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Performance Evaluation of an Automated Whiteboard Cleaner

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Abstract
In order to assist the physically impaired people, an automated whiteboard was designed, fabricated and evaluated AutoCAD Inventor was used for the initial design drawings while Procteus 8 software was used for the electrical circuit construction. Standard materials and components were used for the construction and fabrication of the whiteboard. The fabricated whiteboard was tested based on three criteria's including repeatability, effectiveness and cleaning duration. It was found that the average repeatability was about 9.2 out of 10. Meanwhile, total cleaning was effectiveness only in areas within the wiper radius. Furthermore, an average of 13 seconds was used to effectively clean the board as compared with the manual methodology which takes an average of 27 seconds. This significantly reduced the implementation cost of adapting this method as well as offers simplicity of design and installation.
Keywords: *White board, Automatic cleaner, Successful runs, effectiveness*

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I. INTRODUCTION

White boards have become a central tool by which corporate organisations, institution and other professional use as a means of proper education, presentation, demonstration and training. While several phases and similar technology have been developed overtime, the white board still stand out from the list of electronic boards, chalkboards etc. this is partly due to its relatively inexpensive design mobility, lack of power requirements as well as other factors [1]–[3]. An important aspect embedded in the use of any writing boards is the need to erase or clean the board for reuse. While this is relatively easy, board cleaning may present a problem when there is a frequent and periodic need to clean the board especially for boards which span across a wide surface area. For this reason, several designs have been developed to aid the cleaning of boards through an automated means with the major goal of reducing the labour involved as well as for a more effective and efficient tool.

Cave walls, piece of woods coal and pen have all been tools implemented in writing purpose over the years. With the introduction of the blackboard, chalk and pens gradually became popular such that they can be found in every institution, companies etc. Chalk which is a composite of calcium carbonate creates dust during writing and wiping of boards which is one of the reasons for its reduced popularity [4]. Generally, the material used in whiteboard surfaces are Melamine, Painted Steel or Aluminium, coat laminate. Porcelain etc [5]. Melamine sheets range in quality principally as a result of the measure of resin left on the base material. By and large, this most affordable kind of white board is most usually found being used in non-institutional applications. Painted steel and aluminium surfaces will in general be smoother, which prompts better techniques of erasing while the hard Coat Laminate are less common. The first whiteboards were over the top expensive and were made of an enamelled steel before an economical variant which utilised laminate chipboard, high-pressure laminates and steel sheets with polyester or acrylic, coating was adopted [6]. Different sorts of dry marker sheets are additionally accessible, for example, shiny vinyl and covered paper, which can be moved up, high-thickness two-section reflexive paints, glass and covered acrylics and polypropylene magic boards which utilises static electricity to cling to walls etc [7].

The manual board cleaning has been the traditional method which involves the use of erasers primarily done by the board user. The automated systems however entail horizontal and vertical motion of the cleaning tool which spans across the board writing area. With the electronic boards which employs a unique writing mechanism, they incorporate a resistive layer extended over an inflexible substrate, an electronic module for defining instrument position i.e. pen and a computer for processing and storing the pen coordinates over the board [1], [8], [9]. These board however do not need to be erased manually. Several systems such as the Automatic Erasure System have been developed to automatically clean boards utilizing non–lasting markings.

This framework incorporates an eraser that is coordinated across the outside of the board through an arrangement of rack and pinon plan controlled from a DC engine. The eraser part is coupled to the belt and the board. Thus, as the engine drives the pole which thusly drives the pulley and the belts and are likewise determined with the end goal that the eraser is gotten across the outside of the board, in this manner eradicating any non-lasting markings [10]–[17].

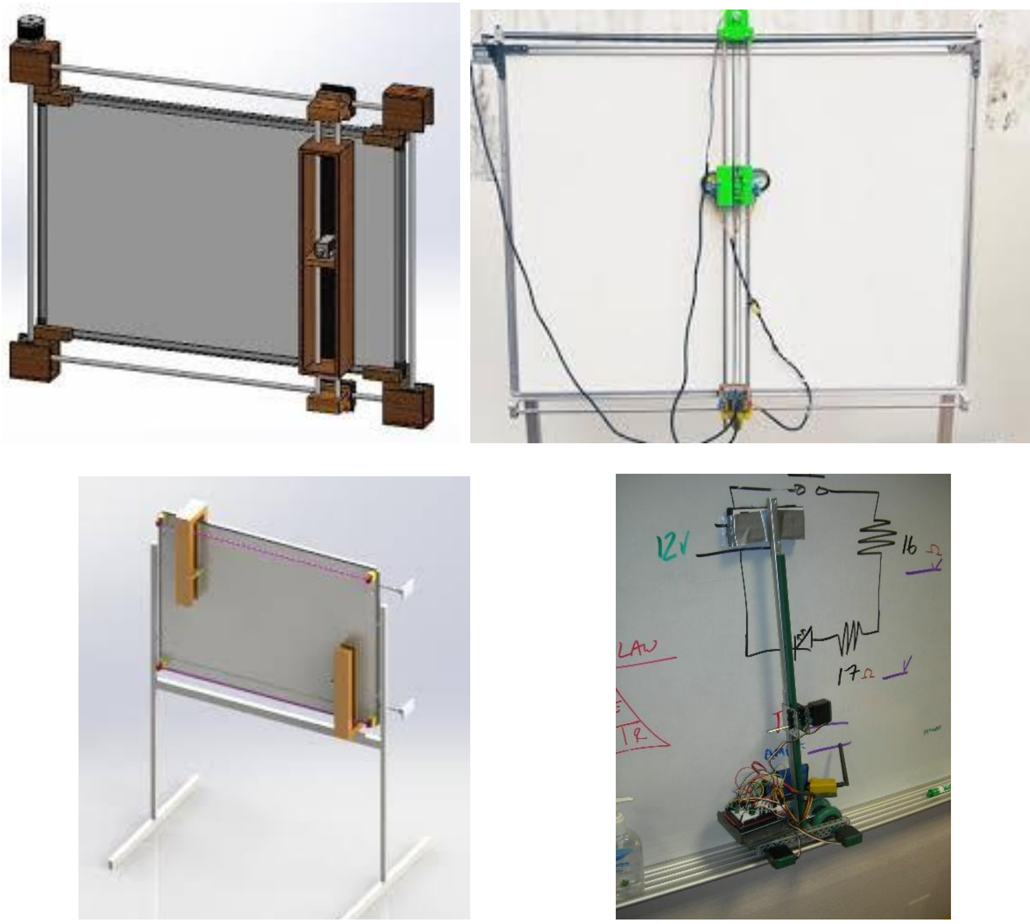

Figure 1: Automatic board cleaning mechanisms

The electric board cleaning framework involves a housing, motor, residue net, film, an absorbing head, pad and the battery compartment. In cleaning applications, the switch of the hold partition is to be squeezed to control the engine which is energized to pivot the fan. The cleaning pad of the retaining head is made to contact the outside of the board, and afterward moved subsequently around to focus on what is composed imprints [17].

The separating of versatile robot cleaning framework efficiently and intelligently gets rid of dry ink from the board while disregarding those confined within a yellow barrier. This necessitates the combination of mechanical and electronic devices into an independent device. A streetcar swung from a track moves slowly and carefully to one side while bringing down and raising the erasing mechanism [17].

The robot configuration eradicates marker totally or with next to no build up remaining. Be that as it may, the outcome is inefficient notwithstanding incredible endeavours made to improve and consummate the robot and its exhibition, it actually experiences huge restrictions. For appropriate obstruction recognition, the line should be in any event half inch thick and ought to have an additional room of a couple of crawls above and underneath the security zone.

The limitations of two major existing designs are the requirement of the use of bel. This becomes problematic in situations of board frequent use which can introduce belt wears due to friction giving room for failure. The principal objective of this paper is therefore focused on the design of a board cleaning module which could be installed as an attachment to whiteboards with the requirement of effectiveness, mobility, repeatability and ease of use.

II. METHODOLOGY

In conceptualization, few designs were sketched and reviewed before an optimal model was selected. The various concepts suitable for the project was then modelled using Inventor professional software application to adequately represent the 2D and 3D views of the model as shown in figure 2. The CAD software was then used to optimise the design.

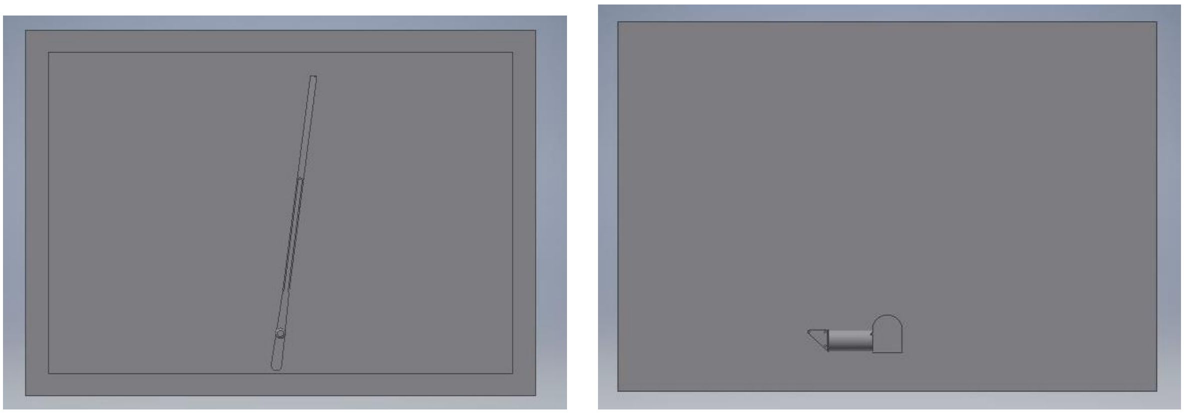

Figure 2: Front and back view of the whiteboard cleaner

Subsequently, the fabrication phase commenced where each parts and units were designed through manufacturing techniques such as cutting, welding, riveting etc. After which all finished parts are checked to ensure that the output of the process follows the product requirements. The material selected were considered based on factors such as strength, durability, availability, economic factor, resistance to corrosion, size and weight, toughness, weldability, ease of handling and fabrication and finally hardness. The interfacing drive joins and the turns the wipe made of galvanized steel same as the suspension and claw to deter the occurrence of corrosion. The blade however are natural rubber or synthetic compounds while some blades are composites of rubbers on the wiping edge. Other materials that include portions of wipers are rubber for washers in the pivots and plastic bushings that connects the linkage. The permanent magnet motors are contained in steel housings which allows the electrical connections to the wiring harnesses. The selected wiper motors (Table 1) for the wiper were ferrite magnet motors incorporating permanent magnets and gears which reduce the output motor speed. Ferrite motor used for the wiper comprises of a low, high and common brush and a cam switch incorporated into the gear section such that the wipers can stop at pre-set location. As current flows the armature coils generate counter-electromotive force with each turn which may reduce the rotational speed of the motor as shown in figure 3. Nevertheless, at high-speed, the current flows into the armature coils from the high-speed brush.

Table 1: Wiper motor specifications

Voltage	12 V		24 V	
Test voltage	13.5 V		27 V	
Braking torque	28 n.m		28 n.m	
Working torque	6 n.M		6 n.M	
Operating range	LOW	HIGH	LOW	HIGH
No-load speed	35rpm	52rpm	35rpm	52rpm
No-load current	1.8A	2.5A	1A	1.5A
Working speed	30rpm	45rpm	30rpm	45rpm
Working current	4.5A	5.5A	2.5A	3.5A
Noise	50dB	55dB	50dB	55dB

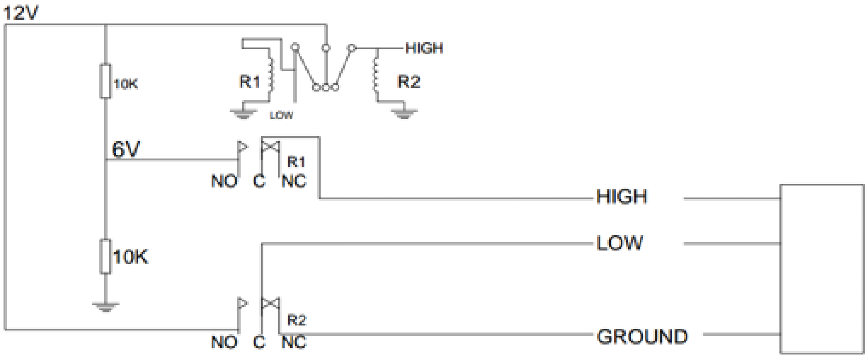

Figure 3: Circuit diagram

Minimum pressure required to clean black board, P =1200 N/m^2 . Where the contact surface of whiteboard is given by

$$A = \frac{\theta}{360} - \pi R^2 - \frac{\theta}{360} - \pi r^2$$

Where
R=sector covered by length of wiper with rubber material
r= sector covered by length of wiper without rubber material
The normal force required is given by:

$$Rn = P\ x\ a = 46.16\ N$$

We assume the co-efficient of friction for the rubber material as 1.15 then the frictional force on rubber material:

$$F = \mu\ x\ Rn = 52.9\ N$$

Arm length of the mechanism is

$$T = F\ x\ r = 37.69\ Nm$$

Figure 4: Automatic whiteboard cleaner hardware and its electrical connection

Table 2: Materials list

S/N	Parts	Material Used	Size
1	Whiteboard	Porcelain and steel	4 × 6 inches
2	Car wiper	Aluminium and steel	28 inches
3	Wiper motor	Steel	1.3 kg

III. RESULT AND DISSCUSION

The fabrication was tested according to three criteria's which are repeatability, cleaning effectiveness and Time analysis. Repeatability zeroed in on the capacity for the whiteboard eraser to play out the eradicating task consistently and to see the constraints. The analysis is finished by noticing the eraser movement achieved at various checkpoints. This was done on three test cycle where each cycle consists of ten runs of task.

Table 3: Number of successful runs

Segment/Part	Set 1	Set 2	Set 3	Set 4	Average
Checkpoint1	10/10	10/10	10/10	9/10	9.75
Checkpoint2	10/10	10/10	9/10	8/10	9.25
Checkpoint3	9/10	9/10	8/10	8/10	8.50

Based on the Table above, the general execution of the whiteboard eraser is fulfilled on the grounds that there is no set that has lower number of successful runs beneath half which is 5. Furthermore, in determining the effectiveness of the setup, the system was checked to determine the percentage of area cleaned. There were two outcomes for each run such that the board is either cleaned or not. For situations where residue was left on the board, this was classified as 'not clean'.

Table 4: Effectiveness of the whiteboard cleaner

Segment/part	Set 1		Set 2		Set 3		Set 4	
Checkpoint 1	Not Clean	0	Not Clean	0	Not Clean	0	Clean	1
Checkpoint 2	Clean	1	Clean	1	Clean	1	Clean	1
Checkpoint 3	Clean	1	Clean	1	Clean	1	Clean	1
Checkpoint 4	Clean	1	Clean	1	Clean	1	Not clean	0
Checkpoint 5	Not Clean	0	Not Clean	0	Not Clean	0	Not Clean	0

It tends to be seen that the majority of the part is totally perfect. Notwithstanding, there are still parts that are not cleaned it can however be assumed that the cleaner is effective even though there is still possibility of improvement on the cleaning mechanism as the wiper does not provide an adequately thorough cleaning system for the board.

Table 5: Time required for complete wiping (24 Sq.in)

Observation	High (sec)	Low (sec)	Average (Sec)	Manual
Checkpoint 1	8.3	11.5	9.9	27
Checkpoint 2	10.2	14.3	12.3	27
Checkpoint 3	14.5	19.1	16.8	27

It is seen that the time needed for complete cleaning utilizing this arrangement 13 seconds which is an improvement on the manual cleaning mechanism which averages 27 seconds.

IV. CONCLUSION

This design implemented in this paper has successfully achieved the objectives of cleaning the writing board in an effective way while reducing time, effort and increasing efficiency. This study is of high relevance given its useful applications particularly in the educational sector where training tools are constantly required.

Future modifications prior to commercialisation of this design to be taken note of are the requirement of a cleaning system which can effectively clean all part of the board thoroughly. Furthermore, the implementation of a remote controlled or an intelligent cleaning system can further introduce more autonomy in board cleaning operation.

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