POCOSEL User's Guide

1. Description

POCOSEL is a C/FORTRAN77 program that computes an approximation of the set of Pareto-optimal predictor weighing systems in the context of complex personnel selections that are based on using different predictor composites. The resulting predictor weighing systems (and the corresponding predictor composites) are Pareto-optimal in the sense that they result in a Pareto-optimal trade-off between the goals of selection quality (gauged by the expected average criterion score of the selected and assigned candidates) and selection diversity (gauged by the adverse impact ratio, AIR). The computation can be based on an analytic or a simulation based calculation of the selection outcomes. For more details on the problem solved by the program we refer to Druart and De Corte (in press). The executable code is offered as is, without any guarantee whatsoever.

At present, the program is limited to 15 criteria, 10 predictors, 5 different applicant groups, 50 different criterion preference subgroups, and no more than 5 different criteria within the criterion preference subgroups. The size of the simulation sample (when using simulation to calculate the selection outcomes) is limited to 10000.

Observe that the program is computationally extremely demanding. When the number of criteria within the application patterns becomes greater than 3, then the computation time increases by a factor of 10-100. In that case, the time can be somewhat reduced by using DRER = 0.01 (see below). The computation time also increases linearly with the value of NPSZ and NGEN (see below).

2. Input

Note that all input is in free format: Variables or vectores that have a name commencing with the letters I, J, K, L, M, N get INTEGER values. All other variables, vectors and matrices get FLOATING POINT values. See the example input file.

- # 1: **KEY**. To obtain a KEY, send an e-mail to wilfried.decorte@ugent.be
- # 2: **NC, NP, NG, PRG(I), I=1,NG**
  - NC: total number of criteria (i.e., jobs, positions a.s.o.); NC < 16.
  - NP: total number of predictors; NP < 11.
  - NG: Number of different applicant subpopulations. At present, the program works for NG = 2, where the first subpopulation is the minority population and the second subpopulation corresponds to the majority population.

  - PRG(I), I=1,NG: Vector of length NG with elements that specify the proportional representation of the applicant subpopulation candidates in the total applicant pool. Note that the sum of the prg(i) values must equal 1; the program does not check this!

- # 3: **IVC, IMOP, ITOP, WMI, WMA**
  - IVC = 0: Predictor validities are constant across criteria;
    IVC = 1: Predictor validities vary across criteria.
  - IMOP = 0: analytic computation of selection outcomes;
    IMOP = 1: simulation based computation of the selection outcomes
  - ITOP = 1: Computation of Pareto-optimal predictor weighing systems;
    ITOP = 2: Computation of worst possible predictor weighing systems. selection outcomes through simulation ($1 < \text{NSIM} < 50$).
  - WMI: minimum acceptable weight of the predictors in forming predictor composites.
  - WMA: maximum acceptable weight of the predictors in forming predictor composites.

- # 4: **NSZ. This line is only required when IMOP = 1!**
  - NSZ: size of the simulation sample; $500 < \text{NSZ} < 2000$. The program does not reject values of NSZ > 2000, but the execution time grows quadratically with the value of NSZ.

- # 4: **QU(I), I=1,NC**.
  - QU(I), I=1,NC: Vector of length NC with elements specifying the quota (expressed as a proportion of the total applicant pool) required for the different criteria.

- # 5 (and eventually the following NC-1 lines): **PV(I,J), J=1,NP and I=1 or I=1,NC**.
  - In case that IVC=0, I=1, and PV(1,J) specifies the validity of the Jth predictor.
  - In case that IVC=1, I=1,NC, and PV(I,J) specifies the the validity of the Jth predictor in predicting criterion I.

- #6: **NCO**.
  - NCO: number of different application patterns.

- # 7: **PRCO(I), I=1,NCO**.
  - PRCO(I), I=1,NCO: Vector of length NCO with elements that specify the proportional presence of the different application patterns. Observe that the sum of the PRCO-elements must equal 1; the program does not check this!
- # 8 and the following NCO-1 lines: **NUP(I), ICO(I,J), J=1,NUP(I)**.
  - In total NCO lines. The Ith line specifies the number of criteria in application pattern I (cf. NUP(I)) and the identity of the NUP(I) criteria that are in this Ith application pattern (cf. ICO(I,J), J=1,NUP(I)).
- #9 and the following NG-1 lines: **ESP(I,J), I=1,NG, J=1,NP**
  - The element in the Ith row and Jth column of ESP(I,J) specifies the effect size of predictor J in applicant subpopulation I. Effect size values must be given relative to the majority group. At present, the program works for NG = 2, where the first subpopulation is the minority population and the second subpopulation corresponds to the majority population.
- # 10 and the following NP-1 lines: **Set of NP-1 lines specifying PC(I,J) (with I = 1, NP-1 and J = I+1, NP) the correlation matrix of the NP predictors**. Note that only the strict upper triangular part of the correlation matrix must be specified! (see example)
- # 11: **DTOL, DREL, DRER**
  - DTOL: relative precision estimation augmentation constants. Recommended value: DTOL = 0.0001.
  - DREL: relative precision quadrature computations. Recommended value: DREL = 0.001.
  - DRER: relative precision computation of multivariate normal probabilities. Recommended value: $0.001 < \text{DRER} < 0.01$.
- #12: **NPSZ, NGEN, NUPO**
  - NPSZ: the size of the population used by the NSGA-II optimization routine (Deb et al., 2002). NPSZ must be a multiple of 4! $20 < \text{NPSZ} < 2000$
  - NGEN: the number of generations used by the NSGA-II optimization routine. $20 < \text{NGEN} < 200$.
  - NUPO: Requested number of distinct Pareto-optimal predictor weighing systems; $\text{NUPO} < \text{NPSZ}$.

- #13 **NAME01, NAME02**
  - NAME01, NAME02: the names of the files with the resulting selection outcome trade-off values. These names must commence with a letter and have a length of exactly 6 characters. The file NAME01 holds the selection quality outcome values, the file NAME02 the corresponding diversity outcome values. The files can be used as input for drawing the front of Pareto-optimal selection outcomes using R graphics utilities.

4. Sample Input File

Important: in preparing the input file, use a simple text editor such as Notepad, Wordpad or any other standard ASCII producing editor. DO NOT USE TEXT PROCESSING PROGRAMS SUCH AS MS-WORD or WORDPERFECT. Also, when saving the input file in Notepad, use the option "All Files" in the "Save as type" box. When saving in Wordpad, use the "Text Document-MS-DOS Format" option in the "Save as type" box, and be **aware that Wordpad has the nasty habit of adding the extension .txt to the file name that you specify**. Thus, with Wordpad, if you specify the name of the input file as "MINPUT", the file will in fact be saved as "MINPUT.TXT"; and this is the name that you have to use in the command to run the present programs. Here is a sample input file (without the first line containing the KEY!!!), for the `POCOSEL` program.

```
  3  4  2  .12  .88
   0  0  1  0.  1.
   .25  .1   .15
 0.510  0.480  0.220  0.320  0.410
  6
  .1  .1  .15  .20  .20  .25
 1  1
 1  2
 1  3
 2  1  2
 2  1  3
 3  1  2  3
 -0.72 -0.31  -0.06  -0.57  -0.04
  0.0   0.0   0.0  0.0  0.0
  0.310  0.030  0.370  0.000
  0.260  0.170  0.000
  0.310  0.390
 .0001  .001  .001
2000  100  50
  QUAL05  DIVE05
```

5. Running the Program

Suppose you copied the executable code of the program to the `C:ssel` directory on your machine. In that case, the input file must also be saved in the `C:ssel` directory. Next, to run the program, you have to open an MS-DOS Command window. The way to do this varies from one operating system (i.e., XP, Vista, Windows 7 a.s.o.) to the other, and you should use your local "HELP" button when in doubt about this feature.

If the MS-DOS Command window does not automatically open with the prompt `C:\>`, then you type in the MS-DOS Command window `C:`, followed by RETURN or ENTER, and your computer will return the `C:\>` command prompt. Next, you type `cd ssel` after the `C:\>` command prompt, again followed by RETURN or ENTER, and your computer will respond with the `C:\ssel>` command prompt. Now, you can execute the program by typing `pocosel < minput > moutput x` where "minput" is the name of the input file, "moutput" is the name of the output file, and "x" is a number between 0 and 1. At the end of the execution the PC will return the command prompt `C:\ssel>`. You can then inspect the output by editing the output file with either Notepad, Wordpad or any other simple editor program.

6. Sample Output and Description

The above input file corresponds to the file pocosel.i3 at the web page http://users.ugent.be/∼wdecorte/software.html. The corresponding output is the file pocosel.o3.

```
DATE: 09/02/2012;   TIME: 16:31:51

THE PRESENT CODE IS FOR DEMONSTRATION PURPOSES ONLY!!

                          +++++++++++++
                          +  POCOSEL  +
                          +++++++++++++

Analytical computation of the front of Pareto-optimal
selection quality-diversity trade-offs for complex selection
decisions using different predictor composites

Program written by Wilfried De Corte, Ghent University, Belgium

The program uses routines from the Slatec library (see
http://www.netlib.org/slatec), a couple of algorithms
from StatLib (see http://lib.stat.cmu.edu/apstat/),
some (adapted) code from Genz to evaluate multivariate normal
probabilities (cf. http://www.math.wsu.edu/math/faculty/genz/homepage),
and the nsga-II code from Kalyanmoy Deb (cf.
http://www.iitk.ac.in/kangal/codes.shtml).
At present, the program is limited to 15 criteria,
10 predictors, 5 different applicant groups, 50 different
criterion preference subgroups, and no more than 5 different
```

```
criteria within the criterion preference subgroups.

PROBLEM SPECIFICATION

Total number of different criteria:   3
Number of predictors:  4
Number of applicant subpopulations:  2
Proportional representation of subpopulations:  0.12  0.88
Number of different application pattern subgroups:   6
 Group  1; Prop.: 0.10; #Crit: 1; Crit:  1
 Group  2; Prop.: 0.10; #Crit: 1; Crit:  2
 Group  3; Prop.: 0.15; #Crit: 1; Crit:  3
 Group  4; Prop.: 0.20; #Crit: 2; Crit:  1  2
 Group  5; Prop.: 0.20; #Crit: 2; Crit:  1  3
 Group  6; Prop.: 0.25; #Crit: 3; Crit:  1  2  3

Predictor validities are stable over the criteria.
Predictor validities
  Criterion                 Predictor
                        1     2     3     4
      1                0.51  0.48  0.22  0.32
      2                0.51  0.48  0.22  0.32
      3                0.51  0.48  0.22  0.32

Predictor effect sizes (relative to the majority applicant subpopulation)
  Subpopulation             Predictor
                        1     2     3     4
      1               -0.72 -0.31 -0.06 -0.57
      2                0.00  0.00  0.00  0.00

Predictor correlation matrix
  Predictor                 Predictors
                        1     2     3     4
      1                1.00  0.31  0.03  0.37
      2                0.31  1.00  0.26  0.17
      3                0.03  0.26  1.00  0.31
      4                0.37  0.17  0.31  1.00

Analytic computation of selection outcomes.
Computation of Pareto-optimal selection outcome trade-offs.

Population size and number of generations in the evolutionary
  optimization routine are  2000 and 100
Requested number of Pareto-optimal trade-offs:   50
Lower and upper bound values of predictor weights:  0.00  1.00

Calculation precision parameters
  Relative precision computation augmentation constants:  0.0001
  Relative precision of quadratures:  0.0010
  Relative precision of multivariate probabilities:  0.0010
```

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PROGRAM DIAGNOSTICS

NUMBER FAIL MAX COR EST CRIT OVER .9999999:      84
NUMBER FAIL IN SOLVING AUGMENTATION CONSTANTS:       0
NUMBER FAIL IN COMPUTING SEL RATIO JOB:       0
NUMBER FAIL ZERO PREDICTOR WEIGHTS:       0
NUMBER FAIL ZERO CRITERION ESTIMATE VARIANCE:       0

TOTAL CPU TIME     4556.804 seconds

PROGRAM OUTPUT

Solution trade-off set values are written on file QUAL05
  for quality outcome and on file DIVE05 for the
  diversity outcome.
  Both files provide input for drawing the trade-off set using
  R graphics utilities.

Overview Pareto-optimal trade-offs

For each trade-off the quality and the diversity value,
followed by the corresponding predictor weights (columns)
per criterion (rows)

Trade-off    1  Quality:  0.1266     Diversity:  0.9520
  Composite 1  0.000  0.001  0.803  0.000
  Composite 2  0.000  0.002  0.683  0.000
  Composite 3  0.000  0.001  0.896  0.001
Trade-off    2  Quality:  0.1336     Diversity:  0.9476
  Composite 1  0.000  0.075  0.990  0.000
  Composite 2  0.000  0.008  0.955  0.000
  Composite 3  0.000  0.004  0.948  0.001
Trade-off    3  Quality:  0.1407     Diversity:  0.9430
  Composite 1  0.000  0.118  0.912  0.000
  Composite 2  0.000  0.020  0.879  0.000
  Composite 3  0.000  0.009  0.856  0.000
Trade-off    4  Quality:  0.1475     Diversity:  0.9388
  Composite 1  0.000  0.158  0.761  0.000
  Composite 2  0.000  0.026  0.957  0.000
  Composite 3  0.000  0.007  0.895  0.000
Trade-off    5  Quality:  0.1547     Diversity:  0.9343
  Composite 1  0.000  0.237  0.742  0.000
  Composite 2  0.000  0.001  0.929  0.000
  Composite 3  0.000  0.007  0.945  0.000
Trade-off    6  Quality:  0.1615     Diversity:  0.9297
  Composite 1  0.000  0.348  0.916  0.000
  Composite 2  0.000  0.011  0.962  0.001
  Composite 3  0.000  0.009  0.923  0.000
Trade-off    7  Quality:  0.1684     Diversity:  0.9252
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  Composite 1  0.000  0.450  0.939  0.000
  Composite 2  0.000  0.003  0.995  0.000
  Composite 3  0.000  0.007  0.933  0.000
Trade-off    8  Quality:  0.1753     Diversity:  0.9204
  Composite 1  0.000  0.555  0.993  0.000
  Composite 2  0.001  0.009  0.984  0.000
  Composite 3  0.000  0.009  0.950  0.000
Trade-off    9  Quality:  0.1821     Diversity:  0.9156
  Composite 1  0.000  0.641  0.983  0.000
  Composite 2  0.000  0.014  0.962  0.000
  Composite 3  0.000  0.010  0.944  0.000
Trade-off   10  Quality:  0.1889     Diversity:  0.9110
  Composite 1  0.000  0.659  0.997  0.000
  Composite 2  0.000  0.006  0.978  0.000
  Composite 3  0.000  0.068  0.944  0.000
Trade-off   11  Quality:  0.1958     Diversity:  0.9060
  Composite 1  0.000  0.694  0.984  0.000
  Composite 2  0.000  0.014  0.975  0.000
  Composite 3  0.000  0.097  0.940  0.000
Trade-off   12  Quality:  0.2027     Diversity:  0.9011
  Composite 1  0.000  0.685  0.942  0.000
  Composite 2  0.000  0.020  0.945  0.000
  Composite 3  0.000  0.139  0.919  0.000
Trade-off   13  Quality:  0.2096     Diversity:  0.8961
  Composite 1  0.000  0.628  0.929  0.000
  Composite 2  0.000  0.019  0.960  0.000
  Composite 3  0.000  0.236  0.914  0.000
Trade-off   14  Quality:  0.2164     Diversity:  0.8911
  Composite 1  0.000  0.633  0.957  0.000
  Composite 2  0.000  0.091  0.945  0.000
  Composite 3  0.000  0.246  0.949  0.000
Trade-off   15  Quality:  0.2234     Diversity:  0.8861
  Composite 1  0.000  0.660  0.934  0.000
  Composite 2  0.000  0.135  0.956  0.000
  Composite 3  0.000  0.255  0.964  0.000
Trade-off   16  Quality:  0.2303     Diversity:  0.8809
  Composite 1  0.001  0.696  0.909  0.000
  Composite 2  0.000  0.132  0.995  0.000
  Composite 3  0.000  0.295  0.917  0.000
Trade-off   17  Quality:  0.2372     Diversity:  0.8757
  Composite 1  0.000  0.707  0.950  0.000
  Composite 2  0.000  0.301  0.979  0.000
  Composite 3  0.000  0.241  0.919  0.000
Trade-off   18  Quality:  0.2440     Diversity:  0.8706
  Composite 1  0.000  0.695  0.822  0.000
  Composite 2  0.000  0.168  0.717  0.000
  Composite 3  0.000  0.148  0.425  0.000
Trade-off   19  Quality:  0.2509     Diversity:  0.8653
  Composite 1  0.000  0.691  0.998  0.000
  Composite 2  0.000  0.322  0.971  0.000
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  Composite 3  0.000  0.407  0.901  0.000
Trade-off   20  Quality:  0.2579     Diversity:  0.8600
  Composite 1  0.000  0.880  0.990  0.000
  Composite 2  0.000  0.332  0.938  0.000
  Composite 3  0.000  0.373  0.918  0.000
Trade-off   21  Quality:  0.2647     Diversity:  0.8548
  Composite 1  0.000  0.743  0.919  0.000
  Composite 2  0.000  0.278  0.710  0.000
  Composite 3  0.000  0.531  0.987  0.000
Trade-off   22  Quality:  0.2715     Diversity:  0.8494
  Composite 1  0.000  0.778  0.813  0.000
  Composite 2  0.000  0.381  0.949  0.000
  Composite 3  0.000  0.504  0.911  0.000
Trade-off   23  Quality:  0.2783     Diversity:  0.8440
  Composite 1  0.000  0.793  0.900  0.000
  Composite 2  0.000  0.573  0.977  0.000
  Composite 3  0.000  0.512  0.895  0.000
Trade-off   24  Quality:  0.2852     Diversity:  0.8382
  Composite 1  0.000  0.802  0.928  0.001
  Composite 2  0.000  0.673  0.978  0.000
  Composite 3  0.000  0.596  0.906  0.001
Trade-off   25  Quality:  0.2921     Diversity:  0.8326
  Composite 1  0.000  0.802  0.797  0.000
  Composite 2  0.000  0.557  0.714  0.000
  Composite 3  0.000  0.596  0.906  0.001
Trade-off   26  Quality:  0.2988     Diversity:  0.8270
  Composite 1  0.000  0.918  0.920  0.000
  Composite 2  0.000  0.668  0.982  0.000
  Composite 3  0.000  0.902  0.952  0.000
Trade-off   27  Quality:  0.3056     Diversity:  0.8211
  Composite 1  0.000  0.892  0.961  0.000
  Composite 2  0.000  0.982  0.965  0.000
  Composite 3  0.000  0.950  0.914  0.000
Trade-off   28  Quality:  0.3124     Diversity:  0.8150
  Composite 1  0.000  0.916  0.821  0.000
  Composite 2  0.000  0.903  0.947  0.000
  Composite 3  0.000  0.526  0.466  0.000
Trade-off   29  Quality:  0.3193     Diversity:  0.8087
  Composite 1  0.000  0.696  0.500  0.000
  Composite 2  0.000  0.960  0.904  0.000
  Composite 3  0.000  0.951  0.847  0.001
Trade-off   30  Quality:  0.3261     Diversity:  0.8021
  Composite 1  0.000  0.718  0.507  0.000
  Composite 2  0.000  0.844  0.717  0.000
  Composite 3  0.001  0.926  0.621  0.000
Trade-off   31  Quality:  0.3329     Diversity:  0.7950
  Composite 1  0.000  0.800  0.400  0.000
  Composite 2  0.000  0.956  0.716  0.000
  Composite 3  0.000  0.999  0.697  0.000
Trade-off   32  Quality:  0.3398     Diversity:  0.7870
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```
  Composite 1  0.001  0.952  0.488  0.000
  Composite 2  0.001  0.850  0.431  0.000
  Composite 3  0.000  0.804  0.402  0.000
Trade-off   33  Quality:  0.3465     Diversity:  0.7782
  Composite 1  0.042  0.891  0.375  0.000
  Composite 2  0.000  0.866  0.398  0.000
  Composite 3  0.000  0.806  0.413  0.001
Trade-off   34  Quality:  0.3533     Diversity:  0.7695
  Composite 1  0.126  0.887  0.409  0.001
  Composite 2  0.000  0.913  0.483  0.000
  Composite 3  0.001  0.774  0.376  0.001
Trade-off   35  Quality:  0.3594     Diversity:  0.7608
  Composite 1  0.154  0.884  0.366  0.000
  Composite 2  0.000  0.878  0.365  0.001
  Composite 3  0.001  0.966  0.402  0.000
Trade-off   36  Quality:  0.3655     Diversity:  0.7519
  Composite 1  0.234  0.900  0.415  0.000
  Composite 2  0.008  0.947  0.403  0.000
  Composite 3  0.000  0.865  0.359  0.001
Trade-off   37  Quality:  0.3715     Diversity:  0.7431
  Composite 1  0.293  0.808  0.350  0.000
  Composite 2  0.001  0.848  0.395  0.000
  Composite 3  0.000  0.872  0.391  0.000
Trade-off   38  Quality:  0.3769     Diversity:  0.7343
  Composite 1  0.425  0.929  0.409  0.001
  Composite 2  0.001  0.846  0.409  0.000
  Composite 3  0.003  0.836  0.383  0.001
Trade-off   39  Quality:  0.3822     Diversity:  0.7254
  Composite 1  0.432  0.967  0.424  0.000
  Composite 2  0.004  0.856  0.336  0.001
  Composite 3  0.050  0.974  0.410  0.000
Trade-off   40  Quality:  0.3874     Diversity:  0.7166
  Composite 1  0.423  0.902  0.384  0.000
  Composite 2  0.002  0.886  0.394  0.000
  Composite 3  0.103  0.951  0.385  0.000
Trade-off   41  Quality:  0.3926     Diversity:  0.7076
  Composite 1  0.442  0.918  0.352  0.000
  Composite 2  0.039  0.952  0.397  0.000
  Composite 3  0.105  0.862  0.365  0.001
Trade-off   42  Quality:  0.3975     Diversity:  0.6989
  Composite 1  0.486  1.000  0.395  0.001
  Composite 2  0.044  0.853  0.367  0.000
  Composite 3  0.166  0.885  0.375  0.000
Trade-off   43  Quality:  0.4023     Diversity:  0.6901
  Composite 1  0.451  0.903  0.383  0.000
  Composite 2  0.105  0.888  0.389  0.001
  Composite 3  0.195  0.962  0.409  0.000
Trade-off   44  Quality:  0.4069     Diversity:  0.6813
  Composite 1  0.468  0.971  0.386  0.001
  Composite 2  0.232  0.881  0.394  0.001
```

```
  Composite 3  0.165  0.986  0.383  0.000
Trade-off   45  Quality:  0.4115     Diversity:  0.6726
  Composite 1  0.504  0.944  0.431  0.000
  Composite 2  0.225  0.873  0.397  0.000
  Composite 3  0.211  0.936  0.376  0.001
Trade-off   46  Quality:  0.4159     Diversity:  0.6640
  Composite 1  0.561  0.983  0.356  0.000
  Composite 2  0.312  0.976  0.446  0.000
  Composite 3  0.201  0.969  0.374  0.000
Trade-off   47  Quality:  0.4205     Diversity:  0.6550
  Composite 1  0.478  0.909  0.332  0.001
  Composite 2  0.255  0.913  0.390  0.002
  Composite 3  0.334  0.945  0.392  0.001
Trade-off   48  Quality:  0.4248     Diversity:  0.6463
  Composite 1  0.503  0.857  0.332  0.010
  Composite 2  0.297  0.881  0.390  0.000
  Composite 3  0.333  0.945  0.382  0.001
Trade-off   49  Quality:  0.4288     Diversity:  0.6375
  Composite 1  0.595  0.982  0.417  0.001
  Composite 2  0.345  0.938  0.387  0.000
  Composite 3  0.442  0.967  0.464  0.001
Trade-off   50  Quality:  0.4329     Diversity:  0.6288
  Composite 1  0.661  0.972  0.421  0.000
  Composite 2  0.311  0.851  0.352  0.002
  Composite 3  0.439  0.897  0.371  0.000
Trade-off   51  Quality:  0.4368     Diversity:  0.6198
  Composite 1  0.520  0.805  0.321  0.000
  Composite 2  0.441  0.875  0.354  0.000
  Composite 3  0.493  0.962  0.408  0.000
Trade-off   52  Quality:  0.4403     Diversity:  0.6111
  Composite 1  0.740  0.966  0.369  0.002
  Composite 2  0.510  0.986  0.410  0.000
  Composite 3  0.480  0.957  0.372  0.000
Trade-off   53  Quality:  0.4438     Diversity:  0.6024
  Composite 1  0.718  0.977  0.389  0.017
  Composite 2  0.535  0.936  0.367  0.000
  Composite 3  0.612  0.992  0.405  0.001
Trade-off   54  Quality:  0.4468     Diversity:  0.5938
  Composite 1  0.742  0.937  0.384  0.000
  Composite 2  0.532  0.835  0.340  0.001
  Composite 3  0.595  0.871  0.370  0.014
Trade-off   55  Quality:  0.4498     Diversity:  0.5850
  Composite 1  0.671  0.794  0.349  0.047
  Composite 2  0.640  0.875  0.388  0.000
  Composite 3  0.536  0.738  0.325  0.005
Trade-off   56  Quality:  0.4524     Diversity:  0.5762
  Composite 1  0.757  0.922  0.390  0.001
  Composite 2  0.727  0.862  0.355  0.053
  Composite 3  0.770  0.950  0.337  0.044
Trade-off   57  Quality:  0.4549     Diversity:  0.5671
```

```
  Composite 1  0.919  0.994  0.382  0.120
  Composite 2  0.698  0.991  0.325  0.039
  Composite 3  0.769  0.978  0.389  0.062
Trade-off   58  Quality:  0.4571     Diversity:  0.5581
  Composite 1  0.771  0.798  0.306  0.130
  Composite 2  0.767  0.891  0.298  0.066
  Composite 3  0.769  0.972  0.376  0.053
Trade-off   59  Quality:  0.4590     Diversity:  0.5493
  Composite 1  0.735  0.801  0.309  0.129
  Composite 2  0.749  0.890  0.324  0.082
  Composite 3  0.934  0.979  0.309  0.162
Trade-off   60  Quality:  0.4607     Diversity:  0.5404
  Composite 1  0.908  0.895  0.309  0.139
  Composite 2  0.799  0.869  0.319  0.097
  Composite 3  0.939  0.897  0.299  0.144
Trade-off   61  Quality:  0.4618     Diversity:  0.5317
  Composite 1  0.785  0.773  0.272  0.144
  Composite 2  0.959  0.958  0.320  0.261
  Composite 3  0.948  0.892  0.255  0.179
Trade-off   62  Quality:  0.4626     Diversity:  0.5227
  Composite 1  0.794  0.714  0.222  0.159
  Composite 2  0.985  0.849  0.332  0.252
  Composite 3  0.943  0.831  0.254  0.171
Trade-off   63  Quality:  0.4627     Diversity:  0.5204
  Composite 1  0.761  0.699  0.220  0.224
  Composite 2  0.988  0.892  0.303  0.236
  Composite 3  0.942  0.833  0.254  0.171
```

7. Acknowledgement

When the user reports results obtained by the present program, due reference should be made to Deb, Pratap, Agarwal and Meyarivan (2002), De Corte (2012) and Druart and De Corte (in press).

8. References

Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. *IEEE Transactions on Evolutionary Computation*, *6*, 182-197.

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