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Warponic

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Abstract: The textile industry relies heavily on warp preparation, an essential process in weaving. Traditional warp preparation in handloom sectors is performed manually, requiring skilled labor and significant time. Manual operation often leads to inconsistenttension,misalignment, and errors thatreduce fabricquality.Thisprojectaims to design and implementa fullyautomatic warp preparation system that eliminates human intervention, maintains consistent yarn tension, and improves operational efficiency.

The proposed system employs an ESP32 microcontroller for control and automation, stepper motors for precise motion, a load cell for tension sensing, and PID control logic for maintaining uniform yarn tension. The system is capable of automatically windingthe warp yarn onto the beam with high accuracy in terms of length and tension. A graphical interface allows users to set desired warp parameters such as tension, length, and speed. The developed prototype reduces preparation time by over 60%, improves uniformity, and enhances repeatability. This system demonstrates the feasibility of low-cost automation in small and medium hand

I. INTRODUCTION

A. Background

Inthe weavingprocess, warp preparation isone ofthe most critical stages. The warp yarns must be wound onto a beam under uniform tensiontoensurehigh-qualityfabricproduction.Inconventionalhandloomoperations,thistaskisperformedmanuallyusinghandcranks and rollers, which is time-consumingand prone to humanerrors.

Automation in textile pre-weavingprocesses can significantly improve accuracy, consistency, and production efficiency. While automatic warpingmachinesexistforindustrialsetups,theirhighcostandcomplexitymakethemunsuitableforsmall-scaleandruralweavers.

B. Objective

Theprimaryobjectiveofthisprojectisto:

Designalow-cost,compact,andautomaticsystemforwarppreparation. Achieveconsistentyarntensionthroughclosed-loop feedbackcontrol.

Eliminate the need for manual interventionduring warping.

Provideauser-friendlycontrolinterface.

C. Scope

Thissystemfocusesonautomatingthebeamwindingandtensioncontrolstages.Itissuitableforsmall-scalehandloomoperators...

II. PROBLEM DEFINITION/NEED OF SYSTEM

Theexistingmanualwarppreparationsystemfacesmultiplechallenges:

1) HighLaborDependency:Skilledlaborisrequiredforwindingandmaintaininguniformyarntension.
2) InconsistentTension:Manualmethodscannotmaintainprecisetension,leadingtounevenfabric.
3) TimeConsumption:Manualwarpingtakesseveralhoursperbeam.
4) FatigueandHumanError:Continuoushandoperationcausesoperatorfatigue,resultingintensionvariation.
5) LackofAutomation:Nofeedbackmechanismorautomaticcontrolispresentinmanualmethods.
6) ImprovedProductivity:Reduceswarppreparationtimesignificantly.
7) Accuracy:Ensuresuniformtensionthroughouttheyarnlength.
8) CostEfficiency:Reducesdependenceonskilledlabor,loweringoperationalcosts.
9) User-Friendly:Simpleinterfaceforparametersetup(length,speed,tension).
10) QualityImprovement:Uniformwarpresultsinconsistentfabricdensity.
11) DigitalIntegration:CapableofIoTintegrationfordataloggingandremotemonitoring.

III. SYSTEM COMPONENTS SPECIFICATIONS

A. Hardware Components

ComponentSpecificationFunction:

- -ESP32MicrocontrollerDual-core32-bit,Wi-Fi,240MHzControlsallsensorsandactuators
- -StepperMotor(NEMA17)1.8°stepangle,0.4N·mtorqueDrivesthewarpbeamwithprecision
- -StepperDriver(DRV8825)Upto2.5Acurrent Providespulsecontroltostepper
- -LoadCell(5kg)±0.01kgaccuracyMeasuresyarntension
- -HX711Amplifier24-bitADCAmplifiesloadcellsignal
- -RotaryEncoder600PPRMeasureslengthand speed
- -DCMotor(optional)12V,100RPM Drivesyarnfeedroller
- -PowerSupply12V,10ASMPSPowersallactuatorsand sensors
- -LCD/TFTDisplay2.8‖ TFTUserinterface
- -FrameandRollersMildsteel/aluminiumMechanicalassemblyforwinding

B. SoftwareTools

- -ArduinoIDE/ESP-IDFforfirmwaredevelopment
- -Proteus/Fritzingforcircuitdesign
- -SolidWorks/Fusion360forCAD
- -MATLAB(optional)fortensioncontrolsimulation

IV. METHODOLOGY

1) Phase1:RequirementAnalysis

Warplength:upto10meters(prototype) Max tension: 1.5 N
Speed:variableupto150RPM Motor torque: ≥0.4 N·m

2) Phase2:MechanicalDesign

Designed3DCADmodelofwindingsetup:includeswarpbeam,feedroller,guideroller,loadcellmount,andtensionsensor. Roller diameter and spacing chosen to maintain smooth winding path.
Framefabricatedfromaluminiumprofilesforrigidityandlightweight.

3) Phase3:ElectricalDesign

CircuitconnectionsincludeESP32→DRV8825→Stepper→LoadCell→HX711→Encoder. Power lines isolated for motors and sensors to reduce noise.

4) Phase4:Software&Algorithm

ControlAlgorithm:Closed-looptensioncontrolusingPID. PID logic:
Input=measuredtensionfromloadcell Setpoint = desired tension
Output=motorspeedadjustment

5) Phase5:Integration

Componentsassembledonthemechanicalframe. Calibrated load cell using standard weights.
ProgramuploadedtoESP32.

6) Phase6:Testing&Validation

Testedfordifferentyarntypesandlengths. Observed uniformity and error tolerance.

V. LITERATURE SURVEY

AuthorYearPaper/WorkFindings Limitation
Sharmaetal.2019 Automated WarpingSystemforSmallLoomsUsedDCmotorsforpartialautomationNo feedbackcontrol,manual start/stop
Patel&Joshi2020TensionControlinTextileWinding DiscussedPIDcontrolfortensionregulation Focusedonindustrialsystems only
Sainietal.2021Arduino-BasedYarnWinderBasicautomationusingArduinoUnoNoloadcellintegration
Lietal.2022SmartTextileMachineControlAdvancedservodrivewithPLCTooexpensiveforsmall-scale
Reddyetal.2023IoT-BasedLoomMonitoring Implementeddataloggingvia ESP32 Focusedonloommonitoring,not warpprep Identified

Research Gap:
Mostresearchfocusesonindustrial-scalesystemsorsemi-automation.Thereislimited workonlow-cost,fullyautomatic warp preparation prototypes suitable for small-scale or handloom industries. Our system fills this gap.

VI. PROPOSED SYSTEM

Working Principle
UsersetswarpparametersviaTFTscreenorwebinterface. ESP32 initializes motors and sensors.
Yarn passes through the tension roller attached to the load cell. Aswindingbegins,theloadcellcontinuouslymonitorstension.
PIDalgorithmadjuststhefeedrollerspeedtomaintainconstanttension.
Rotaryencodercountslength;processstopsautomaticallyafterthesetlengthisreached. System alerts completion and stops all motors.

VII. RESULTS/OUTPUT DISCUSSION

The developed automatic weaving machine prototype was successfully designed and implemented using an Arduino UNO, servo motors,asteppermotor,andaDCmotor.Themachineautomatedthekeyoperationsofweaving —shed formation,weftinsertion,and reed beating — without any manual intervention.
Duringtesting,theprototype:
Completed continuous weaving cycles with stable performance. Achieved a working speed of around 50–60 picks per minute. Producedwovenfabricofuniformtexturewithminimaldefects. Consumedverylowpower(~24W),makingitenergy-efficient.

VIII. FUTURE SCOPE

A. AutomaticFabricTake-up&WarpFeeding:
Addsteppermotorstoautomaticallyrollthewovenfabricandfeednewwarpthreadsforcontinuousoperation.

B. SpeedControlSystem:
Integrateapotentiometerorkeypadtoadjustweavingspeedaccordingtofabrictype.

C. SmartMonitoring:
AddanLCDdisplayormobileapptoshowparameterslikespeed,faultalerts,andproductionlength.

D. TensionControlMechanism:
Introduceloadsensorsorspringsystemstomaintainconstantwarptensionforuniformfabric.

E. AdvancedSensors&FeedbackSystem:
Useencodersandopticalsensorsforclosed-loopmotorcontrol,improvingaccuracyandreducingdefects.

F. IndustrialUpgrade:
Replacelow-torqueservoswithhigh-torqueDCorpneumaticactuatorsforlargerloomsandcommercialweaving.

G. Eco-FriendlyPowerSource:
Connectthesystemtosolarpowerforsustainableandruralapplications.

IX. CONCLUSION

The project successfully demonstrated an automatic, low-cost weaving system capable of operating without manual involvement. By integrating Arduino control, servo motors, and stepper-driven shuttle movement, the prototype efficientlyautomated the mainfunctions of a traditional loom.
Itachievedconsistentperformance withgoodfabricqualityandsignificantlyreducedhumaneffort,time,anderrorcomparedtomanual weaving. The prototype is economical, energy-efficient, and easily upgradable, making it suitable for educational projects, small textile units, and rural entrepreneurs.
In conclusion, this project proves that automation in traditional handlooms is feasible and affordable. With further optimization and mechanical improvements, this system can evolve into a fully automatic, smart weaving machine that supports small-scale industries sector.

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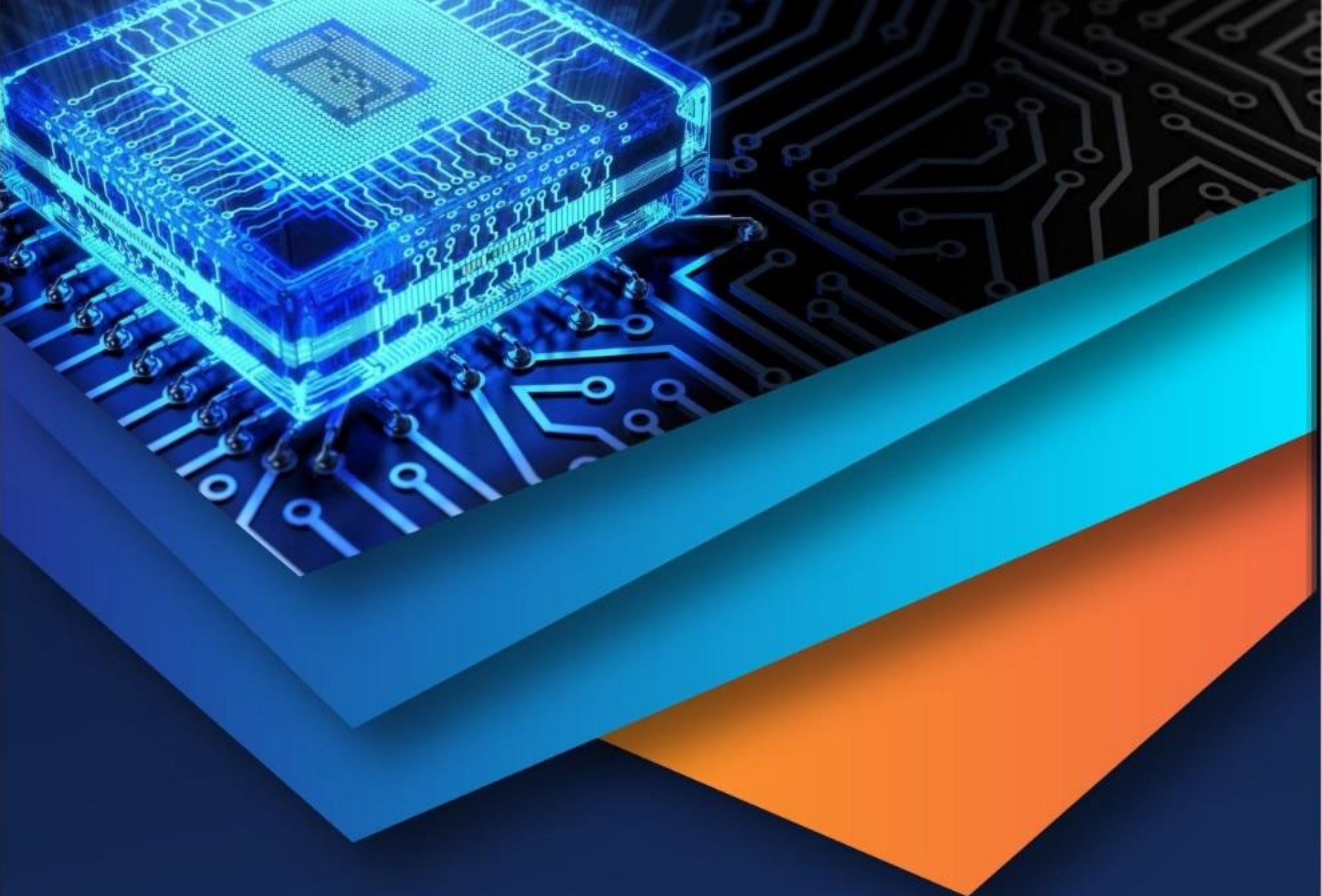

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