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Research Articles

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Abstract

A pervasively high level of braille illiteracy has hampered heavily the large number of partially or completely visually impaired persons in today's society, their integration into society as productive, educated, and capable members. This problem is further compounded by the fact that the braille printers are prohibitively expensive – generally starting from two thousand US dollars, beyond the reach of a common person. The purpose of this paper is to introduce a highly cost-effective Braille printer primarily utilizing an Atmel AVR microcontroller (ATMega 32a) and servomotors acting as rotary and linear actuators, coupled with gears. The printer can be controlled by attaching it to a personal computer. A prototype of the device has been constructed and shown. The prototype in question has been built at a cost of 30 to 80 times cheaper than the current market standard for personal braille printers.

Keywords: Printer, braille, servos, P-module, C-module

I. Introduction

The number of visually impaired people in India has been increasing steadily over the past twenty years. It is estimated to be 24.1 million by 2010, and 31.6 million by 2020. The vast number of blind people in India is a great source of concern. Considering a 2004 survey, out of 72,044 visually impaired individuals, 71% were found to be illiterate, and 84.6% reside in the rural areas [1]. A factor that further makes this problematic is the fact that the cost of Braille printers lies from $2000 to $5000, with a large volume Braille printers costing anywhere from $10000 to $80000 [2].

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Hence, it can be seen that the need for a device to aid this marginalized section of society is pressing and inarguable. Therefore, the primary focus of this work is in introducing an inexpensive Braille printer, the first of its kind, the working of which will be explained in the following sections.

1. Basic Principle

A. Components of the Printer

The printer is effectively composed of three modules each comprises further sub-modules. These three modules are

i) The outlying structure
ii) The Printer module
iii) The Controller module

The outlying structure forms the base for the printer, onto which the entire apparatus rests, as well as the chassis of the printer, which acts as the base for the print heads.

The Printer module (denoted hereafter by 'P-module') comprises an ATMega 32a [4] microcontroller which

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controls the print heads, driven by servomotors. The chief function of the P-module is to receive the input data from the computer to which it is connected, and perform the corresponding printing function onto the input paper.

The Controller ATMega 32a module (denoted hereafter by 'C-module') comprises a second ATMega 32a board, connected to servomotors, coupled with gears. The chief function of the C-module is to receive a signal from the P-module following the printing of a line and bring about a 'Reset' condition, so that the next line can be printed.

B. Operations of the Printer

The printer can be operated in two ways. Firstly, as a typewriter, i.e., the printer prints the text as it is being typed on the computer; and secondly, as a printer, where the entire body of the text is given as an input and the printer performs the intended operation. When the printer is being utilized as a typewriter, the input text can be transmitted to the P-module (connected to the computer) by entering in the text through the keyboard. When the printer is being used as such, the input is given through a .txt file sent through the COM port of the PC to the ATMega 32a utilizing a C++ program, which is then printed.

C. Generalized working of the Printer

Analyzing the working of the printer from a top-down general approach, the printer's operation can be broken down as follows:

i) The PC sends the text input to be printed to the P-Module. Each text character is coded to its corresponding Braille character in the C program being run by the P-module.
ii) The P-module receives the command, prints one character by controlling the print heads.
iii) After printing one character, the P-module transmits a signal to the C-module. This transmission is accomplished by conFigureuring the two pins as TX and RX pins in both the modules; TX being connected to RX and vice-versa. The communication is achieved serially.
iv) Receiving the signal, the C-module moves the print heads by one character spacing.
v) The above steps are repeated until a fixed number of characters per line is printed
vi) Once the line has been printed, the P-module transmits another signal to the C-module that signals the C-module to revert the print head back to the initial position, and to push the paper by one line.
vii) Process i) to vi) is repeated until the entire document is printed.

In the case of a document, which requires multiple pages to be printed, the user must insert a fresh page into the printer feed and manually resume the printing process, and the printer will resume printing.

II. Prototype and Results

A prototype is composed of the same three basic components. It operates on the same general working as stated in the previous section. The details on the working of the printer through the example of the prototype are given in the following sections.

A. *Structure*

The outlying structure is composed of plywood, and consists of a platform (30x50 cm) which acts as a base for the printer. There is a metal chassis – two steel plates of height (9 cm) separated by a distance of 24.5 cms. It acts as the passageway for the paper. The plates are mounted onto the base on a separate (2 cms) raised base of plywood, and fixed by L shaped axle clamps. Through the chassis, one set of metal axles of diameter (0.3 cm) is fitted near the top at a height of 8.5 cms. Each axle in the pair is separated by 3.8 cms. There is a rectangular structure, made of plywood, fixed onto the base, which houses the printer arrangement.

The function of the set of metal axles is to facilitate the paper movement, as well as act as a base for the print heads. There are two cardboard platforms (one on the lower set, the other on the upper set) fixed to the axles for this purpose.

B. *P-module and working of the print heads*

The P-module (or Printing module) is composed of an ATMega 32a, connected to the PC. To this ATMega 32a are connected three micro

servomotors (model SG90 [5]) of torque 1.8 kg cm, capable of 180° rotation. These servomotors form the basis for the print heads. To each servomotor, there are two needles diametrically attached by a distance of (0.6 cm) at a plane perpendicular to the shaft axis of the motor. Two motors are arranged on opposite ends on the lower cardboard platform for printing the upper and the lower pairs of dots for each character. The upper platform has the third servomotor (with longer pairs of needles diametrically attached) arranged such that it is able to print the middle hole pair.

From Figure (i) (refer to the Figureures section), it can be observed that the second (and final design) enables the print head to be more compact overall as it allows all the three servomotors to be placed longitudinally. The print head needles are channeled through the plastic pipes of a diameter (0.4 cm) fitted through perforations in the cardboard platform. Each text character is coded to a specific hole pattern (the corresponding character in Braille). Accordingly, each servomotor rotates clockwise or anticlockwise, to create the right or left hole, respectively. Thereby, the Braille character is printed.

C. *The C-Module and operation of the 'Reset' condition*
The C-module (or Controller module) is composed of a second ATMega 32a, to which two servomotors (model FS5106R) of torque 6 kg cm are connected. These servomotors are capable of continuous rotation, and have the metal gears. One servomotor is fixed on the top of the rectangular plywood structure. The gear of the servomotor is connected to the print head arrangement by way of a rack and pinion arrangement. The function of this servo, therefore, is to move the print heads laterally by one character spacing, in order to print the next character. After a set number of characters is printed (this is accomplished by incorporating a counter in the ATMega 32a code), the servo performs the 'Reset' condition and moves the print head arrangement back to the initial position.

Meanwhile, the second servomotor is connected to a gear axle situated at the back of the printer. Its purpose is to rotate by 1 cm line space after each line and thereby complete the 'Reset' condition by pushing the paper forward by one line.

D. *Cost Analysis of the Prototype and Performance*
One major advantage of this printer can be seen in its cost-effectiveness. The plywood base of the prototype cost approximately ₹200, while the combined cost of the two ATMega 32a microcontrollers being utilized was ₹400. The half rotation micro servomotors cost ₹300 each while the two full rotation servomotors cost ₹600 each. Overall, the entire cost of the prototype is within ₹4000, which is truly minuscule when compared to the cost of a commercial Braille printer ($2000 - $5000).

The prototype has been demonstrated to be able to print one Braille character in 1-3 seconds, and to be able to print a 24-character line in approximately 25-30 seconds, depending on the characters being used.

E. *Power requirements*
Unlike the conventional Braille printers, the prototype does not necessarily require external AC power to operate. The P-module's AVR microcontroller is operated through the connection with the PC, and the motors are powered either through a 9V DC battery, or by connecting to a wall wart.

III. Discussion : Possible Improvements, Future Scope, and Current Printing Technologies

It is imperative that the principle and the basic working of the printer be held in greater importance than the current crude state of the prototype, which requires multiple improvements.

As the writing of this paper is in progress, a new design of the printer is being worked out. The new design would implement the following features

a) *A more compact structure is being developed using more robust materials*
b) *Direct USB interfacing*
c) *Gesture based input for printing*
d) *Faster speed of printing*

As far as the future scope of the printer goes, many applications can be thought of. One major extension

that the printer could be coupled with is that of a speech-to-text software; the user could speak into a voice input device, and the software could convert it to text format – ready to be printed by the printer.

B. *Current existing technologies*

The current Braille printers rely on a printing technique reliant on a technology patented in 1980 (US PATENT 4183683 A – Line printer for the raised-dot language of Braille characters). [3] A printing mechanism of a line printer for printing the Braille characters is disclosed. The printing mechanism comprises a base member having a plurality of printing pins arranged in a row and adapted to be prevented from moving downward in response to the energization of solenoids corresponding to the character patterns to be printed, a semicircular printing plate for pressing a paper against the printing pins and a printing plate driving mechanism. During every printing operation, the printing plate is rocked in a lengthwise direction by a pair of rotating disks provided at the both ends of the printing plate. In addition, each including an eccentric cam groove different in phase with each other, so that the paper is successively pressed against the printing pins in the direction of their arrangement and the raised dots are produced. In another embodiment of the invention, the printing plate is operated by a pair of piston-crank mechanisms provided at the both ends of the printing plate.

The advantages of the current prototype, as compared to the aforementioned patent, are, firstly, it generates significantly less noise. The noise generated from the piston-crank mechanisms of the patented technology is high as compared to the prototype, whose noise level is comparable to a typical bedside clock. The second advantage is, as already mentioned above; the entire apparatus can run off a typical 9V battery, unlike the conventional Braille printers.

IV Conclusion

Considering the large number of visually impaired people in India, and the corresponding high level of illiteracy, the introduction of such a Braille printer would greatly improve their livelihood, and the quality of living.

V. Figureures

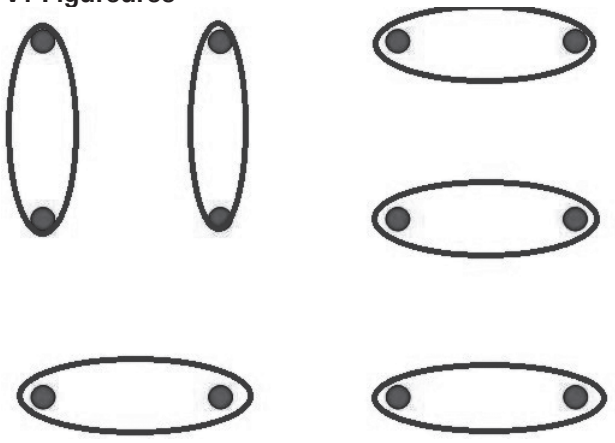

Figure i: Arrangement of servomotors for print heads. The second arrangement is the final design used in the prototype.

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