Low Cost Braille Embosser Phase II

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Abstract
The aim of this project is to design and produce a low cost braille embosser that is both functional and practical. Current braille embossers are expensive, making it difficult for the average blind user to obtain one for personal use. The task of making a more economical braille printer is important because it would make reproducing braille documents easier and more accessible to the blind community, thus increasing braille literacy and increasing the employment of blind people. The design produced by the previous Phase I group was simply a proof-of-concept prototype and illustrated that the method devised for embossing braille characters could successfully emboss letters, which had been typed on a laptop, onto a piece of paper. However, the devised process would theoretically take 20 minutes to emboss one full page and was not capable of embossing a complete page of braille text. Additionally, synchronization of the motors was not addressed, horizontal indexing of the embossing unit was not a priority and the software could not be recreated outside the original system. Phase II of the project has built upon the accomplishments of the previous group, embossing 1 full page of braille text from a file, addressing mechanical strength issues of the previous prototype, converting text documents to understandable commands by the software and increasing compatibility to any computer system while maintaining the $500 price point and quietness of the previous design.

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The Need for Project

The blind community is in need of an economical way to produce braille text. The National Braille Press (NBP) estimates that 2% of the population of the United States is legally blind and that only 12% of that percentage can fluently read braille. The blind community agrees that braille is essential for written communication between members of its community, despite the advent of increasingly blind-friendly technologies in modern PCs and electronics. Although there has been an increase in these blind-friendly technologies, the information on these devices is still most easily accessible to the blind in a physical medium, braille embossments. Currently, braille embossers are extremely expensive relative to normal printing means; the least expensive braille embosser on the market today costs $1,995. More efficient models increase this price point exponentially, making these embossers unavailable to not only families with blind members, but also school systems and offices with blind students or employees. Thus, the blind community is most in need of an economical way to produce braille text.

The Design Project Objectives and Requirements

This embossing unit must convert text written electronically on a computer to physical braille characters embossed on paper at a price that is significantly less expensive than products currently on the market.

Design Objectives

This braille embossing unit must convert text written electronically on a computer to physical braille characters embossed on paper at a price that is significantly less expensive than products currently on the market.

Design Requirements

The final design for this embosser must produce braille according to the standards set by the Library of Congress Standards in the American Braille Technical Specifications at a price of $500 or less. The braille embosser must also emboss on special paper used by the NBP to produce a surface finish agreeable to blind readers. The design must also meet usability requirements of embossing full pages of braille text from an electronic file, at sound levels at or below the industry average of 69.75 dB and utilizing plug-and-play USB technology. Lastly, this design must be mechanically robust to increase product lifespan and be manufactured as quickly and by as few people as possible.

Design Concepts Considered

The Phase I design was

Phase I Design Description
The Phase I design concept featured a mechanical assembly for embossing braille that replaced the ink cartridges in an Epson NX415 inkjet printer. The embossing mechanism utilized three motors to emboss braille characters; a DC motor for linear actuation and two stepper motors for braille character selection. The DC motor achieved linear actuation by rotating an eccentric shaft. When this shaft rotated, the embossing unit moved up or down into a pin-pack that embossed letters onto braille paper. The two stepper motors allowed for selection of different braille characters via two embossing wheels attached to each stepper motor. These embossing wheels featured a specific pattern of holes drilled into the outer diameter of the wheels that allowed for different combinations of up to 6 pins in the pin-pack to be pressed onto a sheet of paper. The final mechanical component in this design is an aluminum back plate which served to stop the pins once they have embossed the paper. The motors in this configuration were controlled by a completely custom control interface that was incorporated into the existing electronic components of the printer.

**Phase I Design Analysis**

This design was initially considered but ruled out due to optimization concerns. The DC motor rotating the eccentric shaft could operate at a maximum of 60 RPM, which limited the theoretical rate of embossment to 1 page every 20 minutes. This slow rate of embossment not only limited the practicality of this design due to slow embossing speeds but it was also a theoretical speed; the embossing unit produced by the Phase I group could not produce braille text from an electronic file. Additionally, this design featured a custom wiring scheme that was entirely disassembled at the start of Phase II of the project and could not be recreated using a second Epson NX415 printer. Lastly, this design featured control software that could not be recreated outside the system it was initially designed on, meaning that the software needed to be redesigned from scratch.

**Recommended Design Concept**

This design meets all major design criteria; it embosses braille from a computer file for a price that is a fraction of the...
mechanism utilizes four motors: a linear actuator stepper motor for linear actuation, two small stepper motors for braille character selection and one large stepper motor for horizontal indexing of the embossing unit. The linear actuator stepper motor uses a power screw attached to an embossing plate to move the two stepper motors up or down into a pin-pack. The two small stepper motors allow for different braille character selection through two octagonal disks. Different patterns of indentations around the perimeter of these two disks allow for different combinations of up to 6 pins in the pin-pack to be pressed onto a sheet of paper. The fourth motor in the design, a large stepper motor, allows for more accurate horizontal indexing of the embossing unit across a sheet of paper. The last mechanical component in this design is a stationary rubber back plate installed beneath the paper feed mechanisms. This back plate serves to stop the pins once they have embossed the paper. The entire embossing mechanism is enclosed in two aluminum brackets to allow for easy attachment to the ink carriage and structural stability while the unit embosses. The motors in this configuration are controlled by two Arduino controllers that allow for easy programming of each motor.

Design Analysis

This braille embossing design meets all major design criteria of a low cost braille embossing unit. Using the Arduino controllers, text written electronically on a computer can be sent to the embossing unit and embossed onto a page of paper. This design also meets the low cost price requirement, as a final product would cost much less than $500. Additionally, the design meets all usability requirements: it embosses onto the special, heavy weight paper used by the NBP, it embosses a full page of braille text from a file, it embosses at a sound level less than the industry average of 69.75 dB and it makes use of USB plug-and-play technology.

Design Advantages

This design has several advantages over the previous design. This design produces braille text from an electronic file and operates at a quieter level because it utilizes a rubber back
plate that naturally dampens sound. Due to the Arduino controllers and the large software library available for use with these controllers, this design is also easier to optimize and transfer to new systems because Arduino software is freeware and open-source. Lastly, this design is more mechanically robust, as it is enclosed in aluminum sheet metal.

Financial Issues

The cost for a final product is $279.78, but this price does not include labor or shipping costs. One of the main design objectives of this embossing unit is to meet a $500 price point to ensure that this unit is affordable and easily accessible to the blind community. In designing the prototype, all effort was made to minimize costs. A total of $640.70 was spent on the prototype design. When considering the cost for a final product, this price reduces to $279.78 for all the components. This price reduction is due to the reduced price associated with buying all parts in bulk and does not take into account the costs for labor or shipping.

Recommended Improvements

Before a final design can be made, further optimization of the control mechanisms should take place. Covers should be designed to enclose the embossing mechanism within the printer and increase the aesthetic appeal of the design. In terms of functionality, the control system can be optimized in terms of increasing the characters per second output by either selecting higher quality motors or by further synchronizing the control motors. The breadboard design currently in use could be created into its own circuit to increase compactness and lower the chances of wires dislodging. The current system is also powered by two separate power supplies due to the different voltage requirements on the DC motor and the stepper motors. A single supply connected to a power distribution port would allow the use of only one power supply that can be connected to any wall jack.

In order to increase the life of the printer and make it more durable, adding DC powered fans to regulate the heat increase from the motors, dampening the system to lower noise and
vibration and improving the embossing pin head design to lessen the wear on the rubber could be implemented. This would ensure the motors last longer and that the whole system stays intact throughout the rapid, repetitive embossing motion.

Many things can also be done to improve the embosser aesthetically. Since the original cartridge was modified and is now higher, a new cover will have to be designed to cover the inside of the printer and protect it from outside objects, water or dust. As stated previously, putting the circuit on a printer circuit board will make the wiring look more orderly and in-turn will make it safer.