MATH 3341: Introduction to Scientific Computing Lab

Libao Jin

University of Wyoming

January 28, 2019

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Lab 14: Built-in ODE Solvers in MATLAB

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Built-in ODE Solvers for Stiff/Nonstiff ODEs

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Stiff ODEs

Definition

A stiff equation is a differential equation for which certain numerical methods for solving the equation are numerically unstable, unless the step size is taken to be extremely small. It has proven difficult to formulate a precise definition of stiffness, but the main idea is that the equation includes some terms that can lead to rapid variation in the solution.

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Choose an ODE Solver

Some ODE problems exhibit *stiffiness*, or difficulty in evaluation. For example, if an ODE has two solution components that vary on drastically different time scales, then the equation might be stiff. You can identify a problem as stiff if nonstiff solvers (such as ode45) are unable to solve the problem or are extremly slow. If you observe that a nonstiff solver is very slow, try using a stiff solver such as ode15s instead. When using a stiff solver, you can improve reliability and efficiency by supplying the Jacobian matrix or its sparsity pattern.

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Nonstiff ODEs Solvers - ode45, ode23, and ode113

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

ode45: Solve non-stiff ODEs, medium order method

- `[TOUT,YOUT] = ode45(ODEFUN,TSPAN,Y0)` with TSPAN = [T0 TFINAL] integrates the system of differential equations y' = f(t,y) from time T0 to TFINAL with initial conditions Y0. ODEFUN is a function handle. To obtain solutions at specific times T0,T1,...,TFINAL (all increasing or all decreasing), use TSPAN = [T0 T1 ... TFINAL].

- `[TOUT,YOUT] = ode45(ODEFUN,TSPAN,Y0,OPTS)` solves as above with default integration properties replaced by values in OPTS, an argument created with the odeset function.

- `SOL = ode45(ODEFUN,[T0 TFINAL],Y0...)` returns a structure that can be used with deval to evaluate the solution or its first derivative at any point between T0 and TFINAL. The steps chosen by ode45 are returned in a row vector SOL.x. For each I, the column SOL.y(:,I) contains the solution at SOL.x(I).

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

ode23: Solve non-stiff ODEs, low order method

- `[TOUT,YOUT] = ode23(ODEFUN,TSPAN,Y0)` with `TSPAN = [T0 TFINAL]` integrates the system of differential equations y' = f(t,y) from time `T0` to `TFINAL` with initial conditions `Y0`. `ODEFUN` is a function handle. To obtain solutions at specific times `T0,T1,...,TFINAL` (all increasing or all decreasing), use `TSPAN = [T0 T1 ... TFINAL]`.

- `[TOUT,YOUT] = ode23(ODEFUN,TSPAN,Y0,OPTS)` solves as above with default integration properties replaced by values in `OPTS`, an argument created with the `odeset` function.

- `SOL = ode23(ODEFUN,[T0 TFINAL],Y0...)` returns a structure that can be used with `deval` to evaluate the solution or its first derivative at any point between `T0` and `TFINAL`. The steps chosen by `ode23` are returned in a row vector `SOL.x`. For each I, the column `SOL.y(:,I)` contains the solution at `SOL.x(I)`.

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

ode113: Solve non-stiff ODEs, variable order method

- `[TOUT,YOUT] = ode113(ODEFUN,TSPAN,Y0)` with TSPAN = [T0 TFINAL] integrates the system of differential equations y' = f(t,y) from time `T0` to `TFINAL` with initial conditions `Y0`. `ODEFUN` is a function handle. To obtain solutions at specific times `T0,T1,...,TFINAL` (all increasing or all decreasing), use `TSPAN = [T0 T1 ... TFINAL]`.

- `[TOUT,YOUT] = ode113(ODEFUN,TSPAN,Y0,OPTS)` solves as above with default integration properties replaced by values in `OPTS`, an argument created with the `odeset` function.

- `SOL = ode113(ODEFUN,[T0 TFINAL],Y0...)` returns a structure that can be used with `deval` to evaluate the solution or its first derivative at any point between `T0` and `TFINAL`. The steps chosen by ode113 are returned in a row vector `SOL.x`. For each `I`, the column `SOL.y(:,I)` contains the solution at `SOL.x(I)`.

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Stiff ODEs Solvers - `ode15s`, `ode23s`,`ode23t`, and `ode23tb`

Lab 14: Built-in ODE Solvers in MATLAB

Built-in ODE Solvers for Stiff/Nonstiff ODEs
Nonstiff ODEs Solvers - ode45, ode23, and ode113
Stiff ODEs Solvers - ode15s, ode23s,ode23t, and ode23tb
Fully Implicit ODEs Solvers - ode15i

Fully Implicit ODEs Solvers - `ode15i`