# 

BAHRIA UNIVERSITY KARACHI CAMPUS

**Department of Software Engineering**

**COURSE: GSL 321**

**NUMERICAL ANALYSIS**

**PROJECT report**

**CLASS: BSE – 7B (FALL - 2024)**

**Analyzing and Implementing**

**Iterative Linear System Solvers:**

**Gauss-Jacobi and Gauss-Seidel**

**Group Members**

|  |  |  |
| --- | --- | --- |
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# **INTRODUCTION & BACKGROUND**

Linear systems, represented as (Ax = b), play a pivotal role in mathematical modeling across scientific and engineering domains. This project delves into the implementation and comparison of three iterative methods—Gauss-Jacobi and Gauss-Seidel. These methods are essential for approximating solutions to large-scale linear systems encountered in applications such as structural analysis and fluid dynamics. The Gauss-Jacobi method, renowned for its simplicity, is augmented by the Gauss-Seidel method, which updates variables more dynamically. This project aims to not only implement these methods but also analyze their convergence rates and stability, providing valuable insights for optimizing solutions to practical problems.

# **PROBLEM STATEMENT**

Effectively solving large linear systems is crucial in various fields, and iterative methods like Gauss-Jacobi, Gauss-Seidel offer solutions. However, understanding their behavior and choosing the right method for specific scenarios remains a challenge. This project aims to investigate the convergence, stability, and efficiency of these methods in different situations, addressing key questions such as their performance in diverse linear systems and the impact of parameters.

# **PROPOSED SOLUTION**

## 3.1. FEATURES OF THE PROJECT

The project will implement and assess the Gauss-Jacobi and Gauss-Seidel methods in Python, focusing on understanding their strengths and weaknesses. Key features include:

* **Method Implementation:** Code development in Python for the three iterative methods.
* **Convergence Analysis:** Systematic evaluation of convergence behavior under varying conditions to identify strengths and weaknesses.
* **Visualization:** Use of Matplotlib for clear visualization of convergence patterns and other relevant metrics.

## 3.2. METHODOLOGY

* **Implementation:** Code development in Python, ensuring simplicity and clarity in the implementation of the Gauss-Jacobi and Gauss-Seidel
* **Convergence Analysis:** Systematic testing and analysis of convergence rates for different types of linear systems.
* **Visualization:** Clear graphical representation of convergence behavior and other performance metrics using Matplotlib.

## 3.3. TECHNOLOGIES TO BE USED

* **Programming Language:** Python for its simplicity and readability.
* **Visualization:** Matplotlib for creating visualizations that aid in understanding the strengths and weaknesses of the implemented methods.

# **PROJECT SCOPE**

The scope of this project is defined by its focus on implementing and evaluating the Gauss-Jacobi and Gauss-Seidel methods for solving linear systems using Python. The project's boundaries and objectives include:

* **Implementation:** Develop Python code for the three iterative methods with a primary emphasis on simplicity, efficiency, and clarity.
* **Method Evaluation:** Conduct a comprehensive analysis of the implemented methods, assessing their strengths and weaknesses in terms of convergence rates, stability, and computational efficiency.
* **Parameter Sensitivity:** Investigate the impact of relaxation parameters, on the convergence behavior to provide insights into optimal parameter selection.
* **Visualization:** Utilize Matplotlib for visual representation of convergence patterns and other relevant metrics, aiding in the interpretation of method performance.
* **Real-world Applications:** Apply the implemented methods to practical linear systems inspired by real-world scenarios in engineering and science to assess their applicability and performance.

**5.Workflow Diagram**

A diagram of a workflow

Description automatically generated

# **Use Case Diagram**

A diagram of a system

Description automatically generated

# **MODULE DISTRIBUTION**

|  |  |  |
| --- | --- | --- |
| **Name** | **Enrollment #** | **Module** |
| Muhammad Shoaib Akhter Qadri | 02-131212-009 | Guass Jacobi and Guass Siedel Iteration Method |

# **Code**

1. if a11<(a12+a13) or a22<(a21+a23) or a33<(a31+a32):
2. print("These linear equations can't be solved by Guass Siedel or Guass Jacobi")
3. else:
4. x0 = 0
5. y0 = 0
6. z0 = 0
7. count = 1
8. print('\nCount\tx\ty\tz\n')
9. condition = True
10. iteration\_counts = []
11. errors = []
12. while condition:
13. x1 = f1(x0,y0,z0)
14. y1 = f2(x0,y0,z0)
15. z1 = f3(x0,y0,z0)
16. print('%d\t%0.4f\t%0.4f\t%0.4f\n' %(count, x1,y1,z1))
17. e1 = abs(x0-x1);
18. e2 = abs(y0-y1);
19. e3 = abs(z0-z1);
20. iteration\_counts.append(count)
21. errors.append(max(e1, e2, e3))
22. count += 1
23. x0 = x1
24. y0 = y1
25. z0 = z1
26. condition = e1>e and e2>e and e3>e
27. max\_iterations.append((count-1))
28. print('\nSolution: x=%0.3f, y=%0.3f and z = %0.3f\n'% (x1,y1,z1))

# **REFERENCES:**

* Wolfram MathWorld. "Successive Overrelaxation Method." [Online]. Available: <https://mathworld.wolfram.com/SuccessiveOverrelaxationMethod.html>.
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* LibreTexts. "Gauss-Seidel Method." [Online]. Available: <https://math.libretexts.org/Bookshelves/Linear_Algebra/Introduction_to_Matrix_Algebra_(Kaw)/01%3A_Chapters/1.08%3A_Gauss-Seidel_Method>.

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