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Computer Chassis Cleaner

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Abstract

Dirt and dust buildup in computers can cause issues such as blocking of fans, vents and overheating which affects the overall operation and longevity of the computer. These concerns are even more apparent when the computers are heavily used in a laboratory setting. Keeping up with cleaning your computer is essential to ensure you get the most out of it. To aid with this time-consuming activity, RIT's Multidisciplinary Senior Design Team P19330 worked to design, test and assemble a functional all in one enclosure to clean the Electrical Engineering Departments computers with minimal manual intervention. This system will be fully automated to be able to take as much dust as possible out of the computers to decrease the turnover rate and make the maintenance process more efficient. After two semesters of research, testing, fabrication and integration, the team was able to create a functioning prototype. Using a shop vac with an xy-axis rail system and stepper motors, this device would clean dust from as many computers as necessary.

Background

The main goal of this project was to create an all in one automated enclosure to clean a multitude of computers. We were made aware of this issue from the Electrical Engineering Maintenance Department at RIT because of the high turnover rate of the lab computers due to the lack of maintenance on them. Currently, cleaning computers is a very time consuming task that results in them being cleaned about once every five years, or when they are ready to be donated. Each computer needs to be taken outside to be cleaned with compressed air from the machine shop because the extreme dust buildup makes cleaning indoors hazardous. Alternatively, vacuuming each of the computers by hand is also inefficient due to the large number of computers in the department and runs the risk of causing electrostatic discharge (ESD) damage to components even though it can be done indoors. A self contained automatic cleaner will cut back on time taken to clean and overall cost of maintenance as well as lengthen the life of the computers.

Description of Design

The design for this enclosure was formed by first establishing that the main functions had to be circulating the air, removing the polluted air, supporting the internal components, and protecting and cleaning the computer. All while keeping in mind that the system had to be entirely self contained and no air or dust could get out. After several meetings with our customer, a list of key customer requirements, listed in Table 1, was established to base our design around. The customer needed it to save time, be completely portable and easy to transport, and successfully clean the computers while keeping the dust contained.

Table 1: Customer Requirements

Category	Customer Rqmt. #	Importance	Description
Portable	P1	9	Simple to move to different locations
	P2	9	Not too large/heavy for relocation
Inexpensive	I1	9	Use of shop vac for air supply
	I2	6	Low budget
Safety	S1	9	No ESD damage to PC
	S2	6	Noise
	S3	9	Dust/dirt containment
Convenient	CN1	9	Bringing to lab
	CN2	9	User friendly
	CN3	6	Minimal manual intervention
	CN4	6	System Longevity
	CN5	9	Power shop vac automatically
	CN6	3	Detect shop vac incorrect connection
Timing	T1	6	Time to clean a PC
	T2	3	Time to restore PC to operation
	T3	3	Time to prepare PC
Cleanliness	C1	6	Cleanliness of PC
	C2	6	Clean fans, power supply, and ports
	C3	6	Cleanliness of enclosure
Usage	U1	6	Ability to fit full towers inside enclosure
	U2	9	Ability to fit mid tower inside enclosure
	U3	3	Ability to fit server board in enclosure
Cust. Rqmt. #: enables cross-referencing (traceability) with engineering requirements			
Importance: 3 (least important) - 6 (Some importance) - 9 (most important).			

One of the biggest constraints the team had to work around was the air source for the entire system; the customer wanted to use a shop vacuum provided by the Electrical Engineering Department. This drove the decision of our final design. Also, we were originally given a budget of $500 which was concerning seeing as the device needed to be completely automated with as little manual intervention as possible. We later got a budget increase and no longer had to worry about this constraint.

In MSD I, the team agreed upon a design that included a static system of multiple nozzles. A divider was going to be made to separate the main airflow into smaller sub-branches to create a field of airflow into the inner enclosure. An intake manifold was going to control the airflow from the shop vac, with the use of valves, to divert the air where needed. However, toward the end of the first semester, after revisiting air flow parameters and the rating of the shop vac, the team realized this design wasn’t feasible. The shop vac would not be able to give a sufficient amount of airflow for the amount of static nozzles needed to properly clean a computer. The amount of nozzles needed would have divided the air flow so much that it would have either generated extreme back pressure, or have little airflow at all. The team quickly brainstormed and came up with a completely new design.

After going through some initial ideas, the team came to the final design which includes a dynamic system with a moving air column. It made most sense to use an XY stage, similar to those in 3D printers, to cover translational movement inside the enclosure. Two 8mm diameter steel rods are positioned in parallel with a 6mm wide timing belt running along both of them to pull the X axis system. Two more parallel steel rods run perpendicular to the X axis rods with two side cards and a main middle cart, Figure 1, for the Y axis. From there, an air column made from PVC with a row of 15/16 inch brass nozzles is hung from the rail systems main cart, Figure 2, and rotates with a bevel gear system. A boom arm is also used as a floating component above the rail system to support the tubing, ensuring that there’s no unnecessary bending or interference from them.

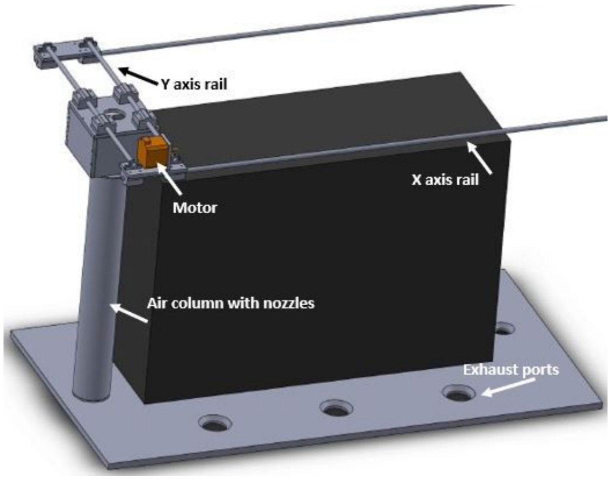

Figure 1: Rail system around computer

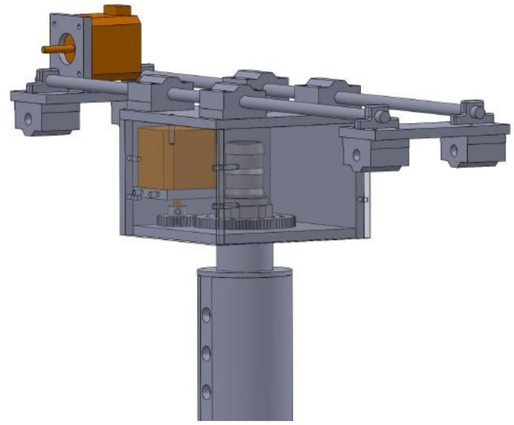

Figure 2: Zoomed in view of Main Cart

All of the mentioned components are located inside an internal box made of plywood. That internal box is then located inside a larger, external box also made of plywood. The external box shares two walls with the internal enclosure. There's spaces in between the other two walls to make room for all electrical components and tubing. There are wooden spacers separating the bottom of the two enclosures that houses the intake and exhaust tubing/connections. The lid is located on top of the enclosure and only opens into part of the internal enclosure to block the internal components from being damaged. This way, when putting a computer inside, the user can't accidentally hit any components.

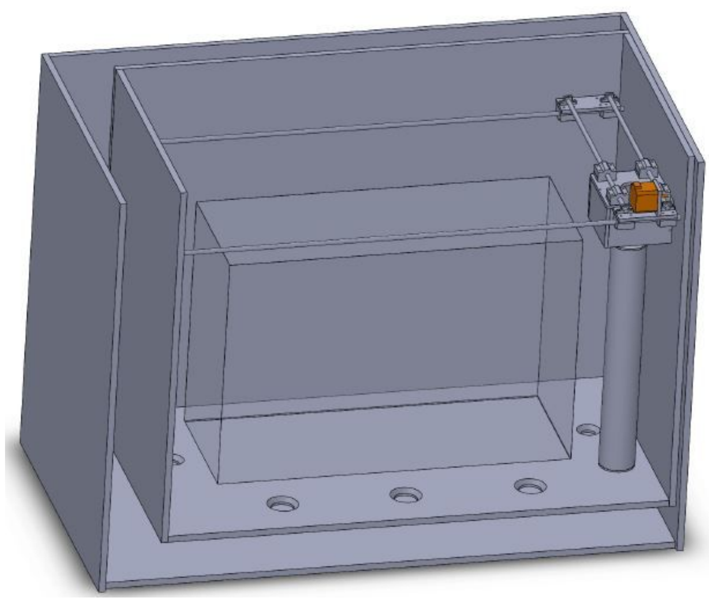

Figure 3: Internal and External Enclosure

The electrical system was designed with four NEMA 17 stepper motors driven with Pololu A4988 Stepper Motor Driving Chips. Two motors move the longer X axis, the third moves the shorter Y axis and a fourth rotates the air column, all seen in Figure 1, so that it's always able to direct the air towards the computer regardless of where it is. Microswitches are used to mark the end of the X and Y axis span. Another microswitch is needed to find a known location on the air column angle. Then the number of steps the motor spins can be counted and recorded through software to move the air column to desired angles.

The system uses a custom control board with a Texas Instruments MSP430 Microcontroller, seen below in Figure 4. The board contains the motor driving chips, a 12V control chip and the microswitch circuitry. Additional functionality for future designs are also available but the parts are not populated on the board. For example, a bluetooth chip could be added to wirelessly control the system if in the future it is ever desired. The 12V control circuitry is used to drive indicator lights for the user's display. 12V indicator lights are used thus requiring 12V control circuitry.

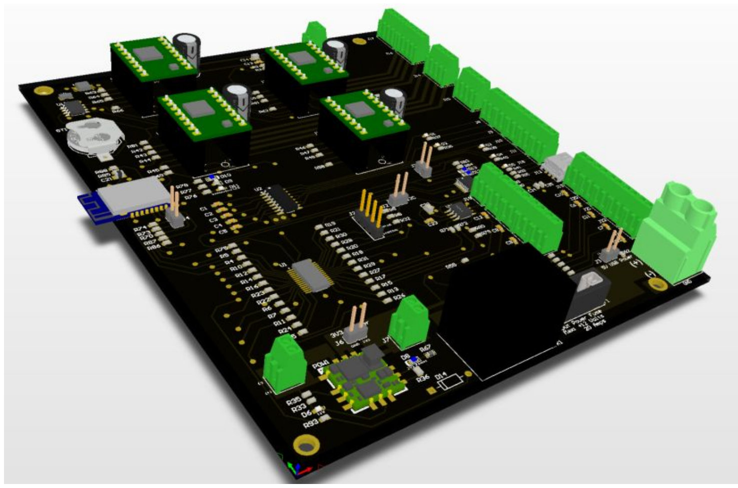

Figure 4: Custom Control Board

The shop vac used with this cleaner is also automated. An AC power receptacle was placed on the enclosure for the shop vac's power cord to plug into. If the shop vac's power switch is left in the 'on' position, the outlet will only provide power when the shop vac is needed for cleaning, thus automating the shop vac usage. The outlet is controlled using a solid state relay. The relay is controlled through the custom controller board using a 12V DC signal, (going through the 12V control chip).

For safety, the control board has a 10 Amp Blade Fuse to protect the power supply if any damage occurs to the board or one of its connections. Additionally, the system contains a 15 Amp Circuit Breaker / Power Switch near the power inlet receptacle. Figure 5 shows the detailed flowchart that explains the full cleaning process and how the code functions on the microprocessor.

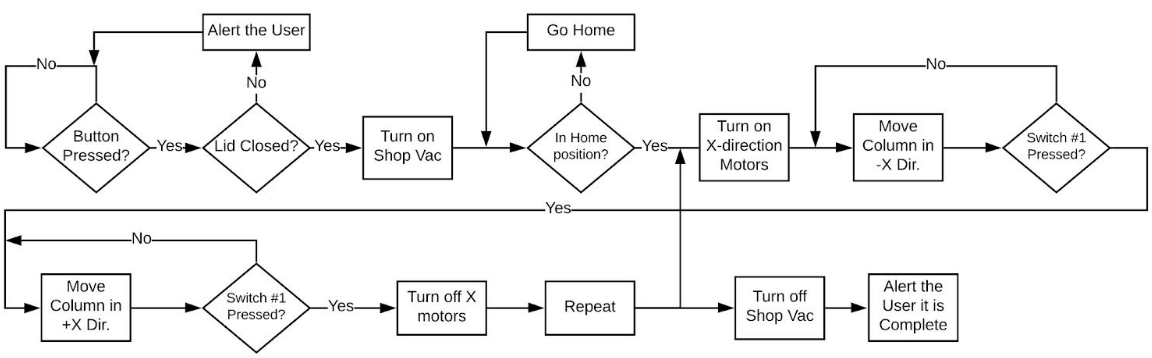

Figure 5: Cleaning Flowchart

Figure 6 illustrates where the switches and motors are placed to follow along with the flowchart.

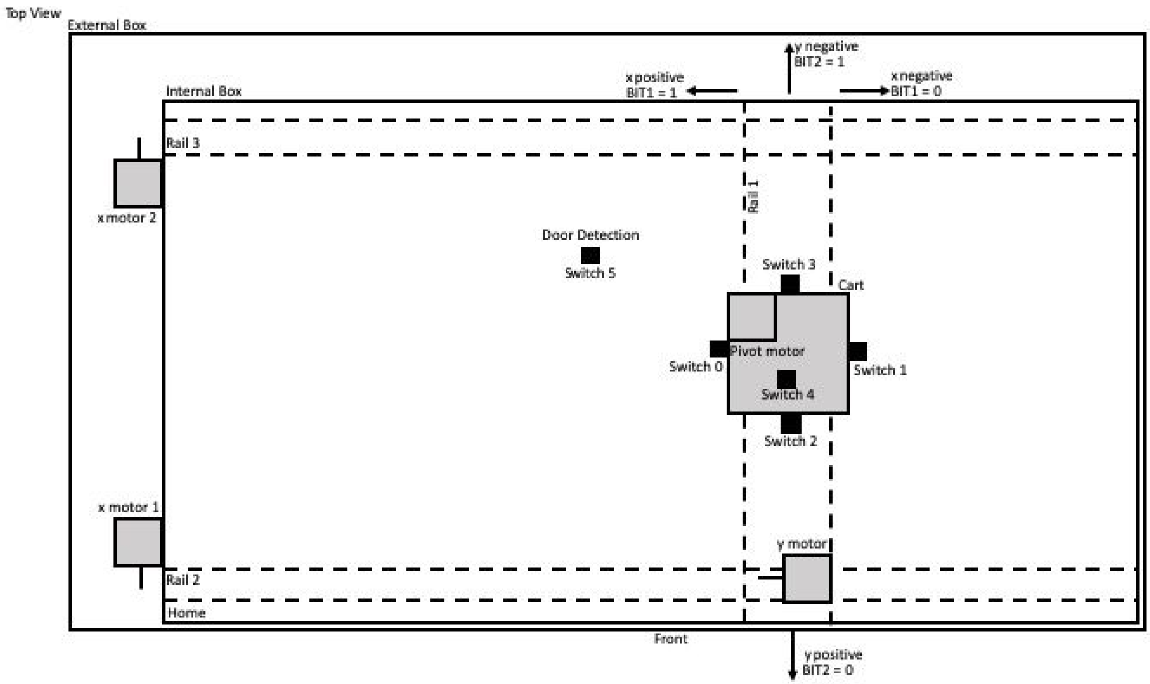

Figure 6: Motor and Switch Designation Drawing

There is further code that could be implemented with adjustments to the hardware to make the air column pivot and travel down the y-axis. This is explained further in the recommendation section.

Supporting Feasibility Evidence

Once the enclosure was fully assembled, various tests were performed to ensure the reliability and safety of the system. Simple tests were performed to ensure it would fit through the necessary lab doorways, fit the various sized computers, not be excessively loud and be light enough to be relocated by anyone. Timed tests were also performed to see how long someone would take to use and prep the system. The goal values for these tests were that it would take someone around 2 minutes to prep the system and 5 minutes to learn how to use the system. The test results showed that it took around 1 minute for people to prep the system and 2 minutes for them to take the manual and learn how to use the system from start to finish. This showed that the system is very user friendly and quick to figure out. Due to technical difficulties, testing a full cleaning cycle could only be done with the system moving in one direction, back and forth. The rotational movement of the air column wasn't in working condition since the gears bind together, making it very difficult for the motor to rotate. With this in mind, testing how long one full cycle takes ended with results of, on average, slightly under 1 minute. The ideal value was around 1 minute so this value meets the requirement.

Since it's important that our system doesn't allow for any dust or dirt to escape, the team performed tests to make sure that wouldn't be an issue. After running the cleaning cycle multiple times with dust inside, it was clear that no significant amount of dust was escaping the system. Also, since one of the most important factors was that the computers would be adequately cleaned after one cycle, extensive tests were performed to see if various sized computers would be sufficiently cleaned with various amounts of dust. The results for these tests were less than ideal since the shop vac didn't give off a sufficient amount of suction for the size and amount of exhaust holes present. Some dust was removed but not the necessary amount to fulfill the requirement. One of the exhaust holes was plugged in an attempt to help with this issue but the results didn't change much. A nozzle was also removed from the air column. This helped somewhat with suction pressure and a stronger stream of air to lift the dust. Recommendations for fixing this issue, had there been time, are discussed later in the report.

The stage functionality was tested, this included the motors and switches as well. Once it was determined that all of the motors could be controlled by the chips on the board, the ability to change direction and vary the speed was tested. After the stage was built, the motors were mounted and tested in application with the switches. They were determined to be functioning properly and little code had to be adjusted. However, the rail system for the stage had to be adjusted to be parallel to allow the cart to travel freely and the switches to be pressed. Possible risk to functioning computers was not tested. Tests were performed using already damaged PCs. A grounding clip is included in the system in an attempt to resolve the risk of ESD damage. Further testing is necessary to ensure no damage will occur to functioning PCs during the cleaning process.

Conclusions

The team experienced various setbacks over the course of the project. One of the main challenges being a strict time constraint. The team was very crunched for time at the end of the second semester and had to ultimately cut some corners in the design and testing. Another factor that contributed to the difficulties the team faced stemmed from the lack of benchmarking for comparison. There are really no other devices out there that autonomously clean computers in such a way.

Through the design process, a few concepts were investigated and considered, most notably a static system with multiple nozzles and a dynamic system with a moving air column. In the end, an enclosure with an XY stage similar to a 3D printer and a moving air column was decided to be the most feasible. Construction of the system became delayed fairly early on in the second semester, from resolving budget constraints before purchasing material to unexpected problems encountered while putting the design together, various road blocks had to be overcome.

In the end, the team assembled a moving proof of concept that possible future teams or students can develop further to fully satisfy the customer. The prototype does not have the complete functionality that was envisioned in the proposed design which includes a rotating air column, a self-cleaning function, or a fully vetted XY stage. Although the current system cannot rotate the air column and the stage has trouble reaching the ends of the axis, the system is automated to move the air column along the main long axis in an attempt to clean the computer. Testing showed that additional work needs to be done in order to efficiently clean the computer. The additional work is investigated in the recommendations section of this report, where the air column rotation and weak air pressure is discussed. In conclusion, tt is proven that the design is feasible and can work appropriately with more time and effort.

Recommendations

There are some ideas the team would have implemented had there been more time. Installing a side door for easier access being one of the biggest. For ergonomic reasons, the team believes the current state of the enclosure is not the most efficient and safest design. Since it is such a large box, lifting the computer up and bending over to gently put it into the internal enclosure is not the easiest task. For anyone with back problems, this isn’t ideal. A side door would help to mitigate this issue so the user can just slide the computer in without lifting it.

Another possible modification is to add the functionality of the pivoting motor that sits within the air column cart and the movement along the y axis. This would improve the cleaning by enabling the air column to blow air directly on the sides of the computer. The code to move down the y axis is written, it would have to be enabled had there been more time. To successfully pivot the air column it is suggested to use a second rolling bearing to be able to constantly turn the column. The current design only has one set of bearings, but due to stress from the vacuum tubing, the air column does not sit evenly on the bearings. Using a second set of bearings on the bottom side of the main cart, the air column could be held in place and glide smoothly along the bearings.

Lastly, as mentioned previously, the computer can not be adequately cleaned with the current system. The team didn’t have time to do proper testing to determine the main cause of this issue but it seems the shop vac may be too weak for the system. Another possible cause is that the nozzles restricted the air flow too much. To mitigate this serious problem, the team suggests using a more powerful shop vac or changing the nozzle sizes. This will allow for a greater suction force so the dirt and dust will be adequately sucked into the exhaust holes and out of the system.

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