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Design, Development and Performance Evaluation of an Automatic Whiteboard Cleaning System

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Abstract - Whiteboards are widely used in classrooms, laboratories and meeting rooms, yet manual cleaning remains time-consuming, repetitive and physically inconvenient for users. This paper presents the design, construction and performance evaluation of a low-cost automatic whiteboard cleaning system developed to reduce cleaning time, improve classroom efficiency and minimize the manual effort associated with board erasure. The proposed system uses a motor-driven mechanical arrangement that converts rotary motion into linear motion for the controlled movement of a foam duster across the board surface. The prototype integrates a whiteboard frame, duster bar, chain and sprocket drive, rack and pinion mechanism, stepper motor, transformer, control switch and supporting structure. The cleaner can be activated by a single control action and is designed to support full-board and sectional cleaning operations. Test observations from the prototype show that the system can clean the board surface quickly and uniformly while preserving the visual quality of the writing surface. The design therefore provides a practical and affordable automation solution for educational institutions where conventional whiteboard cleaning interrupts lecture delivery.

Keywords - automatic whiteboard cleaner; rack and pinion; chain and sprocket; DC motor; classroom automation; electromechanical system

I. INTRODUCTION

A whiteboard, also called a dry-erase board or marker board, is a glossy writing surface on which non-permanent markings can be made and removed. Its adoption in educational institutions and offices increased because it provides a cleaner and higher-contrast writing surface than conventional chalkboards. In classrooms, whiteboards also help reduce chalk-dust exposure and improve visibility during teaching and group discussion.

Despite these advantages, the erasing process is still largely manual in many schools and lecture rooms. Users often depend on handheld dusters, which may not always be available, may leave residues on the board surface and may consume useful teaching time. The difficulty is more pronounced on large boards or boards mounted at heights that make the top edges difficult to reach. These limitations create the need for a faster, accessible and low-cost board-cleaning solution.

The aim of this work is to design and construct an automatic whiteboard cleaning system that reduces human effort, shortens cleaning time and improves the consistency of board erasure. The proposed system uses an electromechanical drive to move a duster across the board surface after activation by a control switch. The system is targeted at lecture rooms, laboratories and training centres where conventional manual cleaning interrupts instruction time.

II. RELATED WORKS

Previous studies and inventions on board-cleaning systems can be grouped into three broad categories: automated erasure systems, electric handheld board cleaners and mobile robotic cleaners. Automated erasure systems commonly use rods, pulleys and belts to move an eraser member across the board. The movement of the eraser is powered by a motor, while brackets or frames hold the mechanism close to the board surface [1], [2].

Electric board cleaners reduce the physical effort required by the user, but they still require manual guidance of the cleaning head over the board surface. Such devices may include a motor, dust chamber, absorbing head, cleaning pad and battery case. Although they improve convenience, the user still performs the wiping motion and the process may remain non-uniform [3].

Mobile robotic cleaners introduce a higher level of automation by using a moving trolley and erasing mechanism that travels along a track. Some designs attempt to identify regions to clean while avoiding marked exclusion zones. However, these designs can be slow, relatively bulky and limited by sensing precision, motor speed and the need for extra board space around the cleaning boundary [4].

The design proposed in this paper addresses the limitations of belt-driven and manually guided designs by using a chain-and-sprocket drive combined with a rack-and-pinion arrangement. Chains provide better resistance to wear than belts and are easier to replace when properly installed. This design objective is to achieve simple construction, reliable movement and low-cost operation for classroom use.

III. MATERIALS AND METHODS

A. Design Description

The automatic whiteboard cleaner was designed as a movable electromechanical device fitted around a whiteboard frame. The main structural material is plywood because it is affordable, readily available and easy to fabricate. Stainless steel was used in parts that come into contact with the duster and moving assembly because of its corrosion resistance and mechanical stability. The prototype board has an approximate height of 740 mm and a cleaning surface area of 1210 mm by

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270 mm. The duster bar has a surface area of approximately 735 mm by 65 mm and is made of foam to provide adequate surface contact during wiping.

The arrangement consists of a whiteboard frame, duster bar, motor stand, chain, sprocket, rack, pinion, control switches, transformer, wiring and top cover. The motor drives the sprocket assembly, and the rotary motion is converted into linear movement of the duster across the whiteboard surface. Pilot or limit switches are placed at the extreme ends of the board to stop the motion when the duster reaches the end of travel.

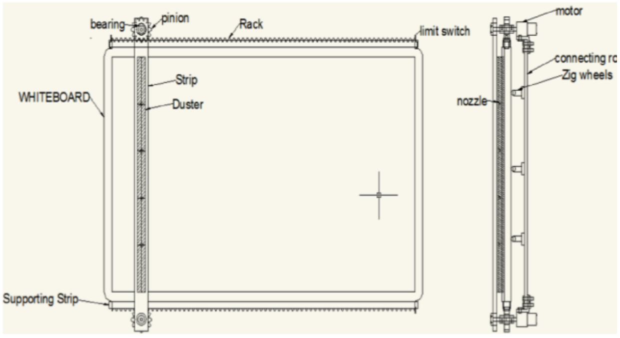

Fig. 1. Whiteboard cleaning arrangement with rack and pinion mechanism.

B. Main Components

The major mechanical components of the system are the chain, sprocket, rack, pinion, duster bar and support frame. The electrical components include the stepper motor, transformer, switches and control wiring. The component selection was guided by availability, cost, ease of fabrication and suitability for repeated classroom operation. The chain and sprocket arrangement is used because it provides positive drive, reduced slippage and improved durability compared with belt-based arrangements.

TABLE I. SPECIFICATION OF COMPONENTS

S/No.	Component	Material/Specification
1	Board	Wooden frame and whiteboard surface
2	Chain	Mild steel roller chain
3	Sprocket	Metal steel sprocket
4	DC stepper motors	Two motors, 150 rpm
5	Switches	Standard DPDT/control switches
6	Duster	Foam cleaning material
7	Transformer	12 V and 5 V supply

The selected chain-and-sprocket components and the rack-and-pinion arrangement used to guide the motion of the cleaner are shown in Fig. 2 and Fig. 3.

Fig. 2. Chain and sprocket components used for the drive system.

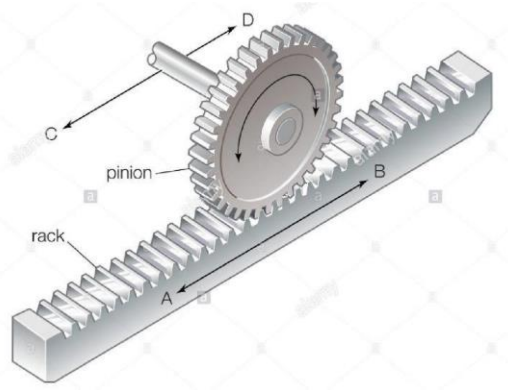

Fig. 3. Rack and pinion arrangement for converting rotary motion to linear motion.

C. Gear and Drive Mechanism

Gears are toothed wheels used to transmit power and motion between rotating shafts. In the proposed cleaner, the gear mechanism is used to control motion transfer and support the conversion of motor rotation into board-length translation. A rack-and-pinion system is particularly useful because the round pinion gear meshes with a straight rack to produce linear motion. This principle allows the duster to sweep the board surface in a controlled direction.

A chain drive was selected because it can operate over short or moderate centre distances, can be lubricated, is comparatively easy to guard and can transmit motion with high efficiency. The chain also occupies less width than some belt systems and is suitable for repeated operation under classroom conditions. In the prototype, the chain length was estimated from the sprocket centre distance and the number of chain links required for the moving duster assembly.

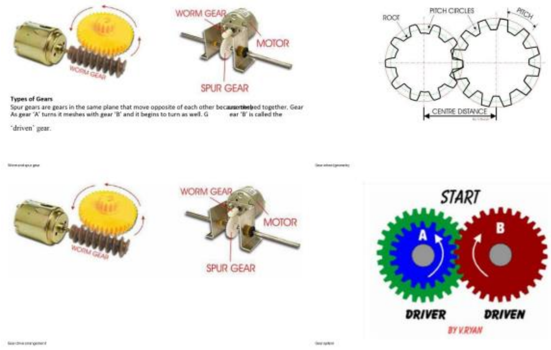

Fig. 4. Gear and drive mechanisms considered in the cleaning system.

D. Electrical and Control Arrangement

The electrical section provides power and user control for the cleaning operation. A transformer is used to step down the mains voltage to the required lower voltage level before rectification and regulation for the control and drive circuits. The stepper motor provides controlled motion of the shaft, while the switches allow the user to start, stop or select a cleaning direction. In the control logic, the microcontroller or switching circuit acts as the interface between the user input and the motor driver.

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Fig. 5. Principal electrical and mechanical components of the cleaner.

The switching circuit is arranged so that the motor can move the duster in the required direction and stop when the travel limit is reached. The use of end switches protects the mechanism from continuous operation after the duster reaches the board edge. This improves safety and prevents unnecessary load on the motor.

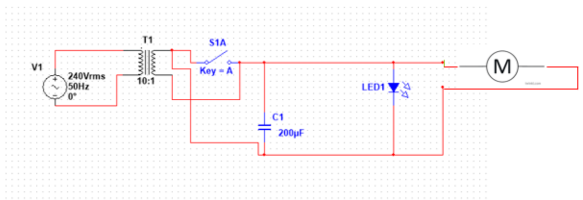

Fig. 6. Switching circuit diagram for the automatic cleaner.

E. Operating Algorithm

The operating algorithm begins when the circuit is energized from the supply. The user activates the required switch depending on whether full-board or sectional cleaning is needed. The motor rotates the drive mechanism, which moves the duster across the board. When the duster reaches the end of travel, the limit switch sends a stop command or reverses the movement depending on the selected operation. The process ends when the duster returns to the initial position or completes the required cleaning section.

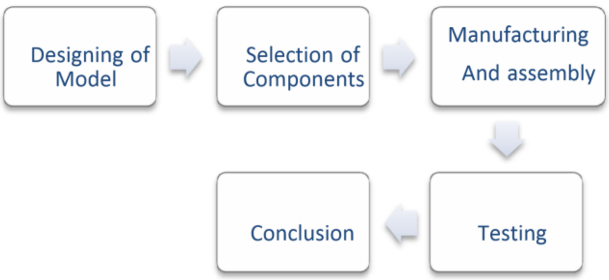

Fig. 7. Flow chart of the automatic whiteboard cleaning process.

IV. FABRICATION AND IMPLEMENTATION

The fabrication stage involved preparing the board frame, installing the chain-and-sprocket assembly, positioning the duster shaft, mounting the motor and wiring the control circuit. The duster was designed to span the board surface sufficiently so that one horizontal movement can clean a large section of the writing area. The top cover protects the motor, chain and control wiring, while also helping to shield users from the moving parts.

The 3D representation of the marker board and the constructed prototype are shown in Fig. 8 and Fig. 9. The prototype demonstrates the practical integration of the mechanical and electrical sections into a single classroom-ready cleaning unit.

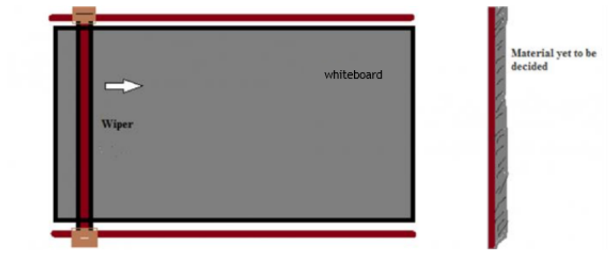

Fig. 8. 3D representation of the marker board and moving cleaner assembly.

Fig. 9. Constructed automatic whiteboard cleaning system.

V. RESULTS AND DISCUSSION

The completed prototype shows that an automatic whiteboard cleaner can be fabricated using locally available mechanical and electrical components. During operation, the motor drives the chain-and-sprocket assembly, and the resulting motion moves the duster across the board surface. The cleaning process reduces manual effort and can complete board erasure faster than conventional handheld wiping. The mechanism also improves uniformity because the duster follows a guided path rather than relying on random hand movement.

The key performance advantage of the design is the conversion of manual board cleaning into a single-action automated process. The arrangement allows the user to initiate board cleaning while continuing lecture preparation or classroom organization. Compared with belt-based arrangements, the chain drive is expected to offer improved resistance to wear and lower risk of sudden drive failure. The use of a foam duster also reduces surface scratching and helps preserve the visual quality of the board.

The main limitations observed are the need for careful alignment of the chain, rack and duster shaft, as well as proper fitting of bearings to reduce the load on the motor. The current design also cleans based on fixed movement paths and does not

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automatically detect the exact location of writing on the board. Future improvements may incorporate microcontroller-based speed control, automatic dirt detection, improved limit-switch logic and adjustable cleaning pressure.

TABLE II. BILL OF ENGINEERING MEASUREMENT AND EVALUATION

S/No.	Description	Quantity	Unit Price	Cost	Remark
1	Stepper motor	2	54	108	New
2	Frame stand	2	50	100	Nailed
3	Board	1	300	300	
4	Transformer	1	30	30	12 V/5 V
5	Chain	1	150	150	New
6	Sprocket	1	100	200	New
7	Switch	3	10	30	
8	Cleaner	1	20	20	New
9	Wires	8 yd	15	15	
10	Local transport	1	200	200	
11	Miscellaneous	-	-	150	
12	Labour	-	-	200	Carpentry work
	Total			GHS 1,503	

VI. CONCLUSION

This paper has presented the design, construction and evaluation of an automatic whiteboard cleaning system for educational institutions. The prototype uses a motor-driven chain-and-sprocket arrangement, rack-and-pinion motion conversion and a foam duster to clean the board surface after a simple user command. The system reduces the effort and time associated with manual erasure and offers a low-cost approach to classroom automation.

The work confirms that a practical automatic whiteboard cleaner can be produced using simple mechanical parts and basic electrical control components. The design is particularly relevant for lecture rooms where frequent board erasure interrupts teaching. Further work should focus on improved control using a microcontroller, better motor speed regulation, automatic detection of written areas and more compact packaging for commercial deployment.

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