Smart Black/Whiteboard Cleaning System

ECE 445 Senior Design

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1 Introduction

1.1 Statement of Purpose

Although powerpoint is widely used in presentation nowadays, black/whiteboards are still not replaceable in some situations. After a long presentation or lecture, it is very possible for the presenter to forget cleaning the board. It is OK if the board is filled with lecture notes. But if the it is confidential information, there will be a problem. Also it is a hassle for professors to clean up the black board every time it is all written, so we would like to design a low cost black/whiteboard cleaning system.

1.2 Objectives

1.2.1 Goals:

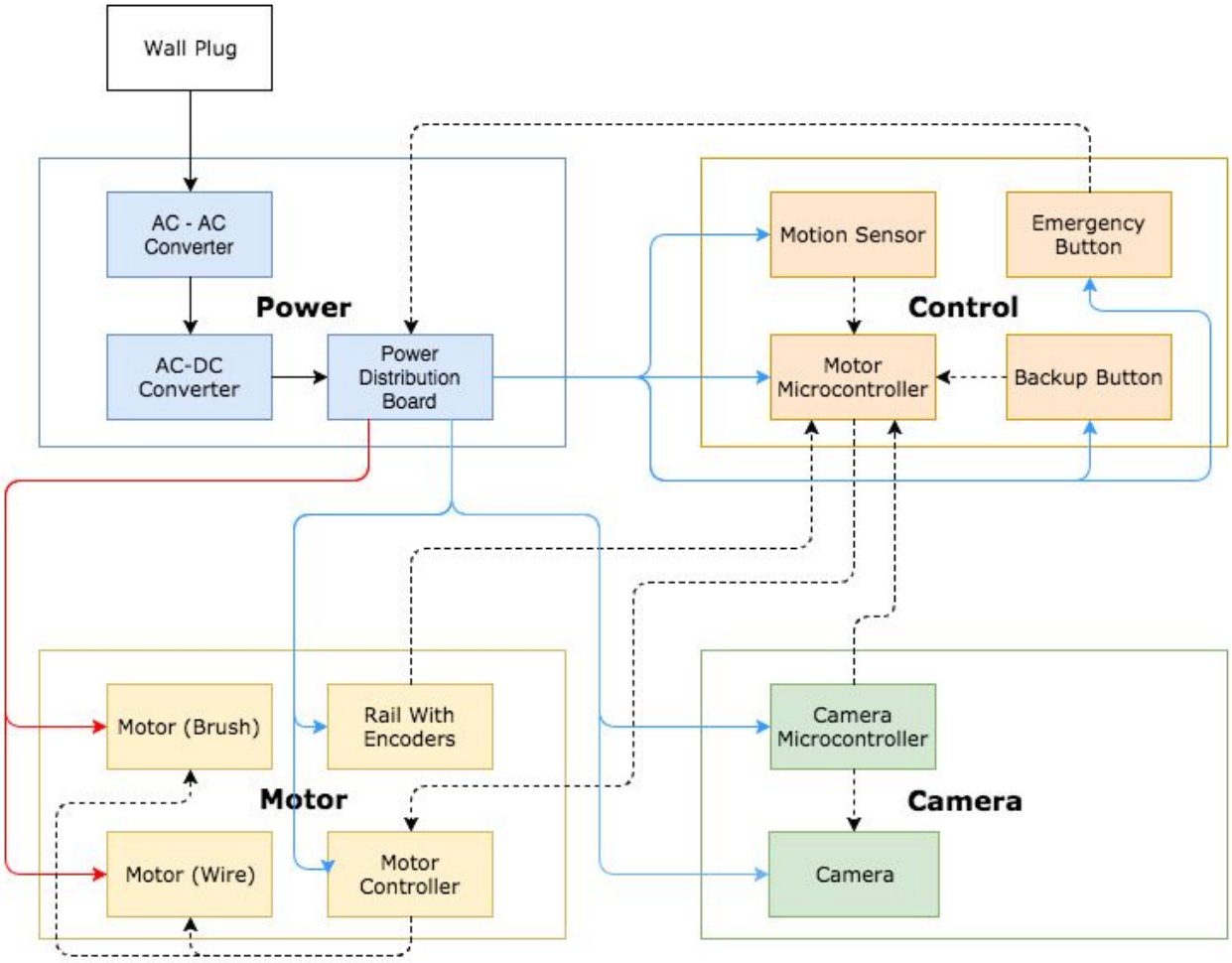
- Less time and effort spent on cleaning boards.
- Prevent unintended access to notes after presenters left.
- Interact with the cleaning system through handwriting.

1.2.2 Functions and Features:

- Allows users to clean the board through writing commands on the board.
- Allows users to decide which portion of the board to clean.
- Cleans the board automatically when room is empty.
- LED indicates which function is on.
- Writing commands choose which function to turn on.

2 Design

2.1 Block Diagram:



Red line: ~12 V power; Blue line: ~5 V power

Dashed lines: Data transmission direction

2.2 Block Description:

2.2.1 Power Module:

- Input:
  - Power input: Wall outlet.
  - Signal input: Emergency button.
- Output:

    - Power output: 11V-13V to motor module, 4.5V - 5.5V to control board.
- Internal: Consists of an AC DC converter to convert voltage from wall outlet, a DC DC converter to step the previous DC value down, and a power distribution board to distribute different voltages to other modules.
- Parts: ($ 10)
    - Wall Plug ($ 1)
    - AC-AC Converter Board ($ 3): Transformer to draw AC voltage down
    - AC-DC Converter Board ($ 3): Full-wave bridge rectifier with diodes, transformer, inductors, resistors, and capacitors
    - Power Distribution Board ($ 3): voltage regulators, capacitors, resistors

2.2.2 Control Module:

- Input:
    - Power input: 5V from power distribution board.
    - Signal input: Image processing module, motion sensor, backup button, and encoders on rails.
- Output:
    - Signal output: Signal to motor controller module and power distribution board.
- Internal: The control board receives signals from image processing module, motion sensor, backup button, and encoders. It uses its own microcontroller keep track of brush position and determine when the brush should move or stop.
    - “ALL ERASE”: If a presenter wants to erase the entire blackboard, just write “ALL ERASE” anywhere on the board
    - “ERASE”: Presenter can write “ERASE” as a cleaning boundary mark on the board. The brush will then move from the side to the the “ERASE” mark, and only cleans part of the board.
    - “CONFIDENTIAL/ANNOUNCEMENT”: When the content of the board is “confidential”, control will clean the board when motion sensor detects no motion for 5 mins. A board is default to be “confidential”, one can stop auto clean by writing “ANNOUNCEMENT” on the board.
    - Backup Whole-Clean Button: Located at the left side of the track, if for some reasons, the image-processing module is not responding to the cleaning command, you can still manually push the Whole-clean button to clean the blackboard.
    - Emergency Stop Button: Push when you need a sudden stop or you need to shut the system down when it is malfunctioning.

- Parts: ($)
    - Microcontroller ($):
    - Motion Sensor ($ 2): Ultrasonic Receiver (up to 3m range) on the control board, Transmitted mounted on desired locations
    - Backup Button: Small push button Switch, such as: ($0.35) http://www.kr4.us/mini-push-button-switch.html?gclid=Cj0KEQjw6uO-BRDbzujwtuzAzfkBEiQAAnhJ0DGkWdFjVYpHo0AfUpTs7or02C4-04yQeiYe6gGybVUaAh7y8P8HAQ
    - Emergency Button: Big push button Switch, such as: ($2) https://www.radioshack.com/products/spst-red-switch?variant=5717517765

2.2.3 Motor Module:

- Input:
    - Power input: 11V to 13V form power distribution board.
    - Signal input: Signal from control module.
- Output:
    - Signal output: Output encoder data to control module to determine brush position.
- Internal: Run or stop the motor according to signals from control module. Rail has attached encoder to send brush position information back to control module.
- Parts:
    - Motor Controller: http://www.ti.com/lit/ds/symlink/l293d.pdf
    - Encoder on rail: Small rotary encoders, such as: https://www.dynapar.com/ATXE_F15/
    - Track Motor: Small servo motor such as: https://www.dynapar.com/ATXE_F15/
    - Motor for rotation:

2.2.4 Camera Module:

- Input: Camera facing the blackboard, taking one picture per second and
- Output: Transmit image-processed data to the control board for later usage.
- Internal: A camera taking pictures and a microcontroller image process these picture dates to recognize if there is a cleaning command on the blackboard. When motion sensor does not detect motion, it sends a signal to the microcontroller to shut the camera off.

- Parts ($):
    - Camera ($ 8):
    - Microcontroller($):

2.2.5 Brush Module:

- Input: Speed data from microcontroller to motor in the rotating brush.
- Output: Speed of the rotating brush
- Internal: Moves as a part of the wire in motor module moves. A vertical rotating brush module, and a motor inside for it to rotate.
- Parts:

3 Requirements and Verification

Requirements	Verification
Wall plug adapter outputs 11V ~ 13V to power distribution board.	Measure the output with a multimeter.
Power distribution board outputs 4.5V ~ 5.5V to sensors and logic unit, outputs 11V ~ 13V to motors.	Support power distribution board with 11V and 13V input and measure the output with a multimeter.
Sensors send appropriate signals back to control module.	Use LEDs to indicate if the sensors are sending signals to control.
Control module correctly recognize sensor signals and trigger corresponding functions.	Use switches to simulate sensor signals and use LEDs to indicate which function is triggered.
Brush stops at edges and pinpoint location.	Start the brush on the edges, between closely located pinpoints to see if it stops properly.
Motors have enough torque to pull brush along the rail and to rotate the brush.	Support motors with 11V input voltage and see if it still have enough torque.
Brush moves along the rail at 0.3m/s to 0.5m/s.	Measure the length of the rail, then benchmark time with 11V input and 13V input.

Brush has enough pressure on the board and rotates at enough speed to clean the board.	Use a constant pressure, move the brush along rail at 0.3m/s and 0.5m/s, with each speed support rotation motor with 11V and 13V input. See if brush properly cleans board.

4 Tolerance and Analysis

4.1 Critical Component

The critical component of our project is the image processing module. Brush position control is second critical component.

4.2 Acceptable Tolerance

95% accuracy in recognizing handwriting in average classroom lighting is acceptable. A 3 cm brush position mismatch is acceptable.

4.3 Test Procedure

Collect handwriting examples from 30 professors and TAs, lighting strength data from 10 classrooms. Set the lighting strength of a classroom to the average of those lighting strength data. Test how many handwriting examples the image processing module can recognize.

5 Cost and Schedule

5.1 Cost Analysis

5.1.1 Parts

	Part Name	Module	Price ($)
1	Wall Plug	Power	3
2	AC-AC Transformer Parts (transformer, diodes, inductors, resistors, capacitors)	Power	4
3	AC-DC Converter Board Parts (diodes,	Power	3

	inductors, resistors, and capacitors)		
4	Power Distribution Board Parts (diodes, voltage regulators, inductors, resistors, and capacitors)	Power	3
			Module Subtotal: $13
5	Microcontroller	Control	8
6	Ultrasonic Motion Sensors	Control	4
7	Backup Push Button Switch	Control	0.35
8	Emergency push Button Switch	Control	2.4
			Module Subtotal: $14.75
9	Small camera	Camera	8
10	Microcontroller for image processing (Rasberry Pi)	Camera	40
			Module Subtotal: $48
11	Motor for track	Motor	8
12	Motor for brush rotation	Motor	5
13	Encoder on rail	Motor	7
14	Motor controller	Motor	8
			Module Subtotal: $28
15	Brush	Brush	4
16	Track Structure	Brush	5
17	Pivot	Brush	0.5

18	Travelling wire/belt	Brush	1
18	Small wheels	Brush	0.5
			Module Subtotal: $11
			Total: $114.75

5.1.2 Labor

Name	Hourly Rate	Total Hour	Total Cost (Hourly Rate x 2.5 x Total Hour)
Yichen Gu	30	$250	$18,750
Lan Li	30	$250	$18,750
Total	30	$500	$37,500

5.1.3 Grand Total

Parts	Labor	Total
$114.75	$37,500	$37,614.75

5.2 Schedule

Week	Task	Person in Charge
09/12	Talk to machine shop	Lan Li
09/19	Mock design review	Yichen Gu
	Determine details of design	Yichen Gu
09/26	Voltage converter (breadboarding + PCB design)	Lan Li

	Handwriting recognition	Yichen Gu
10/03	Design review	Lan Li
	Order parts	Yichen Gu
10/10	Power distribution board (breadboarding + PCB design)	Lan Li
	Control module (breadboarding + PCB design)	Yichen Gu
10/17	Get PCB and solder	Lan Li
	Motor controller board (breadboarding + PCB design)	Yichen Gu
10/24	Get PCB and solder	Yichen Gu
	Revising PCB design	Lan Li
10/31	Integration test and debugging	Yichen Gu
11/07	Integration test and debugging	Lan Li
11/14	Mock demo	Yichen Gu
11/21	Thanksgiving	None
11/28	Demonstration	Lan Li
12/05	Final presentation and paper	Yichen Gu