Chapter 14
Diagram Drawing Using Braille Text:
A Low Cost Learning Aid for Blind People

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ABSTRACT

This chapter presents a novel system for drawing geometric diagrams on the Braille medium in order to make the diagrams tactile and accessible by blind people. The computer graphics algorithms for drawing digital shapes have been suitably modified to make them work for the Braille environment. The goodness of the diagrams is measured by quantifying approximation errors in these diagrams. This chapter further demonstrates how computational intelligence can be embedded in the system to develop an intelligent teaching-learning aid for the blind, especially for teaching them figure-based subjects like geometry, physics, engineering, drawing, etc.

INTRODUCTION

In the study of different science and engineering subjects, we often encounter texts or problems that are essentially illustrated by figures or diagrams. To understand (and also solve) a problem, the representative diagrams are not a mere convenience but also an inherent component in a person's cognitive representation of a scientific text or problem. Therefore diagrams are important for the blind people just as much as it is for the sighted people. But generating and communicating graphics for the blind people, in the context of a subject, is not as straightforward as it is for the sighted people.

There has been substantial research work on communicating informational graphics to the blind students. As a result several interfaces, tools, and

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programs for production of accessible graphics are available in developed countries. But most of these systems are research prototypes and not commercially available. Some systems are available in developed countries but they are prohibitively expensive for wide usage in developing countries. Braille (image) embossers that can generate high resolution tactile images through specialized graphics programs are globally available today, but at high cost. The schools in developing regions cannot afford to have image embossers (for directly printing tactile images) or even image enhancer (for translating any pre-existing image to tactile form). At best the students of these schools can have access to traditional Braille text printers that cannot print tactile image.

So, a genuine problem in mathematics education of the blind people in the developing countries is that they cannot access modern tactile media for sensing geometry drawing. Though manipulatives like nail board or wooden pieces are sometimes used to perceive simple diagrams in lower classes, the lack of frequent access to tactile diagrams of wide varieties in higher classes cause severe compromise with proper science education. Braille text printer is available to them so it would be nice if geometry drawings can be printed on Braille paper. But owing to the irregular dot-grid of the Braille text printing system, standard computer graphics programs or tactile graphics programs cannot be directly used to draw diagrams through such medium.

In the backdrop of the above scenario, one of the two distinct contributions of our research is that we introduce a method by which digital diagrams can be mapped to Braille environment and corresponding tactile diagrams can be produced using traditional Braille text printer. Such printer is the cheapest of its kind and commonly available in most blind schools in countries like India. The proposed method does not make use of any sophisticated interface, rather relies on Braille dot grid with uneven spacing of dots to map elements of a diagram already defined for digital display. Improvisation of such Braille printer (meant to print text only) to represent geometric diagrams is far more challenging than using image embossers with evenly spaced dots. Here, the size or height of the embossed dots cannot be varied and can only be placed within a 6-dot cell (Braille character). In this chapter, we address a complete set of algorithms for representing point, straight line, and circle using Braille code. We have shown how using these basic shapes, simple geometric figures like triangle, rectangle, parallelogram, etc. and diagrams comprising many shapes and configurations can be generated through Braille text printer.

The other contribution of our research is that we have proposed a simple yet useful method to evaluate line and circle represented in Braille by quantifying the approximation errors. In this chapter we have illustrated the method and shown computation of total error of a Braille geometry diagram. Applying the same method we have compared the diagram errors and accuracy of our system (digital to Braille mapping) with that of the systems produced by other researchers before.

Finally the chapter briefly discusses on how this process for representing diagrams in Braille can be automated by integrating it to an (already developed) automated text-to-diagram conversion system. The objective is to maximize the accessibility benefit to a large section of blind student community in the perspective of providing them low-cost learning aid for science subjects like geometry. The role of computational intelligence in developing such system is highlighted in this section. From literature of tactile graphics and review of NLP-based systems (Mukherjee & Garain, 2008) we hardly find any such approach for automatically producing tactile diagrams from digital diagrams using Braille text printer.

BACKGROUND

Upon examining the technologies used worldwide for communicating informational graphics to the blind students, we observe five different

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