Congrats: A System for Converting Graphics to Sound

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Abstract

In this paper, we describe our prototype implementation of the CONGRATS *system first implemented at the Indian Institute of Technology, Bombay,* **(IITB)***for his Masters project by one of the authors of this paper, T. V. Raman. The prototype we have built here is only a small subset of the actual system, and is meant more to show what can be done using sound and elucidate the concepts involved. When complete it will provide a whole new range of educational aids for the visually impaired, and thereby open up subjects that have till now remained inaccessible.*

1 Introduction

Congrats was first developed at the Indian Institute of Technology, Bombay, **(IITB)**as part of a Masters project looking into the development of appropriate computer based aids for the visually impaired. [Ram89] The system was built on the BBC MICRO, a 32K micro-processor to demonstrate the fact that a very useful educational aid could be built using one of the most unsophisticated pieces of computer hardware then available. We are currently in the process of exploiting the ideas involved to the fullest in order to come up with a viable system for conveying concepts in Geometry using sound cues.

The Congrats system which relies on the fact that perception is a constructive process allows the user to build up a view of the computer display through a series of *audio scans*. With the help of these *scans* , the user can build up a functional representation of a curve concurrent with reality. The system focuses on enabling the user to build up a functional model of the curve displayed, and thereby aids in visualization. It can serve as a very useful educational aid, both in conveying simple concepts in Geometry, as well as providing the more sophisticated user the opportunity to have hands on experience with curves plotted on the screen. Thus by allowing the user to interactively scan and manipulate curves, the system helps in building up basic concepts in Geometry, and allows the user to explore as yet unfamiliar concepts.

2 Plotting and scanning curves.

The program allows the user to plot curves on the screen, either by selecting options from a menu, or by specifying the equation of a curve. Once the curve has been plotted, the user can then scan the curve using sound. Curves can be scanned either with respect to the XY coordinate system, or with respect to polar coordinates. When scanning, the system simulates walking along the curve, and gives the listener audio feedback to indicate variation with respect to the scan axis. Thus when scanning a curve with respect to the X axis, henceforth referred to as a X-*Scan*, the pitch of the audio output is determined by the Y coordinate of a moving point on the curve. Since the rate at which the point moves is fixed, different curves can be characterized by the pattern of sound cues generated.

Similarly the user has the option of scanning the curve with respect to the Y axis, as well as perform a radial scan. During any of the scans, the user is provided the ability to stop the scanning, and check on the coordinate position of the moving point in order to obtain more local information. The system also indicates the coordinates of the start and end points of the curve so that the user can determine if the curve drawn was a closed curve.

3 Effectiveness

After a few hours of practice with the system of sound cues used by Congrats, it becomes possible to identify two-dimensional curves with a few scans. The system also allows the user to build up compound drawings using separate curves drawn one after the other, and then scan the resulting *picture*. Again, the scans allow the user to identify the individual pieces that went to make up the drawing , and also investigate their inter-relation.

In order to make recognition of standard shapes easier, the system allows the user to rotate and translate curves displayed on the screen. Thus if after scanning a curve which appears to be a circle, the user could confirm this by first translating the circle to have center at the origin, and then perform a radial scan. Of course the center would be an approximate guess, but a couple of attempts based on the output of the scan is normally enough to position a randomly drawn circle to have its center near the origin. This process also allows the user to distinguish between shapes similar to a circle. Thus an ellipse drawn with its center in the first quadrant can be disambiguated from a circle.

4 The current prototype.

As mentioned Congrats was implemented on a 32K micro-processor to demonstrate what could be done. However this has left us in a rather difficult position, as the micro-processor on which the system was originally built is now extinct. We have been planning to re-implement Congrats on the PC but what we have at present is a prototype system to demonstrate the concepts involved. Hence in the above discussion we have mentioned features that our prototype does not currently implement. We have once again stuck to our policy of trying to achieve the maximum possible with the most basic technology available. Even though a personal computer does not allow for sophisticated sound generation unless extended appropriately, it is possible to bring out the concepts using the sound chip on the PC. Since all we need is the ability to generate sound at a prespecified frequency, a facility afforded on all machines, and by all popular programming languages, this is particularly easy. The preliminary version of our implementation which is written in Turbo C comprises of approximately 900 lines of code.

5 Concepts

As mentioned we have not built in all the functionality that we have foreseen for our system in the present prototype implementation. Here we attempt to elucidate the concepts involved in a system like Congrats, and attempt to outline the direction in which we see our work progressing.

5.1 Why convert graphics to sound?

With the advent of the voice synthesizer, a vast amount of information becomes directly accessible to the visually impaired. However, the information that can be conveyed by using systems based on *text to speech* conversion is limited to being quantitative. It is impossible for a system using just speech to convey curves drawn on the screen. Even if the system were to read out the coordinate values of a set of points on the curve, the user would be no closer to getting a good image of the curve drawn on the screen. A possible alternative is to use a tactile display, but these tend to be expensive. Also touch is extremely slow, and even if a tactile display were built, allowing the user to explore new concepts in Geometry using such a system would be difficult. This is because it becomes prohibitively expensive to build a tactile display that can be changed dynamically.

5.2 Why Congrats works

As pointed out earlier, touch is slow, and therefore the information conveyed tends to be extremely local. Sound on the other hand overcomes this restriction to some extent. Secondly, using sound to output qualitative information has the added advantage that the user is no longer restricted to a flat display. Since Congrats varies the sound output based on the variation of the curve, this combined with the fact that what the ear perceives is variation in the pitch, means that the *audio scans* allow the listener to get at higher order information about the curve. This becomes evident when we realize that variation with respect to a parameter is nothing but the first derivative. Thus the *audio scans* implicitly capture derivative information about the curve being displayed, and therefore provide qualitative information.

6 Future directions

We hope to re-implement Congrats using some of the latest sound synthesis technology available. This will allow us to extend the system to handle curves in higher dimensions. A system like Congrats could conceivably be used not only as an extremely useful aid for the visually impaired, it also presents great potential for use in systems that need to present a vast amount of data. Thus the system of sound cues which we have developed could play a very important role in making the task of scientific visualization easier.

The above drops out as an immediate consequence of the fact that Congrats has been initially designed to output concisely a vast amount of information, namely in our case, a curve representing some data graphically. Since such information is easy to present visually, we can get away with plotting curves. Extending the concepts involved would clearly lead to a system which would allow users to visualize information that is too complex to be plotted on a two-dimensional display. Many of these ideas and further enhancements will be appearing in the Ph. D. dissertation of the first author at Cornell university.

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References

[Ram89] T. V. Raman. Congrats: Converting graphics to sound. Master's thesis, Indian Institute of Technology, Bombay, May 1989. Masters thesis report.