Computational experience with AHYBRIDM for solving some MINPACK2 applications up to 10^6 variables

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1. Elastic-Plastic Torsion Problem

```
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Elastic-Plastic Torsion Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
   40000    241     0    269    27       601 -.4392678188056E+00  .3175759862620E-04
129  112    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL    241     0    269    27      6.01 (seconds)    proc=    .00%

 Total # iter for DY=   129   i.e.   53.53%
 Total # iter for HS=   112   i.e.   46.47%
 Total # iter for CC=     0   i.e.     .00%
    *** Conjugate Gradient Algorithms Project ***
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    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Elastic-Plastic Torsion Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  160000    476     0    506    29      5252 -.4392942848670E+00  .4717600046259E-04
223  253    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL    476     0    506    29     52.52 (seconds)    proc=    .00%

 Total # iter for DY=   223   i.e.   46.85%
 Total # iter for HS=   253   i.e.   53.15%
 Total # iter for CC=     0   i.e.     .00%
    *** Conjugate Gradient Algorithms Project ***
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    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Elastic-Plastic Torsion Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  360000    705     0    734    28     17996 -.4392992067796E+00  .5991586305411E-04
314  391    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL    705     0    734    28    179.96 (seconds)    proc=    .00%

 Total # iter for DY=   314   i.e.   44.54%
 Total # iter for HS=   391   i.e.   55.46%
 Total # iter for CC=     0   i.e.     .00%
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    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Elastic-Plastic Torsion Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  640000    911     0    942    30     41231 -.4393009097428E+00  .5942676089242E-04
371  540    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL    911     0    942    30    412.31 (seconds)    proc=    .00%

 Total # iter for DY=   371   i.e.   40.72%
 Total # iter for HS=   540   i.e.   59.28%
 Total # iter for CC=     0   i.e.     .00%
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    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Elastic-Plastic Torsion Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
 1000000   1113     0   1144    30     78920 -.4393016862060E+00  .6318121566597E-04
511  602    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1113     0   1144    30    789.20 (seconds)    proc=    .00%

 Total # iter for DY=   511   i.e.   45.91%
 Total # iter for HS=   602   i.e.   54.09%
 Total # iter for CC=     0   i.e.     .00%
```

2. Pressure Distribution Problem

```
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    *** Dr. Neculai Andrei
```

```
    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Pressure Distribution Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
   40000    634     0    669    34      1588 -.2828929487236E+00  .2262124595643E-04
263  371    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL    634     0    669    34     15.88 (seconds)    proc=    .00%

 Total # iter for DY=   263   i.e.   41.48
 Total # iter for HS=   371   i.e.   58.52
 Total # iter for CC=     0   i.e.     .00
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Pressure Distribution Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  160000   1222     0   1257    34     14262 -.2829064006018E+00  .4061212965853E-04
567  654    1
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1222     0   1257    34    142.62 (seconds)    proc=    .00%

 Total # iter for DY=   567   i.e.   46.40
 Total # iter for HS=   654   i.e.   53.52
 Total # iter for CC=     1   i.e.     .08
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    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Pressure Distribution Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  360000   1783     0   1811    27     48089 -.2829088979236E+00  .5450096492364E-04
794  989    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1783     0   1811    27    480.89 (seconds)    proc=    .00%

 Total # iter for DY=   794   i.e.   44.53
 Total # iter for HS=   989   i.e.   55.47
 Total # iter for CC=     0   i.e.     .00
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009
```

```
      1    AHYBRIDM Algorithm. Function Pressure Distribution Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  640000   2327     0   2358    30    113091 -.2829097544464E+00  .7693579806992E-04
1030 1297    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL   2327     0   2358    30   1130.91 (seconds)    proc=    .00%

 Total # iter for DY=  1030   i.e.   44.26
 Total # iter for HS=  1297   i.e.   55.74
 Total # iter for CC=     0   i.e.     .00
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Pressure Distribution Problem
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
 1000000   2833     0   2861    27    212057 -.2829101117287E+00  .8163367284139E-04
1232 1601    0
 ---------------------------------------------------------------------------------
-----------
 TOTAL   2833     0   2861    27   2120.57 (seconds)    proc=    .00%

 Total # iter for DY=  1232   i.e.   43.49
 Total # iter for HS=  1601   i.e.   56.51
 Total # iter for CC=     0   i.e.     .00
```

3. Optimal Design with Composite Materials

```
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Optimal Design with Composite Materials
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
   40000   1025     0   1053    27      4371 -.1138128917301E-01  .3791821681957E-04
143  703  179
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1025     0   1053    27     43.71 (seconds)    proc=    .00%

 Total # iter for DY=   143   i.e.   13.95
 Total # iter for HS=   703   i.e.   68.59
 Total # iter for CC=   179   i.e.   17.46
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009
```

```
      1    AHYBRIDM Algorithm. Function Optimal Design with Composite Materials
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  160000   1934     0   1970    35     35855 -.1138240936665E-01  .6523729205783E-04
201 1416  317
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1934     0   1970    35    358.55 (seconds)    proc=    .00%

 Total # iter for DY=   201   i.e.   10.39
 Total # iter for HS=  1416   i.e.   73.22
 Total # iter for CC=   317   i.e.   16.39
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Optimal Design with Composite Materials
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  360000   2822     0   2863    40    119643 -.1138250935410E-01  .7862529408799E-04
230 2134  458
 ---------------------------------------------------------------------------------
-----------
 TOTAL   2822     0   2863    40   1196.43 (seconds)    proc=    .00%

 Total # iter for DY=   230   i.e.    8.15
 Total # iter for HS=  2134   i.e.   75.62
 Total # iter for CC=   458   i.e.   16.23
    *** Conjugate Gradient Algorithms Project ***
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    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Optimal Design with Composite Materials
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  640000   3676     0   3723    46    279313 -.1138233874507E-01  .1077167372668E-03
212 2721  743
 ---------------------------------------------------------------------------------
-----------
 TOTAL   3676     0   3723    46   2793.13 (seconds)    proc=    .00%

 Total # iter for DY=   212   i.e.    5.77
 Total # iter for HS=  2721   i.e.   74.02
 Total # iter for CC=   743   i.e.   20.21
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    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Optimal Design with Composite Materials
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
```

```
 ---------------------------------------------------------------------------------------
-----------
 1000000   4713     0   4755    41    560751 -.1138213421915E-01  .1373995889045E-03
285 3219 1209
 ---------------------------------------------------------------------------------------
-----------
 TOTAL   4713     0   4755    41   5607.51 (seconds)    proc=    .00%

 Total # iter for DY=   285   i.e.    6.05
 Total # iter for HS=  3219   i.e.   68.30
 Total # iter for CC=  1209   i.e.   25.65
```

5. Steady State Combustion

```
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Steady State Combustion
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------------
-----------
   40000    299     0    333    33      1919 -.5611448493596E+01  .2374434222296E-04
29  267    3
 ---------------------------------------------------------------------------------------
-----------
 TOTAL    299     0    333    33     19.19 (seconds)    proc=    .00%

 Total # iter for DY=    29   i.e.    9.70
 Total # iter for HS=   267   i.e.   89.30
 Total # iter for CC=     3   i.e.    1.00
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Steady State Combustion
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------------
-----------
  160000    585     0    615    29     15320 -.5611479470976E+01  .2906019016531E-04
64  500   21
 ---------------------------------------------------------------------------------------
-----------
 TOTAL    585     0    615    29    153.20 (seconds)    proc=    .00%

 Total # iter for DY=    64   i.e.   10.94
 Total # iter for HS=   500   i.e.   85.47
 Total # iter for CC=    21   i.e.    3.59
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Steady State Combustion
           stoptest= 1
```

```
     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  360000    863     0    896    32     51250 -.5611485235586E+01  .3388098447645E-04
139  679   45
 ---------------------------------------------------------------------------------
-----------
 TOTAL    863     0    896    32    512.50 (seconds)    proc=    .00%

 Total # iter for DY=   139   i.e.   16.11
 Total # iter for HS=   679   i.e.   78.68
 Total # iter for CC=    45   i.e.    5.21
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Steady State Combustion
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
  640000   1134     0   1170    35    120287 -.5611487252905E+01  .3908394368808E-04
218  850   66
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1134     0   1170    35   1202.87 (seconds)    proc=    .00%

 Total # iter for DY=   218   i.e.   19.22
 Total # iter for HS=   850   i.e.   74.96
 Total # iter for CC=    66   i.e.    5.82
    *** Conjugate Gradient Algorithms Project ***
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Steady State Combustion
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------
-----------
 1000000   1413     0   1451    37    232354 -.5611488188407E+01  .4244605838999E-04
331 1002   80
 ---------------------------------------------------------------------------------
-----------
 TOTAL   1413     0   1451    37   2323.54 (seconds)    proc=    .00%

 Total # iter for DY=   331   i.e.   23.43
 Total # iter for HS=  1002   i.e.   70.91
 Total # iter for CC=    80   i.e.    5.66
```

7. Minimal Surface Area

```
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Minimal Surface Area
           stoptest= 1
```

```
     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 -------------------------------------------------------------------------------------
-----------
   40000    288     3    315    26      1128  .1000000004110E+01  .3601390204563E-04
48  236    4
 -------------------------------------------------------------------------------------
-----------
 TOTAL    288     3    315    26     11.28 (seconds)    proc=   1.04%

 Total # iter for DY=    48   i.e.   16.67
 Total # iter for HS=   236   i.e.   81.94
 Total # iter for CC=     4   i.e.    1.39
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Minimal Surface Area
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 -------------------------------------------------------------------------------------
-----------
  160000    518     5    550    31      8672  .1000000037322E+01  .6354513265911E-04
70  438   10
 -------------------------------------------------------------------------------------
-----------
 TOTAL    518     5    550    31     86.72 (seconds)    proc=    .97%

 Total # iter for DY=    70   i.e.   13.51
 Total # iter for HS=   438   i.e.   84.56
 Total # iter for CC=    10   i.e.    1.93
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Minimal Surface Area
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 -------------------------------------------------------------------------------------
-----------
  360000    781     3    808    26     30091  .1000000060931E+01  .7246217957673E-04
89  679   13
 -------------------------------------------------------------------------------------
-----------
 TOTAL    781     3    808    26    300.91 (seconds)    proc=    .38%

 Total # iter for DY=    89   i.e.   11.40
 Total # iter for HS=   679   i.e.   86.94
 Total # iter for CC=    13   i.e.    1.66
    *** Conjugate Gradient Algorithms Project ***
    *** Dr. Neculai Andrei

    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Minimal Surface Area
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 -------------------------------------------------------------------------------------
-----------
```

```
  640000   1011     5   1039    27     69555  .1000000167460E+01  .1212136498766E-03
111  883   17
 ---------------------------------------------------------------------------------------
-----------
 TOTAL   1011     5   1039    27    695.55 (seconds)    proc=    .49%

 Total # iter for DY=   111   i.e.   10.98
 Total # iter for HS=   883   i.e.   87.34
 Total # iter for CC=    17   i.e.    1.68
    *** Conjugate Gradient Algorithms Project ***
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    AHYBRIDM Conjugate Gradient Algorithm
    Accelerated convex combination of HS,DY:
    from Newton direction with modified  secant condition
    Powell restart.  January 16, 2009

      1    AHYBRIDM Algorithm. Function Minimal Surface Area
           stoptest= 1

     n   iter   irs  fgcnt lscnt   time(c)        fxnew              gnorm
DY   HS   CC
 ---------------------------------------------------------------------------------------
-----------
 1000000   1714     4   1767    52    184673  .1000000106043E+01  .8367267321721E-04
447  922  345
 ---------------------------------------------------------------------------------------
-----------
 TOTAL   1714     4   1767    52   1846.73 (seconds)    proc=    .23%

 Total # iter for DY=   447   i.e.   26.08
 Total # iter for HS=   922   i.e.   53.79
 Total # iter for CC=   345   i.e.   20.13
```

Performance of AHYBRIDM. CPU time.

Powell restart criterion. $\|\nabla f(x_k)\|_\infty \le 10^{-6}$.

	CPU time (seconds)				
n	**A1**	**A2**	**A3**	**A5**	**A7**
40000	6.01	15.88	43.71	19.19	11.28
160000	52.52	142.62	358.55	153.20	86.72
360000	179.96	480.89	1196.43	512.50	300.91
640000	412.31	1130.91	2793.13	1202.87	695.55
1000000	789.20	2120.57	5607.51	2323.54	1846.73

January 16, 2009