GENDEX-2001:GETTING STARTED AND THE BIB MODULE

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ABSTRACT

The Gendex Toolkit is a computer software package for constructing randomized plans for a variety of experiment designs and treatment designs. The designs are optimal or near optimal in all cases. The Toolkit is a great time-saver and is useful for all designers of experiments, whether experiment or treatment. Instructions are given for installing the package for three modes of receiving a package, i.e., an e-mail attachment using a .zip file, and e-mail attachment using a .jar file, and a disk copy of the program. The use of the Bib module is demonstrated with three different examples.

INTRODUCTION

In the pre-computer age, the *toolkit* for designers of experiments included finite fields group characters, etc., and various catalogues of experiment designs. Gendex is a

toolkit for generating randomized plans for statistical designs in the computer age. It has ten modules, each of which is a by-product of publications by Nam-Ky Nguyen (1993, 1994) in refereed journals. Anyone belonging to one of the following groups will find Gendex a very useful tool:

(i)   designers of experiments with a new philosophy of designing experiments, that is, *"Design for the experiment, do not experiment for the design"* (Federer, 1984),

(ii)   designers of experiments in industrial settings where it is difficult to adjust material to catalogued plans, and

(iii)   designers of experiments in agricultural research where it is easier to get access to a PC than to various catalogues to find an appropriate plan even if one exists.

Anyone, not just those listed above, who designs an experiment will find the Gendex toolkit useful, efficient, and a great time-saver. The current version of Gendex has a module that can generate randomized arrangements for up to 10,000 treatments. The designs produced are always optimal or near optimal. (See Nguyen, 2001.)

The ten modules included in the Gendex toolkit are:

1.   Bib module which is used to construct t-resolvable and non-resolvable incomplete block experiment designs for various block sizes and for up to 200 treatments.

2.   Rrc module which is used to construct row-column experiment designs.

3.   Rcd module which is used to construct resolvable row-column experiment designs.

4.   Alpha module which is used to construct alpha experiment designs for up to 10,000 treatments.

5.   Cib module which is used to construct cyclic incomplete block experiment designs for various block sizes and up to 10,000 treatments.

6.   Noa module which is used to construct supersaturated treatment designs and orthogonal arrays using factors at two levels for up to 128 factors..

7.   Dex module which is used to construct D-optimal treatment designs for factors at two and three levels.

8.   Ffd module which is used to construct fractional factorial and response surface treatment designs for factors at two and/or three levels.

9.   Cut module which is used to divide treatments into blocks.

10.   Rat module which is used to construct treatment designs robust against trend.

In this report, we first demonstrate how to install Gendex on a PC in different ways. Then, we consider the Bib module and demonstrate its use. Several examples are discussed. Federer *et al.* (1998, 1999) described how to install and how to use a previous version of the Gendex toolkit.

GETTING STARTED-INSTALLATION

The Gendex toolkit is designed to run off Java. If Java2, J2RE, is not available on the computer where Gendex is to be placed, it may be obtained from the Internet. J2RE, is needed to run the Gendex toolkit. It may be downloaded from the Internet by going to

http://www.designcomputing.hypermart.net/Gendex.

Windows 95 or higher is required to run Gendex. If Java2 is downloaded on a disk, a zip disk is needed as more storage, 10.9 MB, is required than available on an ordinary disk. To download Java2, proceed as follows:

1. Access http://www.designcomputing.hypermart.net/Gendex on the Internet.
2. Under FILE click OPEN PAGE.
3. Click OPEN.
4. Under Item 9 on the GENDEX DOE TOOLKIT FAQ page, click on JAVA^{IM} Standard Edition Runtime Environment Installed.
5. Click on JRE 1.3.1
6. Download to C:\WINDOWS or any other directory of choice.

The toolkit Gendex may be obtained as an attachment to an e-mail or on a disk. Because the file size is large, the attachments are sent in zipped form and must be unzipped in order for Gendex to run. If a computer does not have a program for unzipping a file, WINZIP80.EXE may be downloaded free from the Internet (http://www.winzip.com).

Installing Gendex from a zipped e-mail attachment:

If a zipped version of Gendex is obtained via an e-mail attachment, named for example Gendex1.zip, the procedure is as follows for Windows 95 or later versions:

1. Save the attachment to the computer's hard drive in an easily accessible location.
2. From the Windows menu bar, select START, then PROGRAMS, and then WINDOWS EXPLORER.
3. Double click on C:\ drive (If that is where it is desired to store the Gendex files. Otherwise, select the appropriate directory for your computer).
4. On the menu bar, select FILE, then select NEW, and then FOLDER.
5. When the NEW FOLDER appears, type Gendex, and hit enter.
6. Locate the e-mail attachments on your computer. say C:\Program Files\Bear Access\WINBA\Eudora\Attach in our case. Right click on the attachment and select EXTRACT TO.
7. Click I agree (on the disclaimer message) and type C:\Gendex in EXTRACT TO box. If the Gendex folder was placed in another directory, type the appropriate drive letter in the EXTRACT TO box.)

8. Select EXTRACT from MENU and then CANCEL.
9. Open C:\Gendex (or correct directory) to observe that the files have been transferred to the C:\Gendex directory.

<u>Installing Gendex from a Gendex1.jar e-mail attachment:</u>

It may be that the e-mail attachment is sent as a .jar file instead of a .zip file. A jar.exe file is needed to open a .jar file. This file may be obtained free if not available on the host computer. To obtain an unzipped version of a .jar file, follow steps 1 to 4 above to create the C:\Gendex folder. Then, proceed as follows for an attached file named, for example, G092001.jar:

1. Go to directory where e-mail attachments reside. In our case the path is
   C:\Program Files\Bear Access\WINBA\Eudora\Attach.
   In Attach, highlight file G092001.jar and select COPY.
2. Go to folder named Gendex and highlight this folder. Then select PASTE. The file name G092001.jar will appear.
3. Highlight the file name G092001.jar. Go to FILE and select "Add to G092001.zip".
4. Click "I agree". This creates a file named G092001.zip in the Gendex folder.
5. Highlight G092001.zip and click on OPEN.
6. Answer YES to start another WINZIP session.
7. Answer "I agree".
8. In WINZIP Classic mode, highlight the file G092001.jar; click on EXTRACT and then click on OPEN. The files in G092001.jar will be displayed.
9. Select the EXTRACT icon at the top of the screen.
10. In the EXTRACT TO box, type the folder name C:\Gendex.
11. Answer NO to all questions. (There may be as many questions as there are files in G092001.jar.)
12. Return to Gendex folder and the file names in G092001.jar will be displayed along with the file names G092001.jar and G092001.zip.

This completes the installation of the Gendex toolkit. The toolkit is now ready to construct incomplete block designs using either of the following commands in DOS

C:\> java -cp C:\Gendex Bib or C:\Gendex>BIB

where Bib (balanced incomplete block) is the module name and must be typed as Bib if the first command is used. For the second command, case is unimportant. An incomplete block design for v treatments in incomplete blocks of size $k \leq v$ in r complete blocks (replicates) may be obtained with this command.

<u>Installing Gendex from a disk:</u>

Go through steps 1 to 4 above to set up the Gendex folder. In our example, the three files on Gendex1.zip to be copied are:

1.   Gendex
2.   Gendex1.zip
3.   WINZIP80.EXE

These three files need to be copied into the C:\Gendex folder. The file WINZIP80.EXE was included on the disk used above. In WINDOWS EXPLORER

1.   Open the C:\Gendex folder.
2.   Insert disk in A:\> drive, and the names of the three files will appear.
3.   Highlight all three files by using the shift bar. From MENU board select COPY.
4.   Hightlight C:\Gendex, select PASTE from MENU Board. The names of the three files will appear.
5.   These are zipped files which need to be unzipped, which we do as follows. Highlight Gendex1.zip and then follow directions on WINZIP WIZARD. Select NEXT. A dot should be in the box labeled Unzip or install from an existing zip file. Click NEXT (Gendex1.zip should be highlighted.); click NEXT. A check mark should be in the box labeled Display icons after unzipping, then select UNZIP.
6.   Open C:\Gendex to observe that the unzipped contents of the disk have been copied into this folder.

Instead of using icons on the DESKTOP, one could go to MS_DOS PROMPT and make a new folder called Gendex as described in the following:

1.   From START go to PROGRAMS.
2.   Select MS_DOS PROMPT.
3.   From C:\Windows\> type CD\ to change directory to the C:\drive where the Gendex folder is to be placed.
4.   Make a new directory folder using the command C:\>MD Gendex.
5.   Copy the three files from the Gendex1.zip disk into this directory using the command *.* C: from the A\:> prompt. This copies the contents on the disk in the A drive to the C drive.

The steps for installing Java2 are given above. To use Gendex from the MS_DOS PROMPT set-up, one needs to open MS_DOS first. Then, type the command

C:\Gendex>java –cp C:\Gendex module name.

To open a module such as Bib, type one of the two following commands

C:\Gendex>java -cp C:\Gendex Bib or C:\Gendex> BIB.

Note that the first command is case sensitive and the spacing is important. Alternatively, one may create a Gendex icon on the desktop by using the shortcut option. Then, within the Gendex icon, create icons for each of the ten modules of the toolkit.

THE BIB MODULE

The steps to use the BIB module from the DOS directory are:

1. Change directory from C:\WINDOWS> with the command C:\WINDOWS>CD\Gendex and return.
2. To open the BIB module use the command C:\Gendex>BIB.
3. Follow directions from "choose number of treatments" to select v the number of treatments, $2 \leq v \leq 200$. For our example, select v = 9.
4. Follow directions from "choose the block size" to select k the block size, $2 \leq k \leq v \leq 20$. For our example, let k = 3.
5. Follow directions from "choose the number of replications" to select r the number of replications, $2 \leq r \leq 20$. For our example, let r = 4.
6. Follow the directions from "Do you want to obtain a 1-resolvable design?" as follows. If complete blocks with each treatment occurring once are desired, click YES. If it is desired to have complete blocks with treatments occurring twice and r is even, click NO and then click YES. If no complete blocks are desired, click NO two times.
7. Follow the directions from "Do you want to print the blocks (incomplete) as columns?" Click YES for blocks as columns and NO if the blocks are to be printed as rows.
8. Follow directions from "enter a random seed" to select random seed number. This may be skipped or any number may be inserted. For our example, 1123 was selected.
9. Follow directions "enter the number of tries" to select number of tries. The number of tries may be skipped, but it is a good idea to insert a number as the program will continue tries and iterations of a try until the plan is as near optimal as possible. The larger v, the more unbalanced the design, the larger r, and the greater the number of tries and the greater the number of iterations for a try, the greater will be the computer time required to search for the best design. The time required to obtain a design for v = 200, k = 10, and r = 20 was approximately 50 minutes in Windows 98. Another attempt required almost three hours. When the process of tries and iterations achieves the best design, the program stops and displays the design. Since the convergence to the best design is usually fairly quick, additional tries and iterations add little to the optimality of a design. With practice, the user will learn what is a good number of tries to insert. With small v, 10-15 tries is sufficient. If the user gets tired of waiting for a design, the program iterations may be

stopped using the command "CTRL+C", and the design to that point will appear.

10. Click OK at bottom of screen after design has appeared to save the design as BIB.HTM.

11. To obtain a printout of the design, under FILE click OPEN, select C:\Gendex. Click on BIB.HTM to open file obtained from last run of module. Go to FILE, select PRINT, click O. K to obtain a printed copy. If an edited copy is desired, use SELECT ALL and then COPY. Paste this copy in a word-processing package such as Word, Notepad, etc.

The output for the example for v = 9 treatments, k = 3 treatments per block, and r = 4 replications is:

**BIB 2.1: Construct incomplete block design of size (v,k,r)
(C) 2001 Design Computing (URL: http//designcomputing.hypermart.net)

Note: Incomplete block design v=9, k=3, r=4, b=12

Try number	1
Seed	1123
# of iterations	5
E	0.75
E/U	1
Concurrences	1(36)

Plan (Blocks as columns)

```
6    4    0
3    7    8
2    4    5

6    0    1
3    7    8
2    4    5

8    0    7
4    1    5
6    3    2

2    5    8
1    6    3
4    0    7
```

Note: BIB used 0.27 seconds

The design was obtained on the first try and the fifth iteration of that try. The letter E stands for the intra-block efficiency factor, denoting the proportion of replicates (complete blocks) where sets of treatments are unconfounded with incomplete blocks (here 3 out of 4 and 3/4 = 0.75). U stands for the highest efficiency factor theoretically possible. Since a balanced incomplete block experiment design was obtained, one cannot do better and hence E/U = 1. There are v(v − 1)/2 = 9(9 - 1)/2 = 36 pairs of treatments

and every pair appears in an incomplete block one time. The number of times a pair occurs in the b = 12 block is called a concurrence. Here every one of the 36 pairs occurs once as indicated by 1(36). The randomized plan is given next. Each item occurs with itself r = 4 times. The concurrences of all possible pairs are one for this balanced incomplete block experiment design. The output may be edited or annotated prior to printing as explained above.

As a second example let v = 9 treatments, k = 2 treatments per block, and r = 6 replications. Note that nine treatments in incomplete blocks of size 2 cannot be put into one complete block but each treatment needs to be replicated twice in order to have complete blocks. At the prompt "Do you want to obtain a 2-resolvable design?", click YES. The output for this example is:

BIB 2.1: Construct incomplete block designs of size (v,k,r)
(C) 2001 Design Computing (URL: http://designcomputing.hypermart.net)

Note: Incomplete block design for v=9, k=2, r=6, b=27.

```
try #            1
seed             991857726470
# of iterations  12
E                0.54298645
E/U              0.9955
concurrences     0(9) 1(27)
```

Plan (Blocks are columns):

```
2   0   6   4   8   1   3   5   7
7   1   3   5   2   4   8   6   0

7   3   0   4   2   3   2   8   6
6   4   5   7   1   0   5   1   8

7   4   0   1   4   5   5   6   2
3   8   8   7   6   3   1   2   0
```

Note: BIB used 0.22 seconds.
Note: this software is licensed to AV Biometrics (Australia).

This plan is near optimal in that E/U = 0.9955. Nine pairs of treatments do not occur together in the b = 27 incomplete blocks as indicated by 0(1) and 27 pairs of treatments occur together once in the 27 incomplete blocks as indicated by 1(27). There are 9 + 27 = 36 possible pairs of treatments.

For a third example, let v = 45 treatments, k = 9 treatments per block, and r = 4 replications. Note that incomplete blocks of sizes 3, 5, 9, and 15 may be selected for 1-resolvable designs. The output is:

BIB 2.1: Construct incomplete block designs of size (v,k,r)
(C) 2001 Design Computing (URL: http://designcomputing.hypermart.net)

Note: Incomplete block design for v=45, k=9, r=4, b=20.

try #	1
seed	991859315630
# of iterations	41
E	0.8902966
E/U	0.9999
concurrences	0(384) 1(498) 2(102) 3(6)

Plan (Blocks are rows):

```
30   44   20   10   25    6    7   18   17
40   37   38    3   16   29    1   24   36
43   42    8   27   41   22   35   28   31
 5   13   15    0   26    4   14   12   23
 9   32   21    2   39   11   19   33   34

25   29   32    8   31   11    3   12   17
 9   37   35   24   39    6   23    0   10
22    1   30   44   13   33   38    5   28
42   14    4   34   40    7   41    2   36
16   27   19   15   43   26   20   21   18

28   39   29    9   18   38    4    7   31
23   16    2   27   12   35   30    1   17
19    0   36   25   44   40   33    8   15
 6    3   21   42   10   11   14   43    5
26   22   32   34   24   41   37   20   13

 4   24    1   15    8   11   41   18   10
31   37   27    5   44   39   14   20    2
36    0   21   22   16   32    7   28   12
43   33   40   29   13   34    6   23   17
38   30   35   42    3   26    9   25   19
```

Note: BIB used 0.6 seconds.
Note: this software is licensed to AV Biometrics (Australia).

The design is very near to the maximum optimality, E/U =0.9999. There are four types of concurrences or four associate classes. 384 pairs of treatments did not occur together in any of the 20 incomplete blocks, 498 pairs occurred together one time, 102 pairs occurred together two times, and six pairs occurred together three times. The rows are the incomplete blocks of nine treatments. This design was obtained at the first try and the forty-first iteration and only required 0.6 second of computer time.

COMMENTS

The Bib Module of the Gendex Toolkit is a great time-saver for constructing efficient incomplete block designs for $v \leq 200$ treatments in incomplete blocks of size $k \leq v$ with r replicates. A randomized plan is obtained and the experiment is ready to be conducted. This is especially pertinent for large v where the randomized plans would require a considerable amount of time if a toolkit such as Gendex were not used. Thus, the Toolkit is a great time-saver for an experimenter.

One may use SHORTCUT to place icons on the DESKTOP. This would be quicker and would require less time to construct a randomized plan for an experiment design. Since these are .class files instead of batch files, it is not as easy to place icons on the DESKTOP as with .BAT files.

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