

DESCON versus CG-DESCENT for solving 5 applications from MINPACK2

Neculai Andrei

Research Institute for Informatics
8-10, Averescu Avenue, Bucharest 1, Romania.
Academy of Romanian Scientists
54, Bdl. Independentei, Bucharest 5, Romania.
E-mail: *nandrei@ici.ro*

September 13, 2012

In this paper I report some results of DESCON versus CG-DESCENT for solving 5 applications from MINPACK2 collection. In these numerical experiments the maximum number of line searches in the subroutine LINESEARCH from the DESCON package is limited to 5. The rest of parameters remain the same along all the numerical experiments. CG-DESCENT uses the Wolfe line search with default values of parameters.

In Table 1 we present these applications, as well as the values of their parameters. The infinite-dimensional version of these problems is transformed into a finite element approximation by triangulation. Thus a finite-dimensional minimization problem is obtained whose variables are the values of the piecewise linear function at the vertices of the triangulation. The discretization steps are $nx=1000$ and $ny=1000$, thus obtaining minimization problems with 1,000,000 variables.

Table 1. Applications from MINPACK-2 collection.

A1	<i>Elastic-Plastic Torsion, $c = 5$.</i>
A2	<i>Pressure Distribution in a Journal Bearing, $b = 10, \varepsilon = 0.1$.</i>
A3	<i>Optimal Design with Composite Materials, $\lambda = 0.008$.</i>
A4	<i>Steady-State Combustion, $\lambda = 5$.</i>
A5	<i>Minimal Surfaces with Enneper conditions.</i>

A comparison between DESCON ($v=0.05, w=0.875$, Powell restart criterion, $\|\nabla f(x_k)\|_{\infty} \leq 10^{-6}$, $\rho=10^{-4}$, $\max ls=5$) and CG_DESCENT (Wolfe line search, default settings, $\|\nabla f(x_k)\|_{\infty} \leq 10^{-6}$) for solving these applications is given as follows.

Firstly, I present the numerical results given by DESCON and after that those corresponding to CG-DESCENT.

1) Elastic – Plastic Torsion Application

```
*****
* DESCON                      Neculai Andrei ***
* Another Accelerated Conjugate Gradient with ***
* Guaranteed Descent and Conjugacy conditions. ***
* ----- ***
* Project: FCGA ***
* The Fastest Conjugate Gradient Algorithm ***
*****
```

Parameters: Descent= .8750000000000E+00 Conjugacy= .5000000000000E-01

Date: --- Month: 9 Day:12 Year: 2012

DESCON. Powell restart.

1 DLDC Algorithm. Function:Elastic-Plastic Torsion Problem
stoptest= 1

n	iter	irs	fgcnt	lscnt	time(c)	fxnew	gnorm	ib	it
1000000	1113	0	2257	30	30585	-.4393016862081E+00	.6317026461045E-04	0	0
TOTAL	1113	0	2257	30	305.85 (seconds)	proc=	.00%		

2) Pressure Distribution in a Journal Bearing

```
*****
* DESCON                      Neculai Andrei ***
* Another Accelerated Conjugate Gradient with ***
* Guaranteed Descent and Conjugacy conditions. ***
* ----- ***
* Project: FCGA ***
* The Fastest Conjugate Gradient Algorithm ***
*****
```

Parameters: Descent= .8750000000000E+00 Conjugacy= .5000000000000E-01

Date: --- Month: 9 Day:12 Year: 2012

DESCON. Powell restart.

1 DLDC Algorithm. Function:Pressure Distribution in a Journal Beari
stoptest= 1

n	iter	irs	fgcnt	lscnt	time(c)	fxnew	gnorm	ib	it
1000000	2833	0	5694	27	101669	-.2829101117260E+00	.8161761464862E-04	0	0
TOTAL	2833	0	5694	27	1016.69 (seconds)	proc=	.00%		

3) Optimal Design with Composite Materials

```
*****
* DESCON                      Neculai Andrei ***
* Another Accelerated Conjugate Gradient with ***
* Guaranteed Descent and Conjugacy conditions. ***
* ----- ***
* Project: FCGA ***
* The Fastest Conjugate Gradient Algorithm ***
*****
```

Parameters: Descent= .8750000000000E+00 Conjugacy= .5000000000000E-01

Date: --- Month: 9 Day:12 Year: 2012

DESCON. Powell restart.

```
-----
1 DLDC Algorithm. Function: Optimal Design with Composite Materials
  stoptest= 1

      n   iter   irs  fgcnt  lscnt   time(c)      fxnew          gnorm          ib   it
-----
1000000  4734    0   9506   37   197487 -.1138214247580E-01 .1381685343931E-03  0   0
-----
TOTAL   4734    0   9506   37   1974.87 (seconds)  proc=   .00%
```

4) Steady State Combustion

```
*****
* DESCON                      Neculai Andrei ***
* Another Accelerated Conjugate Gradient with ***
* Guaranteed Descent and Conjugacy conditions. ***
* ----- ***
* Project: FCGA                ***
* The Fastest Conjugate Gradient Algorithm      ***
*****
```

Parameters: Descent= .8750000000000E+00 Conjugacy= .5000000000000E-01

Date: --- Month: 9 Day:12 Year: 2012

DESCON. Powell restart.

```
-----
1 DLDC Algorithm. Function:Steady State Combustion
  stoptest= 1

      n   iter   irs  fgcnt  lscnt   time(c)      fxnew          gnorm          ib   it
-----
1000000  1413    0   2864   37   112720 -.5611488188408E+01 .4244605574220E-04  0   0
-----
TOTAL   1413    0   2864   37   1127.20 (seconds)  proc=   .00%
```

5) Minimal Surface Area

```
*****
* DESCON                      Neculai Andrei ***
* Another Accelerated Conjugate Gradient with ***
* Guaranteed Descent and Conjugacy conditions. ***
* ----- ***
* Project: FCGA                ***
* The Fastest Conjugate Gradient Algorithm      ***
*****
```

Parameters: Descent= .8750000000000E+00 Conjugacy= .5000000000000E-01

Date: --- Month: 9 Day:12 Year: 2012

DESCON. Powell restart.

```
-----
1 DLDC Algorithm. Function:Minimal Surface Area
  stoptest= 1

      n   iter   irs  fgcnt  lscnt   time(c)      fxnew          gnorm          ib   it
-----
1000000  1279    2   2580   21   52483 .1000000212644E+01 .1246002906394E-03  0   0
-----
TOTAL   1279    2   2580   21   524.83 (seconds)  proc=   .16%
```

Now I present the results given by CG-DESCENT.

1) Elastic – Plastic Torsion Application

CG-DESCENT, standard Wolfe line search, September 12, 2012

```
1    CG_DESCENT Algorithm:    Elastic-Plastic Torsion          Function
      n      iter    nfunc    ngrad  time(c)              f              gnorm          s
-----
1000000    1145     2291     1147   43601    - .4393012991437E+00    .9703406971102E-06 0
-----
TOTAL          1145     2291     1147   436.01(seconds)
```

2) Pressure Distribution in a Journal Bearing

CG-DESCENT, standard Wolfe line search, September 12, 2012

```
1    CG_DESCENT Algorithm:    Pressure Distribution in a Journal Function
      n      iter    nfunc    ngrad  time(c)              f              gnorm          s
-----
1000000    3368     6737     3369  157657    - .2829101441860E+00    .9571140068903E-06 0
-----
TOTAL          3368     6737     3369  1576.57(seconds)
```

3) Optimal Design with Composite Materials

CG-DESCENT, standard Wolfe line search, September 12, 2012

```
1    CG_DESCENT Algorithm:    Optimal Design with Composite MaterFunction
      n      iter    nfunc    ngrad  time(c)              f              gnorm          s
-----
1000000    4841     9684     4843  290825    - .1138220375091E-01    .9988011843742E-06 0
-----
TOTAL          4841     9684     4843  2908.25(seconds)
```

4) Steady State Combustion

CG-DESCENT, standard Wolfe line search, September 12, 2012

```
1    CG_DESCENT Algorithm:    Steady State Combustion          Function
      n      iter    nfunc    ngrad  time(c)              f              gnorm          s
-----
1000000    1806     3613     1807  209649    - .5611488039275E+01    .9690689195721E-06 0
-----
TOTAL          1806     3613     1807  2096.49(seconds)
```

5) Minimal Surface Area

CG-DESCENT, standard Wolfe line search, September 12, 2012

1		CG_DESCENT Algorithm: Minimal Surface Area			Function		
n	iter	nfunc	ngrad	time(c)	f	gnorm	s
1000000	1226	2453	1227	71529	.1000000259829E+01	.9405265186902E-06	0
TOTAL		1226	2453	1227	715.29 (seconds)		

These performances are synthesized in Table 2.

Table 2. Performance of DESCN and CG_DESCENT.
1,000,000 variables. cpu seconds.

	DESCN			CG_DESCENT		
	#iter	#fg	cpu	#iter	#fg	cpu
A1	1113	2257	305.85	1145	2291	436.01
A2	2833	5694	1016.69	3368	6737	1576.57
A3	4734	9506	1974.87	4841	9684	2908.25
A4	1413	2864	1127.20	1806	3613	2096.49
A5	1279	2580	524.83	1226	2453	715.29
TOTAL	11372	22901	4949.44	12386	24778	7732.61

From Table 2 we see that subject to the CPU time metric the DESCN algorithm is top performer, and the difference is significant, about 2783.17 seconds for solving all these 5 applications.

References

- N. Andrei**, *An acceleration of gradient descent algorithm with backtracking for unconstrained optimization*. Numerical Algorithms, (2006) 42: 63-73.
- N. Andrei**, *Acceleration of conjugate gradient algorithms for unconstrained optimization*. Applied Mathematics and Computation, 213 (2009) 361-369.
- N. Andrei**, *Another conjugate gradient algorithm with guaranteed descent and conjugacy conditions for large scale unconstrained optimization*. ICI Technical Report, April 12, 2012.
- N. Andrei**, *DESCN user's guide and program*. ICI Technical Report, September 10, 2012
- N. Andrei**, *PERF2N user's guide and program*. ICI Technical Report, September 10, 2012
- R. Aris**, *The mathematical theory of diffusion and reaction in permeable catalysts*. Oxford, 1975.
- J. Bebernes, D. Eberly**, *Mathematical problems from combustion theory*. Applied Mathematical Sciences 83, Springer-Verlag, 1989.
- G., Cimatti**, *On a problem of the theory of lubrication governed by a variational inequality*. Appl. Math. Potim., 3 (1977) 227-242.
- R., Glowinski**, *Numerical Methods for Nonlinear Variational Problems*. Springer-Verlag, Berlin, 1984.
- J., Goodman, R., Kohn, L., Reyna**, *Numerical study of a relaxed variational problem from optimal design*. Comput. Methods Appl. Mech. Engrg., 57, 1986, pp.107-127.
- W. Hager and H. Zhang**. *CG_DESCENT user's guide*. November 14, 2005.