SEE-MATH : A Math Visualization Website

A THIRD YEAR PROJECT REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF B.Sc. IN COMPUTATIONAL MATHEMATICS

BY

1. Mukesh Tiwari (026615-19)

2. Bishesh Kafle (026600-19)

3. Priyanka Panta (026605-19)

4. Prajanya Parakram Shrestha (026614-19)

SCHOOL OF SCIENCE
KATHMANDU UNIVERSITY
DHULIKHEL, NEPAL

November 2022

CERTIFICATION

This project entitled ”SEE-Math : A Math Visualization Website” is an original work carried out under my supervision for the specified entire period satisfactorily, and is hereby certified as a work done by following students

1. Prajanya Parakram Shrestha (026614-19)

2. Bishesh Kafle (026600-19)

3. Priyanka Panta (026605-19)

4. Mukesh Tiwari (026615-19)

in partial fulfillment of the requirements for the degree of B.Sc. in Computational Mathematics, Department of Mathematics, Kathmandu University, Dhulikhel, Nepal.

Dr. Samir Shrestha
Associate Professor
Department of Mathematics,
School of Science, Kathmandu University,
Dhulikhel, Kavre, Nepal
December 18, 2022

Mr. Amrit Dahal
Lecturer
Department of Computer Science
and Engineering,
School of Science, Kathmandu University,
December 18, 2022

APPROVED BY:

I hereby declare that the candidate qualifies to submit this report of the Computer Project (Comp-311) to the Department of Mathematics.

Head of the Department
Department of Mathematics
School of Science
Kathmandu University
December 18, 2022

ACKNOWLEDGMENTS

This project has been carried out under the supervision of Dr. Samir Shrestha from the Department of Mathematics and Mr. Amrit Dahal from the Department of Computer Science and Engineering. We would like to express our sincere gratitude towards our supervisors for their excellent supervision, guidance, and suggestion for accomplishing this work and to the entire faculty of the Department of Mathematics for encouraging, supporting, and providing this opportunity to learn and explore.

We are indebted to our friends for motivating us throughout.

Lastly, we would like to thank everyone who helped us directly and indirectly during the completion of our project work.

ABSTRACT

This project aims to implement the numerical method algorithms, namely Bisection and Newton-Rhapson along with their step-wise visualization in a web page. This will be beneficial to students and teachers in classrooms for explanation and intuition regarding these topics and also aid self-exploration into these materials. The demonstrations are fully client side and written in JS using popular and powerful libraries like JSXgraph.

CONTENTS

LIST OF FIGURES

CHAPTER 1

Introduction

1.1 Background

See-Math is a website created for visualizing various algorithms of Numerical Methods[1]. Designed using Jekyll [2] and JavaScript [3], the website asks for appropriate inputs from the user and then generates tables for all iterations. It helps users visualize the solution through animations and graphs. The goal is to create a more friendly and comfortable environment for a better teaching-learning experience where they learn by seeing. The project focuses on being an exploratory tool for students to play around and discover firsthand mathematical beauty and patterns in algorithms and their underlying mathematics.

1.2 Objectives

1.2.1 Primary Objectives:

- To be able to have step by step visualization for numerical method algorithms [4].
- To have a user interactive platform for teaching and learning aid.

1.2.2 Secondary Objectives:

- Learn Web Development Frame work including back-end and front-end.
- Learning to build mathematical animations and interactive plots.

1.3 Motivation And Significance

- Provide platform for interactive visualization of algorithms.
- Improve on existing tools.
- Learn various tools for visualization and animation.
- Explore the field of web development.

1.4 Related Works

See-math is website for solving and visualizing various mathematical problems. The approach of solving problems is table based and graph based. Numerous works related to visualizing mathematical problems have been previously done, some of them being code-sansaar.com, atozmath.com, keisan.casio.com, planetcalc.com and many more. Most of the mentioned websites solve the problems and display output table-based without graphical representations but some websites such as planetcalc.com have improved by taking into consideration previous works and adding new aproaches such as graphical representaions along with table based ones but yet have not made visualization possible for all mathematical problems.

The main contribution of our work to this problem is the implementation of graph based visualization along with table based outputs. The impact of our approach that adresses these existing limitation is going to help on better understanding of various mathematical problems.

CHAPTER 2

Design And Implementation

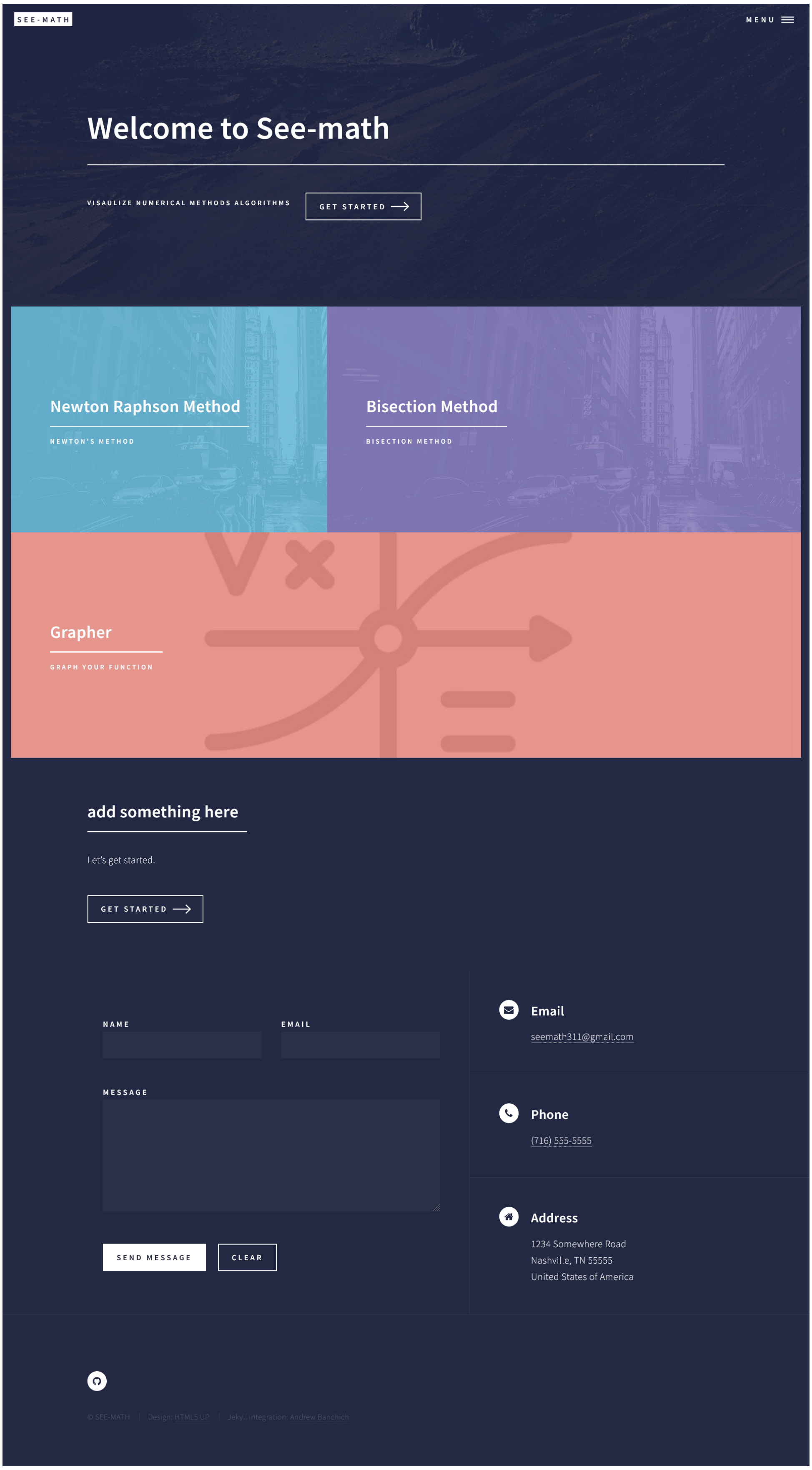
The first step in this project was to choose a framework and type of website we wanted to build. We had two options :

- Static Website
- Dynamic Website

Dynamic Website provided us with great flexibility in the choice of programming language. It was much easier to build using existing libraries and tools. However, It was costly to deploy because an active server running the scripts on the back end as per the requests is needed. The programs to implement the various algorithms of numerical methods are not too complex and require no database.

On the other hand, static sites can be run on the client side but the lack of libraries specific to mathematical visualization and functions meant that we had to code a lot of it by ourselves. They are however free to deploy and serve.

We went with the static option and decided to use Jekyll, which is a static website generator. It utilizes markdown along with HTML and CSS to easily generate websites that are blog-like. The following figure show this.



Welcome to See-math

VISAULIZE NUMERICAL METHODS ALGORITHMS

Newton Raphson Method

NEWTON'S METHOD

Bisection Method

BISECTION METHOD

Grapher

GRAPH YOUR FUNCTION

add something here

Let's get started.

Email

seemath311@gmail.com

Phone

(716) 555-5555

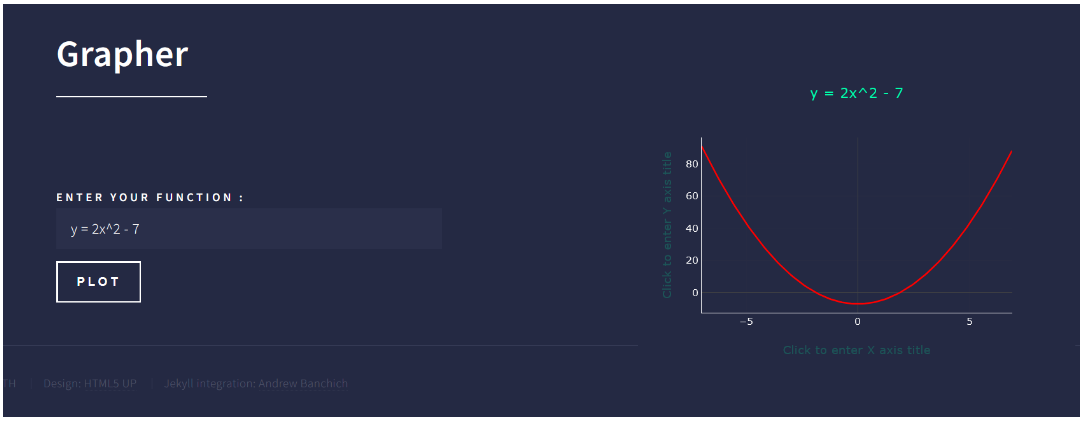
Address

1234 Somewhere Road
Nashville, TN 55555
United States of America

© SEE-MATH | Design: HTML5 UP | Jekyll integration: Andrew Banchich

Figure 2.1: UI layout of website

The next step was to design the method for getting user inputs, which are mathematical formulas in our case, and converting them to functions. We also needed to get a way to plot them and display the output. We utilized various libraries like 'math.js', 'mathjax.js', and 'plotly.js' to get the desired result.



Grapher

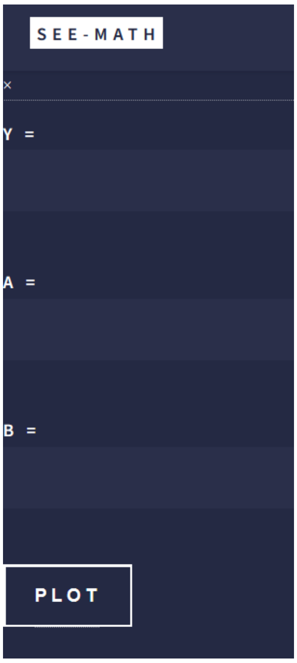
ENTER YOUR FUNCTION :

y = 2x^2 - 7

PLOT
y = 2x^2 - 7
Click to enter Y axis title
80
60
40
20
0
−5
0
5
Click to enter X axis title
TH | Design: HTML5 UP | Jekyll integration: Andrew Banchich

Figure 2.2: Input and Graphing Features

However, for getting step-wise solutions and visualizations associated with each iteration of algorithms like Bisection or Newton-Rhapson, we need a canvas-like library to be able to draw and remove geometrical objects. After extensive research, we found that 'JSXgraph' fitted the bill. we then began with implementing the algorithms and then the steps to visualize them in JS.



Y =

A =

B =

Figure 2.3: User Input for Bisection

The graphs for both the methods are generated by using plot button. the next and animate button show the iterations with animation. Each graph can be panned, zoomed and interacted with. There are no zoom and pan feature in the JSXgraph library. Thus, we had to look at other methods. We utilized the fact that we could change the boundary box of the graph and changed it in a slow and controlled way to slowly transition from one state to another.

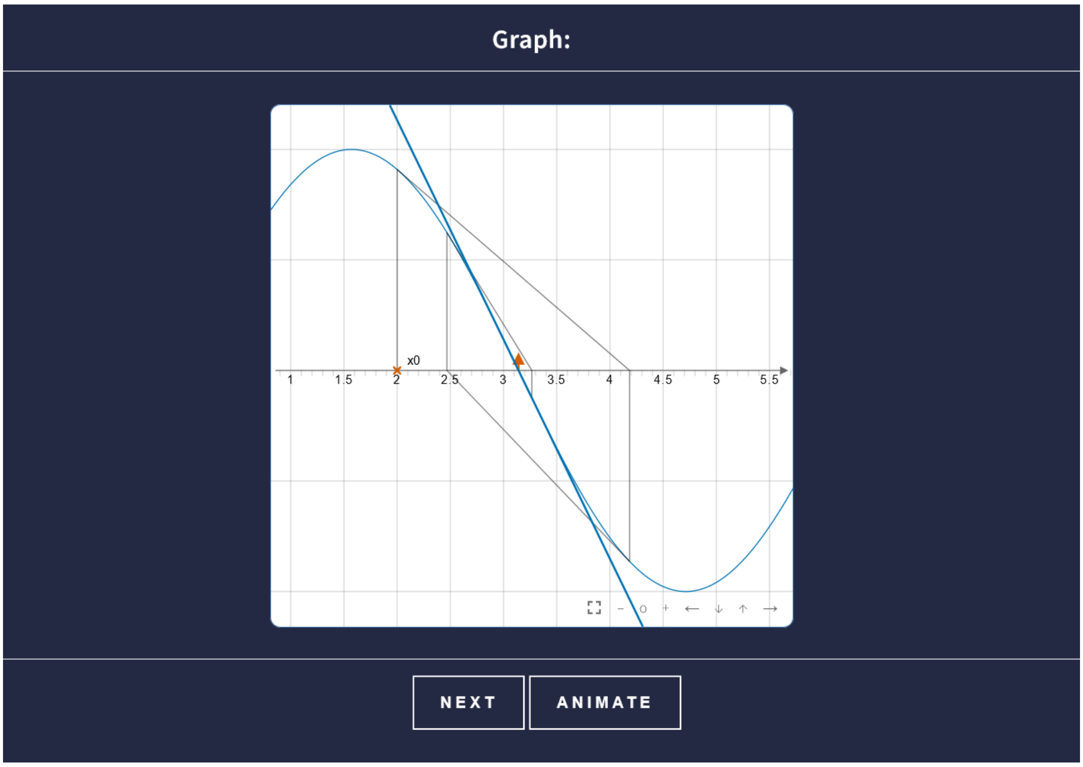


Figure 2.4: Newton Rhapson Method

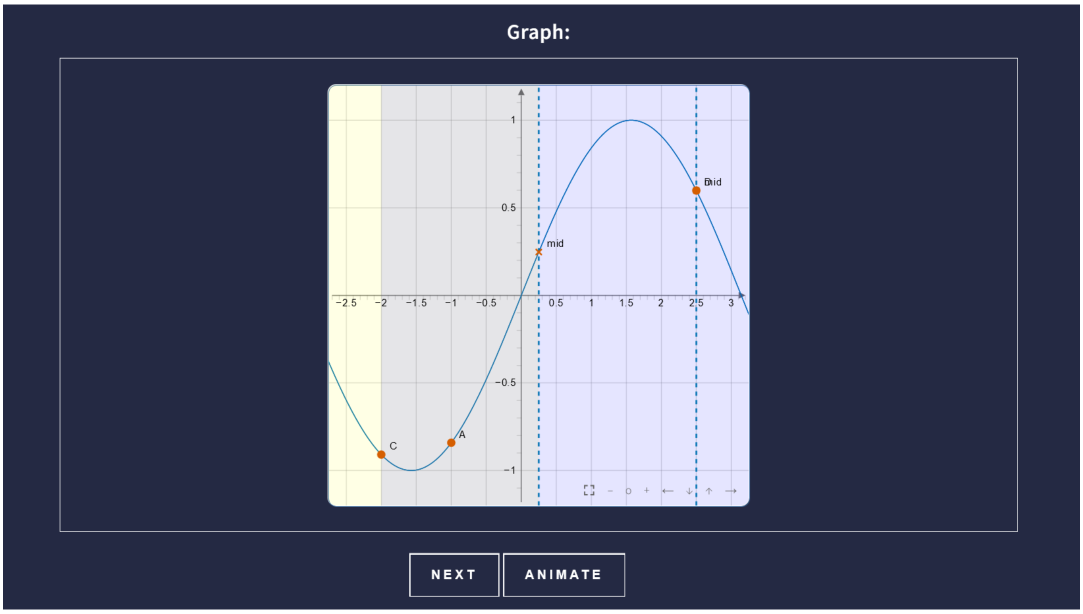


Figure 2.5: Bisection Method

To make getting feedback and suggestions easier, we added a contact form. Since there is no dynamic elements in our website or a central server to receive the feedback and process it. We utilized a service known as 'Formspree'[5] to get emails containing the feedback.

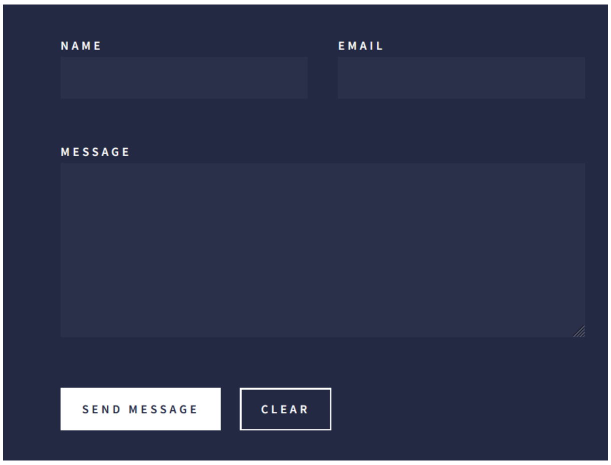


Figure 2.6: Feedback Form

CHAPTER 3

System Requirement Specification

3.1 Software Specification

3.1.1 Front-End Tools

- **Front-End Design** : HTML, CSS, Jekyll , Ruby, Markdown
- **Code Editor** : Visual Studio Code
- **Browser** : Any modern browser that supports JavaScript

3.1.2 Back-End Tools

- **Back-End Tools** : JavaScript

3.1.3 Utility Tools

- **Source Control** : Git, GitHub
- **Project Management** : Viber, Gmail
- **Report Writing** : Latex

3.2 Hardware Specification

Any modern computer with computing power enough to connect to the Internet via a browser that supports JavaScript and follows standard web protocols.

CHAPTER 4

Discussion On The Achievements

This project has been a topic that was completely new for all of us team members. With interests on learning web development, knowing how they operate and with a motive to construct a tool, that not only supports us as a learners base, but has the ability to be used for practical learning and making concepts plain and understandable. The following work has been achieved as a result of this project:

- Gained a deep understanding of web frameworks, communication with the server and user-interaction.
- Built proficiency in scripting for websites as well as developed a hint for web design.
- A completely working graphing function, that plots the user defined curves has been integrated.
- Root finding through bisection method and Newton-Raphson method has been successfully implemented.
- Implemented the functionality to message the developers for reviews and complaints.

4.1 Features

See-math promises to be a great visualization tool for various numerical method algorithms as well as the construction of finite automata machines. Till date, the following features have been integrated on our website:

- A message form for interaction.
- Grapher : Plots the given function.

- Bisection Method
- Newton-Raphson Method

4.2 Limitations

See-math is a website meant for visualizing mathematcal problems and gaining better understanding of the problem. The goal of the website is to solve and visualize as much mathematical problems as possible but current only some of the problems reated to numerical methods such as bisection methon and newton raphson method can be fully calculated and visualized.

4.3 Future Enhancements

The current see-math lacks in comaprisoin to the ideal visualization website meant to solve numerous mathematical problems. Various methods are yet to be added and many enhancements are yet to be made and in the near future various features and new method will slowly but surely be included.

REFERENCES

[1] G. Dahlquist and Å. Björck, *Numerical methods.* Courier Corporation, 2003.

[2] Jekyll • simple, blog-aware, static sites. [Online]. Available: jekyllrb.com

[3] Jsxgraph. [Online]. Available: https://jsxgraph.org/wiki/index.php/Documentation

[4] J. H. Mathews, K. D. Fink *et al.*, *Numerical methods using MATLAB.* Pearson prentice hall Upper Saddle River, NJ, 2004, vol. 4.

[5] Formspree: Custom forms with no server code. [Online]. Available: https://formspree.io/