



Tribhuvan University

Institute of Engineering

Pulchowk Campus

A Project Proposal On:

Fourier Transform Drawing

Submitted By:

Nabin Da Shrestha(076BCT037)

Nirajan Bekoju(076BCT039)

Submitted To:

Department of Electronics and Computer Engineering

Submission Date: 9th July, 2021

Acknowledgement

First and foremost, we would like to thank everyone who has helped us to create this project. We would like to thank our lecturer, Daya Sagar Baral and all lab instructors and seniors for their guidance which has directly helped us to work on this project.

We sincerely thank the Department of Computer Engineering, Pulchowk Campus for giving us an opportunity to work on this project to expand our knowledge on Fourier Series and Object Oriented Programming.

Nabin Da Shrestha

Nirajan Bekoju

Abstract

Drawing any closed path is possible with epicycles using Discrete Fourier Transform. In this project, we have two methods to draw an object with epicycles. First one is with Canvas Drawing in which the user is given a canvas and he/she is able to draw anything in the given canvas. When the drawing is completed, the program redraws the same path with epicycles. Second method is with binary images in which the program detects the object in the given Image(White Color represents object and Black Color represents background). Then the coordinate of the given image is extracted from the image whose path is retraced by this program with the help of Discrete Fourier Transform.

Contents

1. Introduction	3
2. Objectives	3
3. Proposed System	4
a. Description	4
b. System Block Diagram	5
4. Methodology	6
5. Project Scope	6
6. Project Schedule	7

FOURIER TRANSFORM DRAWING

Objectives

The main objectives of this project are to

1. To understand the basics about the fourier series.
2. To understand the importance of Discrete Fourier Transform and Discrete-time Fourier Transform.
3. To learn the scope of fourier series and why it is one of the most significant algorithms in history.
4. To understand the basics of image processing and extract the object from the given binary image.
5. To learn and understand the object oriented approach to build a project.

Introduction

Fourier Transform Drawing is drawing anything or any shape outline with the help of fourier series. In this program, we can draw anything on a canvas and the same thing will be drawn with the help of fourier transform. We will be able to take any shape from an input image and draw the given shape with a fourier transform.

Fourier series is an expansion of a periodic function in terms of an infinite sum of sines and cosines. Fourier series make use of the orthogonality relationships of the sine and cosine functions. With appropriate weights, one cycle or period of the summation can be made to approximate an arbitrary function in that interval. The discrete-time fourier transform is an example of a fourier series.

$$s_n(x) = \frac{a_0}{2} + \sum_{n=1}^N \left(a_n \cos \left(\frac{2\pi}{P} nx \right) + b_n \sin \left(\frac{2\pi}{P} nx \right) \right)$$

$$a_n = \frac{2}{P} \int_P s(x) \cdot \cos \left(\frac{2\pi}{P} nx \right) dx$$

$$b_n = \frac{2}{P} \int_P s(x) \cdot \sin \left(\frac{2\pi}{P} nx \right) dx$$

In mathematics, the discrete-time fourier transform (DTFT) is a form of Fourier analysis that is applicable to the sequence of values. The DTFT is often used to analyze samples of

a continuous function. The term discrete-time refers to the fact that the transform operates on discrete data, often samples whose interval has units of time.

In this program, we are going to use discrete fourier transform in order to generate the fourier series of the given discrete coordinate data.

In mathematics, the discrete Fourier Transform (DFT) converts a finite sequence of equally-spaced samples of function into a same-length sequence of equal-spaced samples of the discrete-time fourier transform(DTFT), which is a complex valued function of frequency.

The discrete Fourier transform transforms a sequence of of N complex numbers $\{\mathbf{X}_n\} := x_0, x_1, \dots, x_{N-1}$ into another sequence of complex numbers, $\{\mathbf{X}_k\} := X_0, X_1, \dots, X_{N-1}$, which is defined by

$$X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-\frac{i2\pi}{N}kn}$$

$$X_k = \sum_{n=0}^{N-1} x_n \cdot \left[\cos\left(\frac{2\pi}{N}kn\right) - i \cdot \sin\left(\frac{2\pi}{N}kn\right) \right]$$

Application

Application of this project are:

1. To draw any shapes with epicycles.
2. It is easier to understand the fourier series and Discrete Fourier Transform with this project. So, it is an effective way to teach students.
3. This program can be used to extract coordinates of an object from a binary image.

Literature Survey

In this project, we have done image processing to extract objects, perform discrete fourier transformation in order to obtain amplitude, frequency and phase of each part of epicycles so that the path of the object can be retraced.

Discrete Fourier transform is considered as one of the most important and powerful algorithms since it has wide applicability in digital signal processing. We refer to the videos of 3Blue1Brown so as to understand the Fourier series and The Discrete Fourier Transform (DFT) by Steve Brunton.

For the graphical part, we have used SFML for which we have read the documentation of SFML and solved different problems with the help of the query section of SFML.

For Object Oriented Implementation, we have referred to several online e-books as well as youtube videos which broadens our concept on object oriented programming.

Methodology

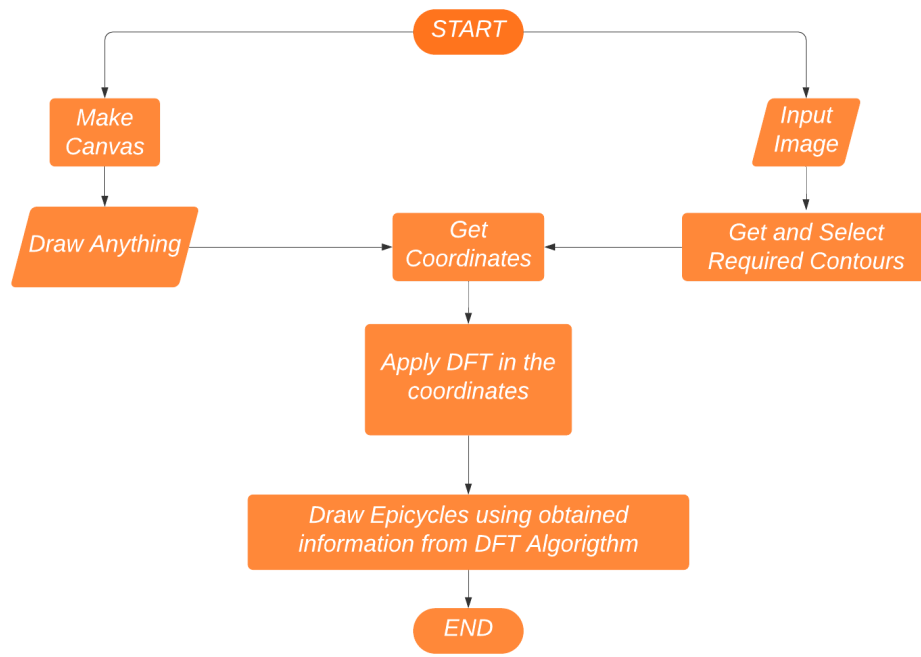
We had used an object oriented approach to build this project. C++ (g++ version 9.3.0) programming language along with the SFML library and Python-3.8.10 and OpenCV Python (version 4.5.2) for image processing was used in order to build this project.

First, we made a canvas window from the SFML library in order to get user drawing in the window. Then we retrieve the coordinates from the drawing of the user and apply discrete fourier transformation. Then we made a Fourier Transform Drawing window and then retraced the same path drawn by the user using the epicycles.

Then, we used image processing to get the object in the given binary image and extract its coordinates. Then we repeated the same process mentioned above to retraced the object in the Fourier transform drawing window with epicycles.

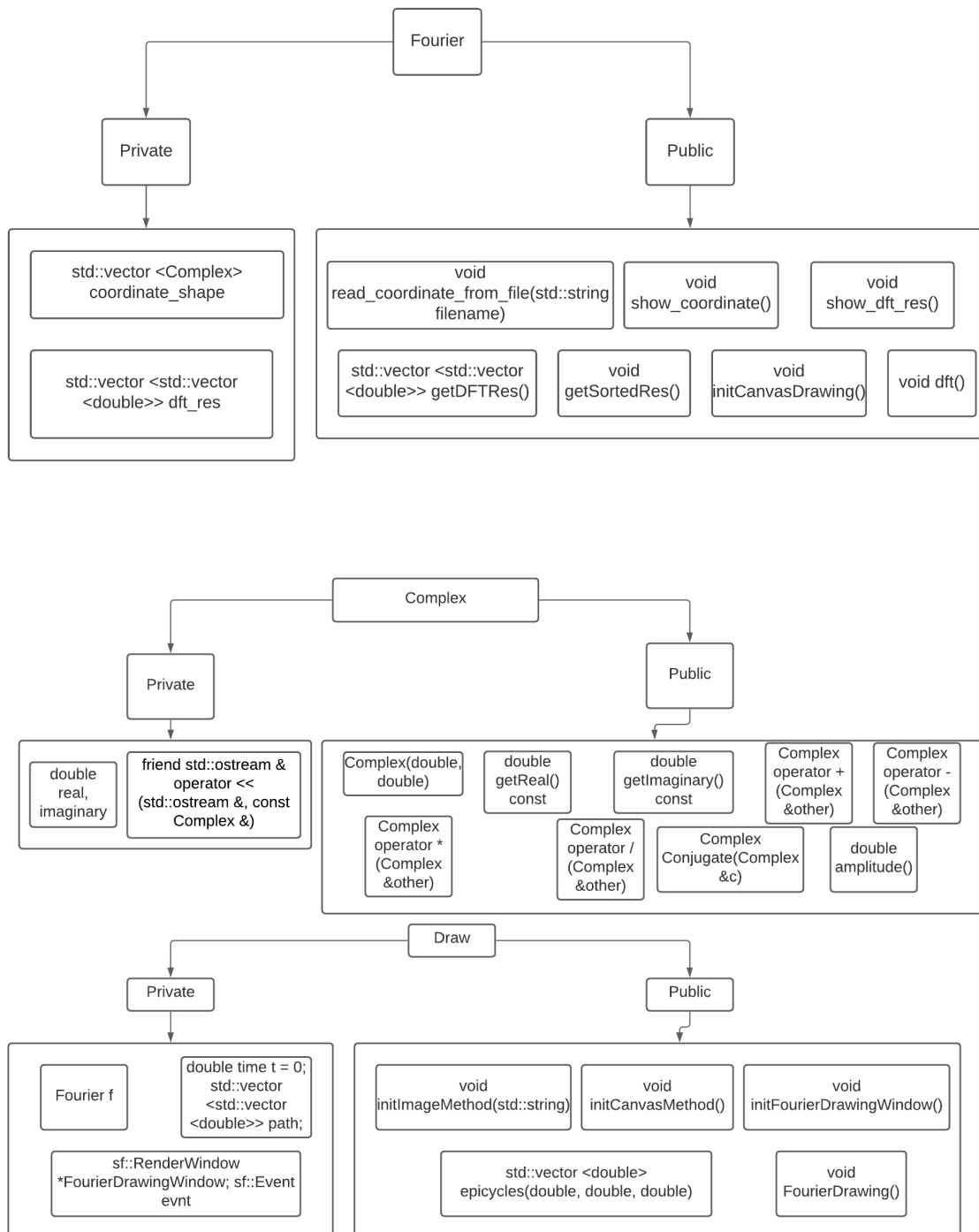
Implementation

1. Block Diagram

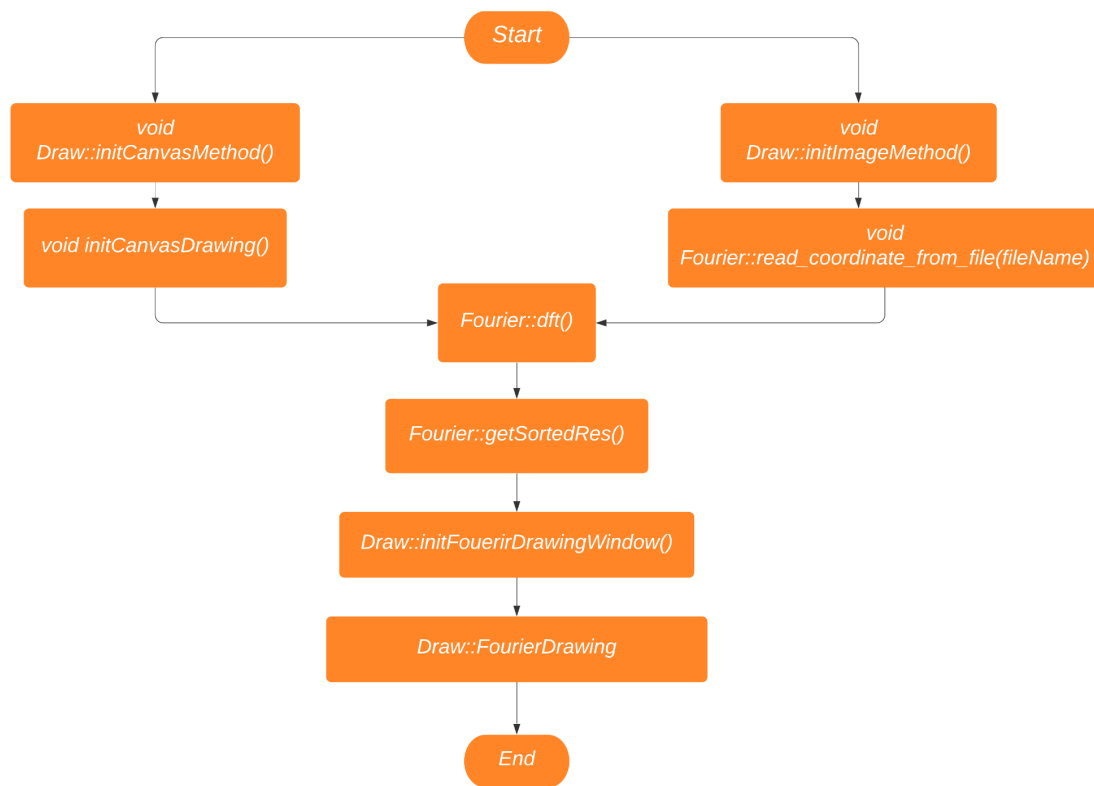


Block Diagram of Fourier Transform Drawing

2. Class Variable and Methods Description



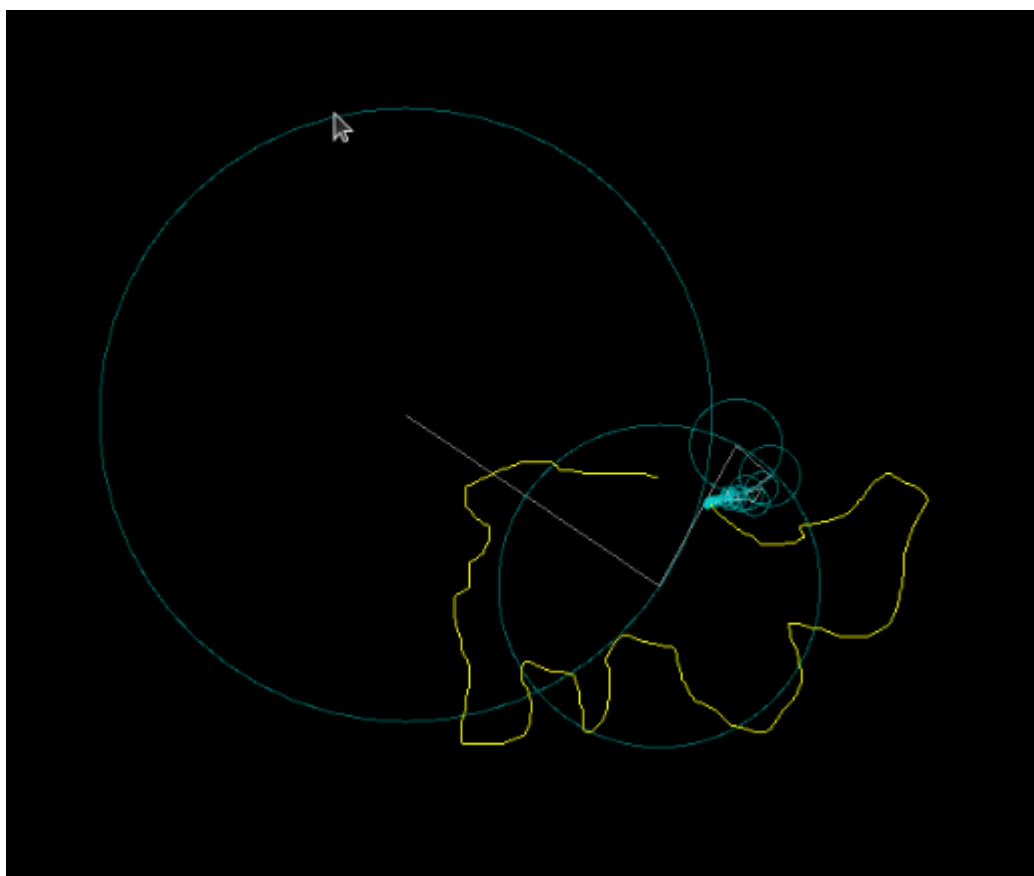
3. Program Flow



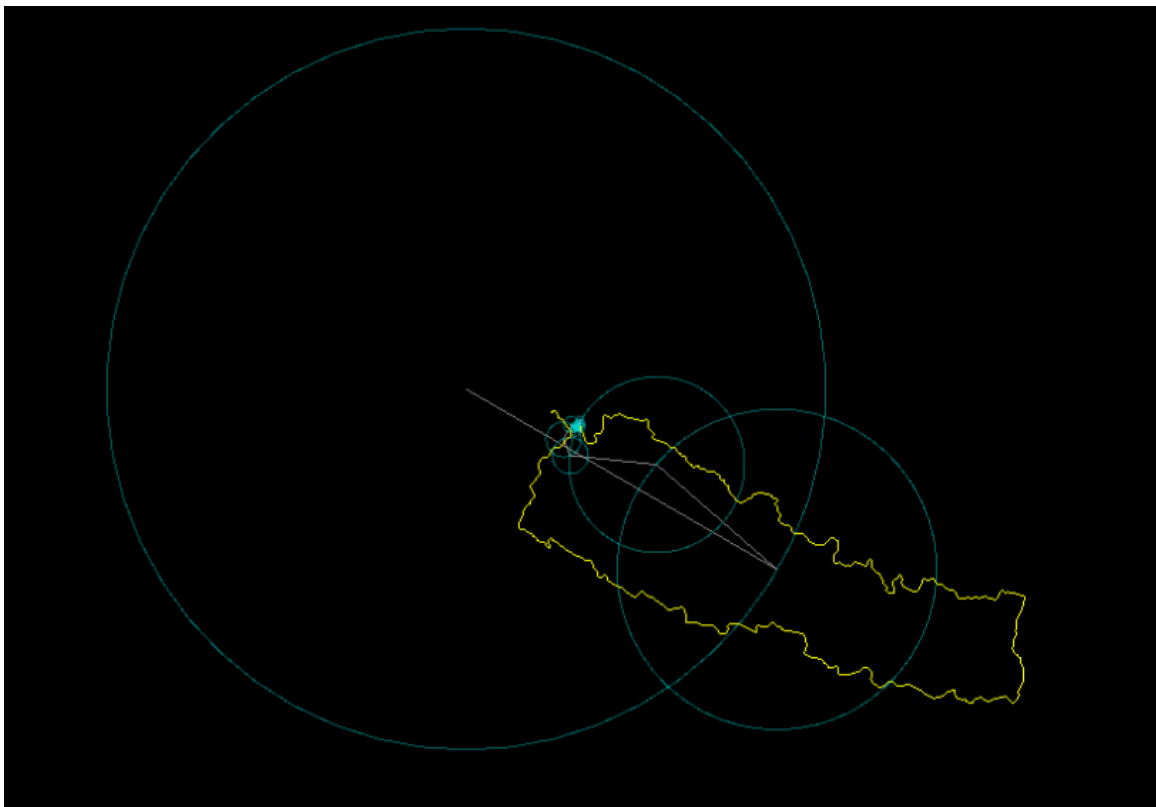
Program Flow Diagram

Result

1. Canvas Method



2. Image Method



Problems Faced and Solution

1. The main problem we have faced in this project is to obtain the object from the image and get it converted into csv data which we solved with the help of OpenCV Python.
2. Then we got a problem in the Fourier transform algorithm due to logical error but we solved it with the help of a debugger in VS Code.
3. There was some issue in rendering the epicycles in the correct position in the Fourier Transform Drawing window but later we solved it with a debugger.

Limitations and Future Enhancements

1. If there are more than 1 contours in the given binary image(it may be due to noise), then we will have to manually select the required contour so as to get the desired object from the image. So as to solve this problem, we have to build the image processing model so effectively that it totally reduces the noise in the given image such that there is only one contour i.e required object.
2. For now, we have to manually select the scaling percent of the image so that we can fit the fourier transform drawing in our monitor size. This can be solved by specifying certain general dimensions of the given image without losing more pixel data of the given binary image.
3. If there are lots of coordinates then it might be computationally expensive and might slow down the computer. In order to solve this, we can skip some coordinates but we might lose accuracy too.

Conclusion and Recommendation

Discrete Fourier Transform is of paramount importance in all areas of digital signal processing. It is used to derive a frequency-domain(spectral) representation of signal. In this project, we show how discrete fourier transform can help us provide amplitude, frequency and phase of all circles on epicycles and how it can be used to trace any kinds of closed path.