Project Report: Drug Dosage Modeling Using Numerical Methods in Octave GUI

Overview

This project involves the development of an interactive GUI application using Octave to simulate drug concentration over time in the human body, based on a basic first-order differential equation:

$$\frac{dC}{dt} = -kC$$

Where:
- C(t) is the drug concentration at time t
- C0 is the initial concentration
- k is the elimination rate constant

Objective

The goal of the application is to allow users to:
- Enter initial simulation parameters.
- Visualize the drug concentration curve over time.
- Compare multiple numerical methods for solving the ODE.
- Interactively add or remove methods from the plot.

Features

Graphical User Interface (GUI)

- Created using uicontrol elements in Octave.
- Clean layout: input fields on the left, plot on the right.
- Resize disabled for consistency.

Input Parameters

- Initial concentration (C0)
- Elimination rate constant (k)
- Total simulation time (T)
- Time step (h)

Plotting Panel

- Dynamic axes showing concentration vs. time.
- Grid, axis labels, and title.
- Legend updates dynamically based on user selections.

Numerical Methods Implemented

Method	Description
Forward Euler	First-order explicit approximation
Backward Euler	First-order implicit method
Heun's Method	Predictor-corrector method (2nd order)
Midpoint Method	Second-order Runge method
Runge-Kutta (RK4)	Classical 4th-order Runge-Kutta scheme
Adams-Bashforth	Explicit multi-step method (2nd order)
Adams-Moulton	Implicit multi-step method (2nd order)
Exact Solution	Analytical solution: C(t) = C0 * exp(-k*t)

User Interaction

- Each method has a dedicated button; clicking it adds its curve to the plot.
- The “Show Exact Solution” checkbox toggles the analytical curve on/off.
- “Clear Plot” button resets the entire figure and deselects the exact solution.

Backend Logic

- Inputs are read dynamically from edit boxes.
- Time vector and number of steps are computed using:
  t = 0:h:T , N = T / h
- DisplayName is used to manage legends without duplicates.
- Checks prevent duplicate plots when methods are added multiple times.

Testing & Validation

- Verified correct visual output for known test cases.
- Each method produces expected behavior and convergence trend.
- GUI tested for usability and error-handling in input.

Notes

- The previously used “Show All Methods” checkbox was removed to simplify control and improve clarity.
- The Exact Curve now toggles properly when the checkbox is unchecked.

Possible Extensions

- Add CSV export for simulation results.
- Allow real-time updating of plots when changing parameters.
- Implement more advanced pharmacokinetic models.

Summary of Methods: Advantages and Disadvantages

Method	Advantages	Disadvantages
Forward Euler	Very easy to implement.	Not accurate; unstable for stiff systems.
Backward Euler	Unconditionally stable.	Requires solving equations implicitly.
Heun's Method	Better accuracy than Euler.	Requires two function evaluations per step.
Midpoint Method	Balances efficiency and accuracy.	Needs midpoint value, not ideal for stiffness.
Runge-Kutta (RK4)	High accuracy with no need for previous values.	Needs 4 evaluations per step.
Adams-Bashforth	Efficient with large steps.	Less stable and sensitive to step size.
Adams-Moulton	More accurate than explicit methods.	Requires previous steps and implicit solution.