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Introduction to Problem Solving and Programming (CSE1021)

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Report of Project (linear algebra in 3-D solver)

INTRODUCTION

This project focuses on solving a system of three linear equations in three variables using matrix algebra. The program also visualizes the three planes represented by these equations in 3D space and shows the intersection point, which represents the exact solution of the system.

THEORY

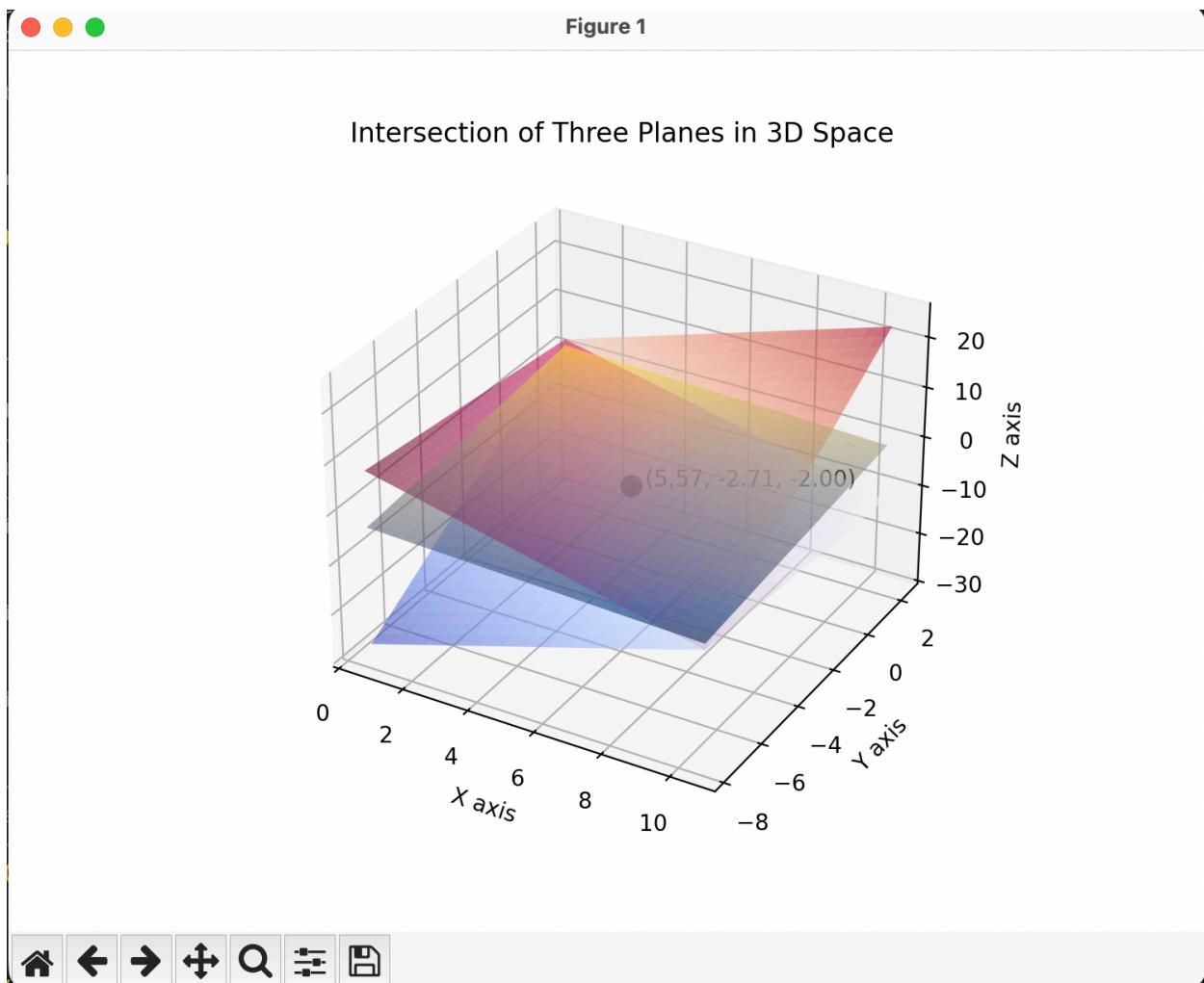
A system of linear equations such as $ax + by + cz = d$ can be expressed in matrix form $AX = B$. The solution exists and is unique only when $\det(A) \neq 0$. Each equation represents a plane in 3D space. The point at which all three planes intersect is the unique solution (x, y, z) that satisfies all equations simultaneously.

CODING EXPLANATION

The program initializes by accepting three sets of coefficients (a, b, c, d) for the linear equations of the form $ax + by + cz = d$, and constructs the corresponding coefficient matrix A and constant vector B . Using the numerical linear algebra routine `numpy.linalg.solve()`, the system $AX = B$ is solved through optimized LU decomposition, ensuring an accurate computation of the unique solution vector (x, y, z) provided that $\det(A) \neq 0$. For visualization, a discretized domain of X and Y values is generated using `numpy.meshgrid()`, upon which each plane is reconstructed by explicitly solving for Z using the rearranged equation $z = \{d - ax - by\}/\{c\}$. The planes are rendered as continuous surfaces in a 3D projection using Matplotlib's `plot_surface()` function with colormap differentiation and adjustable transparency to enhance depth perception. The computed solution point is then superimposed on the plot as a marker, providing a precise geometric representation of the intersection of the three planes and validating the algebraic solution obtained by the solver.

GRAPHICAL REPRESENTATION

Below is the 3D plot showing the three planes and their intersection point. This plot helps visualize the geometric meaning of the solution.



CONCLUSION

This project demonstrates how linear algebra concepts and visualization tools can be effectively combined to understand geometric interpretations of systems of equations. The unique intersection point of the three planes represents the exact solution to the system.