitate constant lower limb movement. This design makes it extremely difficult for those with locomotor disabilities to participate in the tailoring and clothing production processes.Despite having full cognitive and communicative capacities, these people are excluded from machine-based jobs, which hinders their ability to flourish economically and personally. The development of automation, the Internet of Things, and embedded systems presents a chance to transform sewing machines into inclusive, assistive technology that enables people with disabilities to operate freely and competitively in the sector. Although many industries have changed as a result of automation and assistive technology, the textile industry still relies significantly on manual labor. Because sewing machines, in particular, need fine motor skills, people with disabilities cannot use them.Traditional machinery can be redesigned for inclusivity with the advent of Industry 4.0 and IoT-enabled gadgets. The goal of this project is to create an inexpensive, Arduino-based sewing machine modification that will allow people with disabilities to use sewing machines with little physical strain.

Problems Faced by Physically Disabled People in Operating Sewing Machines

Foot Pedal Dependency: Conventional industrial sewing machines rely on foot pedal operation, which is inaccessible for persons with locomotor disabilities affecting the lower limbs.

Limited Employment Opportunities: People with disabilities are frequently barred from jobs in the clothing sector because they are unable to operate regular machinery.

Physical Strain: Without the right assistance aids, attempting to adjust to foot-based machines can lead to discomfort, exhaustion, or even damage.

Lack of Inclusive Design: The majority of sewing machines are not ergonomically made to be operated by hand, therefore people with disabilities must rely on outside help.

Skill Development Barriers: Training programs in clothing manufacture and tailoring usually presuppose regular machine operation, which hinders disabled people from learning employable skills.

Economic Challenges: Lack of access to sewing-related jobs lowers one's standard of living and financial independence.

2. Literature Review: Assistive Devices in Manufacturing: Previous studies highlight the role of automation in empowering disabled workers, particularly through sensor-based control systems .Arduino in Industrial Applications: Arduino microcontrollers have been widely adopted for low-cost automation due to their flexibility and open-source ecosystem .IoT in Textile Industry: IoT integration has improved process monitoring, predictive maintenance, and remote control in textile operations .Gap Identified: While automation in textiles is well-documented, assistive sewing machines for disabled individuals remain underexplored, creating a research opportunity.

- Graber (2022) emphasizes manufacturer responsibility and empowerment.
- Waude (2023) provides a user-centered perspective with practical tool reviews.
- MovingMood (2021) demonstrates low-cost, scalable adaptations for inclusivity.

Scope of the Study: The design, development, and assessment of assistive mechanisms that convert traditional foot-operated sewing machines into inclusive, hand-based or sensor-controlled systems appropriate for people with locomotor disabilities are all included in the study's scope. In order to enable impaired operators to autonomously and effectively do sewing operations without physical strain, the main goal is to remove the reliance on foot pedals.

To accomplish this goal, the study explores a number of strategies, such as the combination of opto-electronic infrared (IR) sensor modules, servo motor-based actuation, and electro-mechanical load cell systems. Every mechanism is made to provide accessibility without sacrificing the accuracy, dependability, and efficiency of industrial sewing machines. To find the most adaptable and energy-efficient option, clutch motor and servo motor layouts are compared.A crucial component of the scope is performance evaluation, which involves the methodical analysis of metrics including sewing cycle time, efficiency, energy usage, and total productivity. To ensure a fair evaluation of inclusivity and performance parity, trials are conducted with both disabled operators using the adapted machines and non-disabled operators using normal machines.

The study looks at the modified machines' wider socioeconomic effects in addition to their technical performance. It evaluates how these technologies can help people with locomotor disabilities become more employable, develop their skills, and become more financially independent. This project attempts to offer a scalable, affordable solution that encourages disability inclusion in the textile and apparel sector by bridging the gap between industrial automation and assistive technology.

Objectives

1. To identify the challenges faced by locomotor disabled persons in operating conventional sewing machines.
2. To design and implement low-cost assistive devices for industrial sewing machines.
3. To develop and test multiple mechanisms (clutch motor, servo motor, IR sensor–based systems) for inclusive operation.
4. To evaluate the safety, accuracy, and efficiency of the modified machines.

5. To provide a pathway for training and employment of disabled individuals in the garment industry.

3. Methodology

Functional requirements: Automation features are integrated into the modified sewing machine to increase efficiency and accessibility. An infrared sensor is used to automatically detect fabric, guaranteeing sewing readiness. A potentiometer permits speed control, and an Arduino UNO controls a servo motor for machine actuation. Strong start/stop logic guarantees accurate operation, and thorough fault handling protects against abnormal conditions, motor stall, and sensor failure.

Hardware requirements: The Arduino UNO (ATmega328P), which serves as the central controller and provides enough digital and analog input/output for sensors, motors, and controls, is one of the hardware needs for the customized sewing machine. Reliable fabric detection close to the presser foot is ensured with a reflecting or break-beam infrared sensor. The sewing mechanism is driven by a high-torque servo motor that is regulated by a steady 5–6 V supply. For speed control, an analog input is provided by a 10 kΩ linear potentiometer. Signal conditioning using resistors and filters, vibration-resistant wiring and connectors, and appropriate mechanical integration with mounts and brackets for dependable operation and ergonomic placement are further requirements.

Software requirements: The software development of the modified sewing machine relies on Arduino IDE for firmware programming and Tinkercad for simulation and early validation. The firmware incorporates modules for sensor reading, input filtering, control logic, PWM servo control, and speed mapping. Essential calibration routines define IR sensor thresholds and potentiometer ranges. Robust error detection ensures safety through timeouts, range checks, and failsafe mechanisms. Diagnostics are supported by serial logging and LED indicators for real-time status monitoring. To ensure long-term adaptability, the code follows a modular structure with clear interfaces for sensors, actuators, and user inputs, simplifying maintenance and future enhancements.

Performance requirements

The altered sewing machine must guarantee a detection latency of less than 50 milliseconds between cloth sensing and actuation. Control must respond to changes in potentiometer speed in less than 100 milliseconds. Servo repeatability under load must be within ±2° for actuator precision. For the system to function continuously for at least eight hours without deteriorating, uptime and reliability must be guaranteed.

Safety and compliance requirements

The modified sewing machine incorporates multiple safety measures to ensure reliable and secure operation. Electrical safety is achieved through overcurrent protection on the servo rail, along with proper grounding and insulation to prevent hazards. Operational safety includes immediate stop functionality in case of sensor mismatch or dual-signal failure, with an emergency override reserved for critical situations. To address EMI/EMC considerations, decoupling capacitors and physical separation of motor power and logic lines are implemented, reducing interference. Additionally, mechanical safety is ensured by protective guards that prevent fabric snagging and restrict operator contact with moving linkages, enhancing overall system safety.

Usability requirements: The modified sewing machine emphasises ergonomic controls by ensuring the potentiometer and any operational buttons are positioned within comfortable hand reach, with tactile feedback to enhance usability. Clear status indication is provided through visual signals that display 'Ready', 'Running', and 'Fault' states, allowing operators to monitor machine conditions easily. To improve accessibility, training support is incorporated with straightforward setup and calibration procedures, enabling even novice operators to quickly adapt to the system. These features collectively enhance user comfort, reduce learning barriers, and ensure safe, efficient operation for individuals with locomotor disabilities in both industrial and domestic environments.

Interface requirements: The modified sewing machine employs a sensor interface using digital or analog input channels with thresholding and noise filtering for reliable fabric detection. The actuator interface provides PWM output to control the servo motor, with an optional enable line for motor power gating. The user interface includes a potentiometer, start/stop button, and serial service mode.

Environmental requirements: The modified sewing machine is designed to operate reliably within 10–40°C, matching typical garment floor conditions. All components are mounted with vibration tolerance to prevent signal drift during continuous operation. Additionally, careful sensor placement and protective housings minimise the impact of dust and textile fibres, ensuring accurate detection and consistent performance in industrial environments.

Testing and validation requirements: The testing process for the modified sewing machine involves multiple stages to ensure reliability and performance. Unit tests verify sensor detection accuracy, potentiometer linearity, and servo command compliance under controlled conditions. Integration tests evaluate complete system behavior, including start/stop cycles, speed control stability, and fault recovery. Calibration verification ensures repeatable detection thresholds and consistent speed mapping across different operators. Finally, pilot trials compare sewing cycle time (SCT), efficiency, and operator comfort between disabled users on the modified machine and normal operators on conventional machines. These evaluations confirm the system's effectiveness, safety, and suitability for industrial and domestic applications.

3.1 System Components

Table 1 System components with their specifications

Component	Function	Specification
Arduino UNO (Central Controller)	Acts as the main control unit, processes sensor inputs and controls actuators	ATmega328P microcontroller, 14 digital I/O pins, 6 analog inputs, 16 MHz clock, USB programmable
IR Sensor	Detects presence of fabric under the presser foot	Reflective or break-beam type, operating voltage 3–5 V, detection range ~2–30 cm
Servo Motor	Actuates sewing mechanism based on Arduino signals	High-torque servo, operating voltage 5–6 V, PWM controlled, angular precision ±2°
Potentiometer	Provides user input for sewing speed control	Linear type, ~10 kΩ resistance, analog output to Arduino analog pin (A0)
Software Tools	Used for programming, simulation, and validation	Arduino IDE for firmware development; Tinkercad for circuit simulation and testing

3.2 Working Principle The modified sewing machine operates through an automated control system designed for accessibility and ease of use. When cloth is placed under the machine, the IR sensor detects the presence of fabric and sends a signal to the Arduino UNO controller. The Arduino processes this input and subsequently activates the servo motor, initiating the sewing mechanism. Once triggered, the sewing process begins automatically without requiring foot pedal operation. Additionally, a potentiometer is provided for user-

controlled speed adjustment, allowing operators to regulate stitching speed according to their comfort and requirements. This ensures efficient, safe, and inclusive operation.

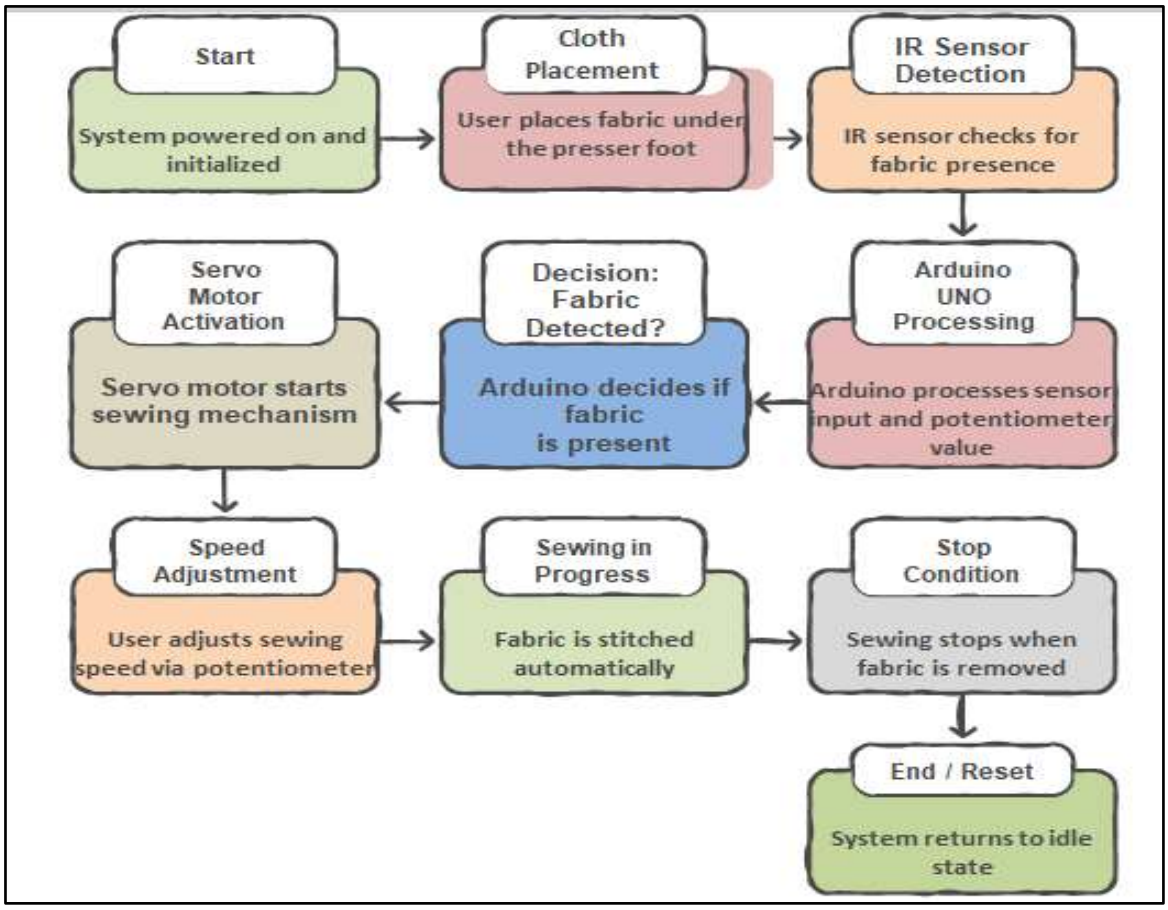

Fig 1 Working Process of modified sewing machine operation

4. Results and Discussion

The prototype of the modified sewing machine successfully demonstrated key automation features. It enabled automatic cloth detection using an IR sensor with minimal user input, smooth actuation of the sewing mechanism via a servo motor, and customisable speed control through a potentiometer. These features collectively enhanced usability, precision, and accessibility for locomotor-disabled operators.

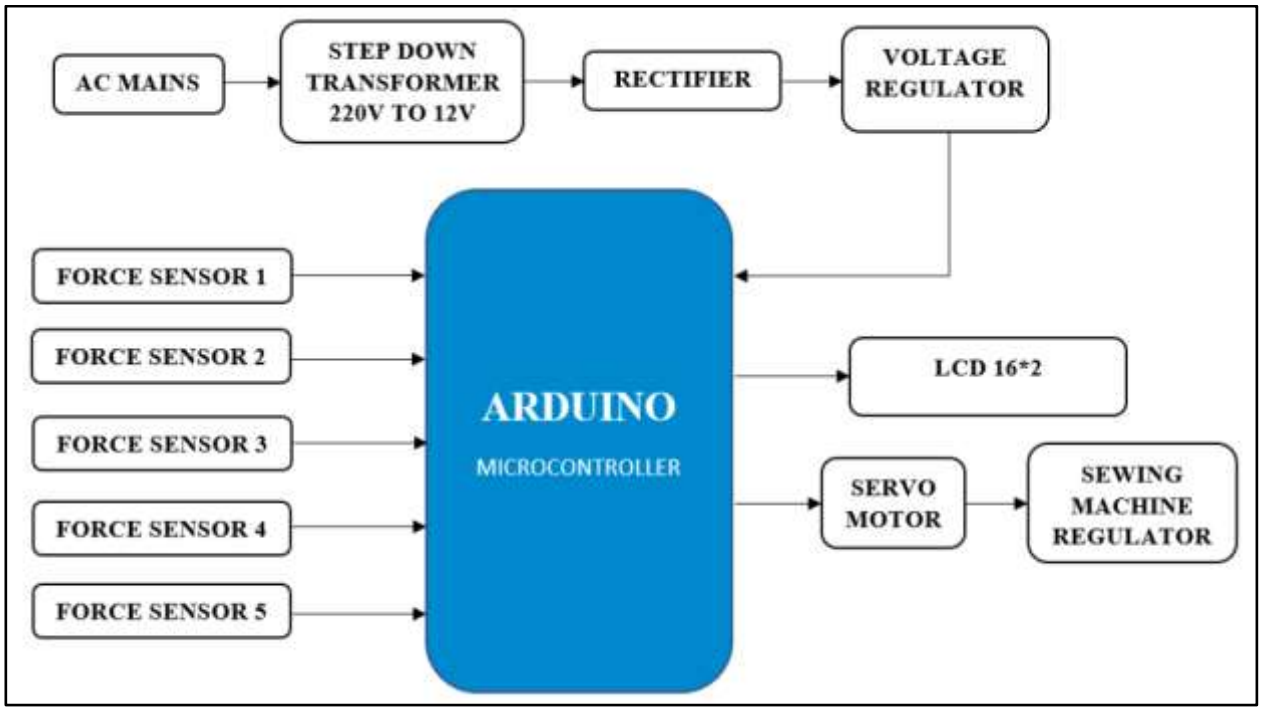

Fig 1 Sewing Machine With Components

5. Applications: Textile & Garment Industry – inclusive employment opportunities.Home-based Tailoring – empowering disabled individuals for self-employment.Vocational Training Institutes – teaching automation and assistive technology.

6. Conclusion: The development of a modified sewing machine equipped with assistive technologies such as IR sensors, servo motors, and Arduino-based control systems has proven to be a transformative solution for locomotor-disabled individuals. By enabling hand-based operation without the need for foot pressure, the system significantly enhances accessibility and usability. The IR sensor mechanism simplifies fabric detection and initiates sewing with minimal effort, allowing disabled operators to perform tasks with efficiency comparable to normal users.

Single cycle time analysis for full sleeve shirt production confirms that trained disabled operators can match the performance of conventional operators. Although initial statistical analysis reveals a performance gap, it can be effectively minimised through structured training and consistent practice. This innovation not only empowers disabled individuals with technical independence but also opens pathways for employment and economic inclusion in the garment industry.

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