String Art

Abstract

String Art integrates computational thinking and artistic creativity by weaving strings on a circular frame to form digital images. This paper discusses the pixel representation of grayscale and coloured images, the implementation process, and the development of an open-source tool by the Center For Creative Learning, IIT Gandhinagar (CCL IITGN) to generate string weaving patterns. The paper highlights a 10-feet exhibit of the IIT Gandhinagar logo and the creation of a coloured string art portrait of Dr. A.P.J. Abdul Kalam using 4500 iterations of RGB strings. The algorithm employs a greedy approach to iteratively optimise string placement, ensuring the final string art closely matches the original image. This project demonstrates the feasibility of integrating computational thinking into large-scale art projects, offering an engaging and educational experience.

Keywords: String Art, Computational Thinking, Pixel Representation, Algorithm Optimization, Educational Art Projects, Digital Image Processing

Introduction

An image in a computer is represented using pixels and their intensity. Suppose for a grayscale image, the intensity or brightness will range from pixel values 0 to 255. The 0 value represents the darkest shade (black) and 255 represents the brightest shade (white). Similarly, if it is a coloured image, the intensity or brightness for each pixel will be represented by three separate values, one for each colour channel: red, green, and blue. Each of these values ranges from 0 to 255.

String Art is a pixel-art which promotes integration of art and computational thinking. The perimeter of a circle is divided into equidistant points and an image is constructed by weaving strings between these points.

Implementation

Arrange nails evenly around the border of a circular frame. The number of nails should balance detail and complexity. Nail count around 250-300 seems good for complex patterns. We successfully approached with around 300 nails. Select the width of the threads according to the size of your canvas. Make it as thin as possible.

Figure 1(a) shows the ***10 feet diameter exhibit*** of the IIT Gandhinagar logo using ***10 km long thread*** (***4000 straight lines***) weaved among ***300 points*** on a circle. 200 undergraduates at IIT Gandhinagar made this in 6 hours as part of the foundation program 2022. Our organisation CCL (Center For Creative Learning) also created an open-source tool to generate string weaving patterns to construct images of any text. For a given alphabet, the tool generates a sequence to weave strings onto the points on the circle. Consider the pattern generation of the letter C in the text CMSC. The tool outputs a spreadsheet with 1500 sequences of numbers to weave a letter. It takes 90 minutes to weave ***1500 straight lines*** in a circle with ***150 nails***.

Figure 1(a)

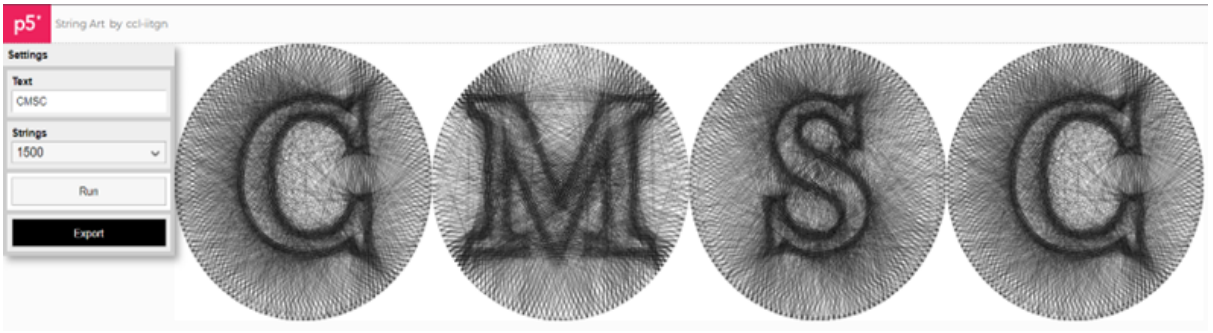

Figure 1(b)

Figure 1(c)

Figure 1 (a) 10 feet IITGN logo using 4000 straight lines and 300 points on a circle (b) “CMSC” string art using 1500 straight lines and 150 nails on a circle (c) Group activity at CCL for string art portrait making.

Above glimpse were the implementation of string art only using a black string. We made our first attempt of making coloured string art with the image of a renowned Indian Scientist Dr. A.P.J. Abdul Kalam used ***4500 iterations of RGB Strings*** and ***300 nails*** over a ***3.28 feet*** wooden canvas.

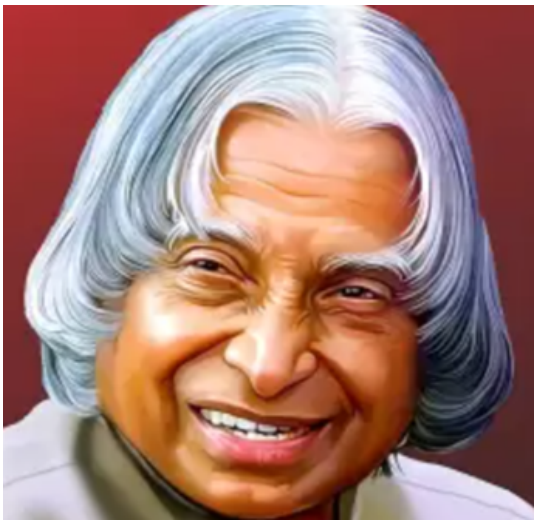

Figure 2(a) Input image

Figure 2(b) Computer Generated Output

Figure 2(c) Actual Output

Methodology

Our application converts digital images into coloured string art which can be made using red, green, blue coloured threads. Firstly, the program resizes the image into ***300x300 pixel resolution***, allowing each pixel to be

represented by a segment of the string art, and then further process it into separate layers for red, green, and blue colours. The process involves applying ***200 blue strings, followed by 200 red strings, and then 200 green strings***, repeating this cycle for about ***4500-5000 iterations***. Each cycle improves the image by connecting nails over the circular frame.

Algorithm:

- Initialise the string art as a blank canvas and start with any random nail.
- For each iteration, use *Bresenham's line drawing algorithm* to find the line segment between the current and potential nails, compute the *squared differences* between original and current pixel values, and select the nail that results in the highest improvement.
- Repeat this process, updating the current nail and pixel values, until the string art closely matches the original image.

The algorithm uses a **greedy *approach*** for choosing nail sequence, ensuring the pixel value deviations are optimised.

Conclusion

Integrating Art and an unplugged way of introducing computational thinking makes the portrait-making activity engaging. Various designs of exhibit making are executed by the center to show the feasibility of such computational thinking based large-scale projects on various extracurricular school occasions.

References

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