9 Solver VODE

9.1 General information

Authors:	Peter N. Brown, George D. Byrne and Alan C. Hindmarsh
first version:	June 15 1989
last update:	April 30, 2000
language:	Fortran 77
availability:	the code VODE is freely available (in the public domain)
official link:	http://www.netlib.org/ode/vode.f
problem type:	ODE
IVPtestset files:	solver: vode.f
	driver: voded.f
	auxiliary files: vodea.f (auxiliary linear algebra routines)

9.2 Numerical method

The code is based upon linear multistep methods used with variable coefficients (but fixed leading term) to take account for the stepsize change. It allows the use of Adams and BDFs methods to handle both non stiff and stiff problems [Byr75].

9.3 Implementation details

VODE [BBA89] is a package based on the EPISODE and EPISODEB packages [HB77, BH76], and on the ODEPACK user interface standard [Hin83], with minor modifications. The code may switch between two different techniques, namely functional iteration and the modified Newton method, to solve nonlinear systems at each time-step. Recently, a FORTRAN 90 version of this solver has been made available at the URL http://www.radford.edu/~thompson/vodef90web/.

9.4 How to solve test problems with VODE

Compiling

```
f90  -o dotest  voded.f  problem.f  vode.f  vodea.f  report.f,
```

will yield an executable `dotest` that solves the problem, of which the Fortran routines in the format described in Section IV.3 are in the file `problem.f`.

As an example, we perform a test run, in which we solve problem HIRES. Figure I.9.1 shows what one has to do.

References

[BBA89] P. N. Brown, G. D. Byrne, and Hindmarsh A.C. Vode: A variable coefficient ode solver. *SIAM J. Sci. Stat. Comput.*, 10:1038–1051, 1989. Also, LLNL Report UCRL-98412, June 1988.

[BH76] G. D. Byrne and A. C. Hindmarsh. Episodeb: An experimental package for the integration of systems of ordinary differential equations with banded jacobians. Technical Report UCID-30132, April 1976., LLNL, 1976.

[Byr75] A. C. Byrne, G. D.and Hindmarsh. A polyalgorithm for the numerical solution of ordinary differential equations. *Acm Trans Math Software*, 1:71–96, 1975.

```
$ f90 -O5 -o dotest voded.f hires.f vode.f  vodea.f report.f
$ dotest
  Test Set for IVP Solvers (release 2.3)

  Solving Problem HIRES using VODE

 User input:

 give relative error tolerance:
1d-4
 give absolute error tolerance:
1d-4

 Numerical solution:

                                              scd
       solution component              ---------------------------     ignore
                                       mixed       abs        rel    mix - abs,rel
 ---------------------------------     -----      -----      -----   -------------
 y(  1) =  0.7405428802164954E-003       5.47       5.47       2.33
 y(  2) =  0.1449232356407335E-003       6.17       6.17       2.33
 y(  3) =  0.5951034500912568E-004       6.21       6.21       1.98
 y(  4) =  0.1182096389331148E-002       5.19       5.19       2.26
 y(  5) =  0.2483586047844519E-002       4.01       4.01       1.39
 y(  6) =  0.6494848234786107E-002       3.59       3.59       1.39
 y(  7) =  0.2954272405089350E-002       3.98       3.98       1.44
 y(  8) =  0.2745727594910732E-002       3.98       3.98       1.44

 used components for  scd                   8          8          8
 scd of Y (maximum norm)                 3.59       3.59       1.39


 using mixed error yields mescd          3.59
 using relative error yields scd                                1.39

 Integration characteristics:

    number of integration steps        133
    number of accepted steps           131
    number of f evaluations            191
    number of Jacobian evaluations      10
    number of LU decompositions         25

 CPU-time used:                       0.0010 sec
```

FIGURE I.9.1: *Example of performing a test run, in which we solve problem HIRES with VODE. The experiment was done on an ALPHAserver DS20E, with a 667MHz EV67 processor. We used the Fortran 90 compiler* `f90` *with the optimization flag* `-O5`.

[HB77] A. C. Hindmarsh and G. D. Byrne. Episode: An effective package for the integration of systems of ordinary differential equations. Technical Report UCID-30112, Rev. 1, April 1977, LLNL, 1977.

[Hin83] Alan C. Hindmarsh. ODEPACK, a systemized collection of ODE solvers. In R. Stepleman et al., editors, *Scientific Computing*, pages 55–64, Amsterdam, 1983. IMACS, North-Holland Publishing Company.