Numerics of Dynamical Systems

Assignment 2

Conny Schweigert

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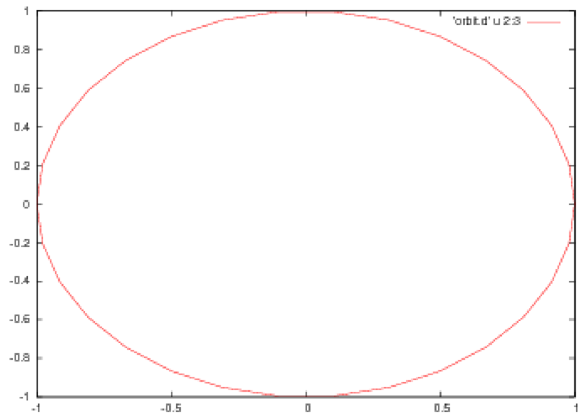
1 Exercise a)

The matrix after 100 iterations looks like:

$$\begin{pmatrix} x(3) & x(4) \\ x(5) & x(6) \end{pmatrix} \approx \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \tag{1}$$

The determinant of this matrix is 1.

Abbildung 1: Orbit of the variated differential equation system.



$$eq_os_var.eq$$
$$diff(x1,t) = x2;$$
$$diff(x2,t) = -x1;$$
$$diff(x3,t) = x5;$$
$$diff(x4,t) = x6;$$
$$diff(x5,t) = -x3;$$
$$diff(x6,t) = -x4;$$

Listing 1: eq_os_var.eq

```
diff(x1,t)=x2;
diff(x2,t)=-x1;
diff(x3,t)=x5;
diff(x4,t)=x6;
diff(x5,t)=-x3;
diff(x6,t)=-x4;
```

Listing 2: MAIN_OS_FLOW.f

```
c*****************************************************************
c
c  MAIN_OS_FLOW.f
c
c       We integrate the harmonic oscillator field with Taylor
c       from t=ti up to t=tmax
c       idir= +1 (integration forward in time); =-1 (backward)
c       np= number of intermediate points (apart from the initial one)
c           that we want to write on the file orbit.d. If np=1
c           only the initial and final points are written
c
c  input: xi,ti,tmax,idir,np
c*****************************************************************
       implicit real*8 (a-h,o-z)
       parameter (n=6)
       dimension xi(n),x(n)
       open(10,file='orbit.d',status='unknown')
       write(*,*) 'Initial condition x(1),...,x(n)'
       read(*,*) (xi(i),i=1,n)
       write(*,*) 'ti,tmax,np (number of points)'
       read(*,*)ti,tmax,np
c particular example integration up to t=pi
       pi=4.d0*datan(1.d0)
       tmax=pi*2.d0
       if (tmax.ge.ti)then
c         'idir (=1 forward in time, =-1 backward)'
           idir=1
       else
           idir=-1
       endif
       do i=1,n
        x(i)=xi(i)
       enddo
c **************************************************
       ham=(x(1)*x(1)+x(2)*x(2))/2
       ham_new=(x(1)*x(1)+x(2)*x(2))/2
       dif = dabs(ham-ham_new)
       if(dif.gt.1.D-11)then
          write(*,*)'problem in first input'
```

```
            stop
         endif
c *****************************************************
          write(*,*) ti,'   initial t, initial cond:'
          write(*,*)(x(i),i=1,n)
c REMARK: xinctime positive
        xinctime=dabs(tmax-ti)/np
          write (10,*) ti,(x(ii),ii=1,n)
        do 20 i=1,np
          call flow(ti,n,x,idir,xinctime)
          write (10,*) ti,(x(ii),ii=1,n)
 20     continue
c ************************************************
          detM = (x(3)*x(6)-x(4)*x(5))
          difdet = abs(detM -1)
          if (difdet.gt.1.d-8) then
          write(*,*)'problem with determinate'
          endif;
c ****************************************************
        write(*,*) ti,'  final t,  final point:'
        write(*,*)(x(i),i=1,n)
         end


        subroutine flow(t,n,x,idir,xinctemps)
        IMPLICIT REAL*8 (A-H,O-Z)
        dimension x(n)
        tmax=t+idir*xinctemps
c
c parameters for the integration
c
         hab=0.1e-16
         hre=0.1e-16
         pabs=dlog10(hab)
         prel=dlog10(hre)
c Option of control of step
         istep=1
         ht=0.d0
 1          CALL taylor_f77_eq_os_var_(t,x,idir,istep,pabs,prel,
     &   tmax,ht,iordre,ifl)
c         write(10,100) t,(x(i),i=1,n)
```

```
      if (idir.eq.1.and.t.lt.tmax)go to 1
      if (idir.eq.-1.and.t.gt.tmax)go to 1
c check t=tmax
      if (dabs(t-tmax).le.1.d-13)return
      write(*,*)'problems in taylor'
      stop
c 100    format(f15.8,2f22.15)
      return
      end
```

2 Exercise b)

Listing 3: eq_lorenz.eq

```
diff(x1,t)=10.*(x2-x1);
diff(x2,t)=28.*x1-x2-x1*x3;
diff(x3,t)=x1*x2-(8./3.)*x3;
```

Listing 4: main_det.f

```
c **************************************************

      implicitreal*8(a-h,o-z)
      parameter(n=3)
      dimension a(n,n)

      call det(a,deta,n)
      write(*,*) deta
      end
*      do 1 i=1,n
*      write(*,*) 'now i',i
*      read(*,*)(a(i,i)j=1,n
*      continue
c ******************************************************
```

Listing 5: MAIN_OS_FLOW.f

```
c*****************************************************************
c
c  MAIN_OS_FLOW.f
c
```

```
c       We integrate the harmonic oscillator field with Taylor
c       from t=ti up to t=tmax
c       idir= +1 (integration forward in time); =-1 (backward)
c       np= number of intermediate points (apart from the initial one)
c           that we want to write on the file orbit.d. If np=1
c           only the initial and final points are written
c
c  input: xi,ti,tmax,idir,np
c************************************************************
        implicit real*8 (a-h,o-z)
        parameter (n=3)
        dimension xi(n),x(n)
        open(10,file='orbit.d',status='unknown')
        write(*,*) 'Initial condition x(1),...,x(n)'
        read(*,*) (xi(i),i=1,n)
        write(*,*) 'ti,tmax,np (number of points)'
        read(*,*)ti,tmax,np
c particular example integration up to t=pi
c         pi=4.d0*datan(1.d0)
c         tmax=pi/2.d0
        if (tmax.ge.ti)then
c          'idir (=1 forward in time, =-1 backward)'
            idir=1
        else
            idir=-1
        endif
        do i=1,n
         x(i)=xi(i)
        enddo
         write(*,*)ti,'   initial t, initial cond:'
         write(*,*)(x(i),i=1,n)
c REMARK: xinctime positive
       xinctime=dabs(tmax-ti)/np
         write (10,*)ti,(x(ii),ii=1,n)
       do 20 i=1,np
         call flow(ti,n,x,idir,xinctime)
         write (10,*)ti,(x(ii),ii=1,n)
 20    continue

       write(*,*)ti,'  final t,  final point:'
       write(*,*)(x(i),i=1,n)
```

```
      end


      subroutine flow(t,n,x,idir,xinctemps)
      IMPLICIT REAL*8 (A-H,O-Z)
      dimension x(n)
      tmax=t+idir*xinctemps
c
c parameters for the integration
c
       hab=0.1e-16
       hre=0.1e-16
       pabs=dlog10(hab)
       prel=dlog10(hre)
c Option of control of step
       istep=1
       ht=0.d0
 1      CALL taylor_f77_eq_lorenz_(t,x,idir,istep,pabs,prel,
     &  tmax,ht,iordre,ifl)
c       write(10,100) t,(x(i),i=1,n)
       if (idir.eq.1.and.t.lt.tmax)go to 1
       if (idir.eq.-1.and.t.gt.tmax)go to 1
c check t=tmax
       if (dabs(t-tmax).le.1.d-13)return
       write(*,*)'problems in taylor'
       stop
c 100    format(f15.8,2f22.15)
       return
       end
```

Abbildung 2: Lorenz system (x, y, z)

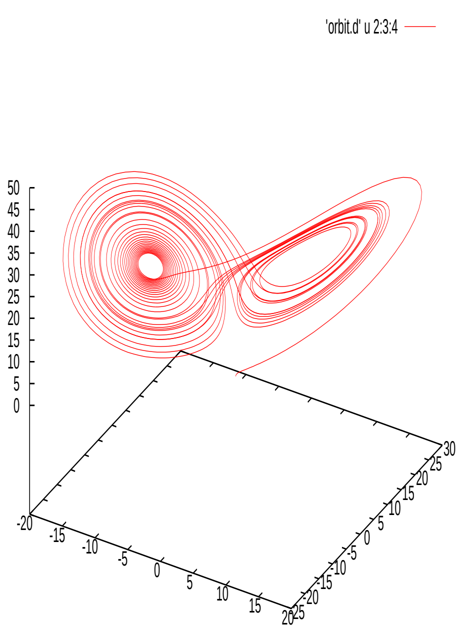


Abbildung 3: Lorenz system (x, z)

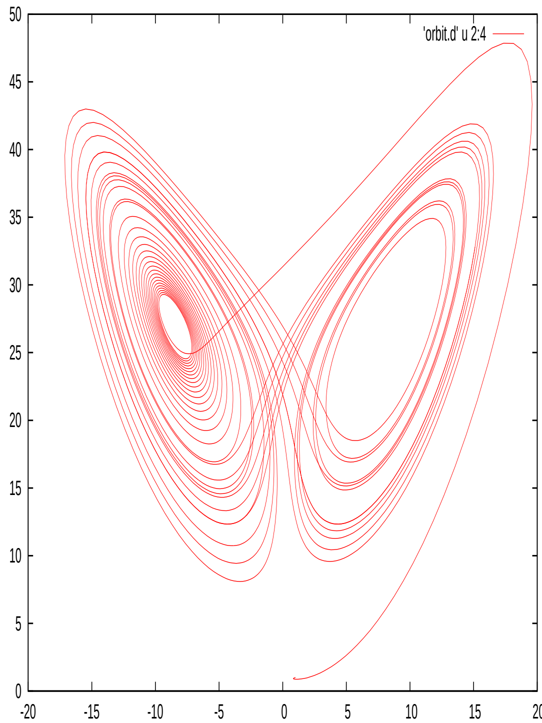


Abbildung 4: Lorenz system (t, y)