

JIp22

User's Guide

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1 Preface

The **Jlp22** software is the newest version of **J** software. Don Shepard told via Fortran Discourse that there is already **J** programming language. In order to avoid confusion, the name of **J** is now changed into **Jlp22**, the name which shows the inheritance from JLP. The name **J** was used in everything which happened to the software before this point. In the current version **Jlp22**, the beef is still the linear programming in forest management planning. But **Jlp22** has so many tools for data management and numeric computations, that also vegetarians can use it. Perhaps these tools will be first used for preprocessing data and postprocessing the results in conjunction of linear programming. The random number generators provide possibilities to do risk computations related to linear programming within **Jlp22**.

History of J before Luke

JLP is the linear programming (LP) software I made for the forest planning system Mela which was created by Markku Siitonen in Finnish Forest Research Institute (Metla). Section 'JLP linear programming algorithm' describes the development and key points in the algorithm. Here only the development is described from the organizational point of view. JLP was published 1992 (see [jlp92.pdf](#)) and Finnish Forest Research Institute (Metla) started to distribute it. I wrote most part of it when paid by Academy of Finland. NMBU started to use JLP from the beginning in its GAYA software which was then called GAYA-JLP.

I wrote **J** as a successor for JLP. First version of **J**, version 0.9.3 was published in 2004. The beef in **J** was the same linear programming algorithm as in JLP. **J** provided many new possibilities for preprocessing of data and postprocessing of results, and these computations can be used also without LP problems. Even Bergseng from NMBU started to use **J** in a premature phase and thus he had to tolerate quite much mix-up. The GAYA started to use **J** in the planning system called thereafter GAYA-**J**. Mela has not included **J** as the optimizer, but it is possible to pull out simulated schedules from Mela and then define and solve linear programming problems using **J**.

Simosol started to use **J** as an optimizer from the beginning. Simosol has privately admitted that they are using much **J**. For some reason Simosol wants to keep this hidden from the users of their software and from the public. It would be important for an open source software that the users would raise a flag when they use the software. This would give feedback to the developers and would allow communication between users.

J version 2.0 published in 2013 made it possible optimize simultaneously forestry and transports to factories and factory production. Reetta Lempinen started to work with me in the factory optimization. Reetta has professional training in programming, while I'm a self-learning amateur. Reetta had a clear head to keep complicated data structures I had created in order.

She also maintained the spirit during the black moments. The theory for **J** with factories was published [Lappi and Lempinen 2014](#).

J in Luke

When working with Reetta, I noticed how terribly dirty the code was. I started to clean the code. In 2015 Metla and two other institutes were merged into Institute of Natural Resources Finland (Luke). When my retirement was approaching, I suggested Luke that **J** would be published as an open source software so that I could continue its development after my retirement. The leaders of Luke told that it is a good idea to open the software, and this is so important that Luke cannot let me take care of the publication but the leaders wanted to publish **J** themselves. This started a frustrating and humiliating process which lasted until 7.10. 2021.

It has been difficult for me to recover from the time when I waited so many years for the possibility to complete my life's work and saw that the days of my life were just running out without giving me that possibility, just because the leaders of Luke had so decided. This process has been a me-too experience for me, or perhaps a similar experience what a mother undergoes when social workers take her child and put him into a orphanage where the child is given only water and bread but no education or care. In the previous versions of the preface, I decribed the process with details which kept my bitterness alive. From this version I have dropped the names of the involved eleven leaders and all details of their doings and wrong doings. But I anyhow want to tell what was the essence of the process from my point of view.

The process can be described as a hostile take over. I waited that the leaders would make the opening decision so that I could start develop **J** after my retirement. But finally I retired in February 2017 without getting that decision. Research director Johanna Buchert signed the opening decision 30. 8. 2017. I was not informed of the decision. I heard later that such decision has been made but I was not told what the decision contained even if I asked. After my retirement I had make several improvements and bug corrections. Luke rejected my co operation offer to include these codes in the publication it was preparing. Luke pretended that it did not need anything from me. This put Reetta into a difficult position because of course she would need my support for preparing publication of tens of thousands code and manual lines I had written.

When Lauri Mehtätalo became a professor in Luke, he was able to mediate negotiations between me and Luke. The co-operation agreement was signed 7.10. 2021, after some dramatic episoded, in the 100 years celebration of NFI in Kings Hall in the medieval Olavinlinna castle in Savonlinna.

I got a permission to publish the software, and Luke agreed to provide treatment schedules simulated with Mela using NFI data from whole Finland and data from pulp mills and saw mills. Luke should provide me access to CSC supercomputers. Luke should distribute **JIp22**

via Github. This point was not necessary as Reetta advised me how to use Github.

Being an old-time researcher, in the heart of my researcher identity is the conviction that a researcher of a government research organization has the right to publish the results of his research himself. The leaders of Luke expressed explicitly, and I have enough e-mails to prove this, that they do not agree. They made it clear already when I was employed by Luke, so my retirement is no explanation. Are the leaders brave enough to state their view now publicly? Does the board of Luke and the Ministry of Agriculture and Forestry agree with me or the leaders of Luke? A task of the Board of Directors is to promote cooperation with stakeholders. I am now a stakeholder in this matter, and other stakeholders are also linked to this project through their cooperation with me. Can the board of Directors help to solve this dispute. Or are the leaders even so brave that they could admit that they did not recognize during the process that a researcher has the right to publish his results but they have changed their opinion? I got finally the permission to publish my results, but if the leaders of Luke do not accept this as right of a researcher, other researchers will be in trouble in the future.

Putting the ethical and legal aspects aside, the behaviour of the leaders of Luke was not rational with respect to the interests of Luke. During the hostile take over, the leaders knew nothing of the code, and were not willing to learn to know. Thus the leaders did not know that the code contained so much dirty code that it could not be maintained and developed without my assistance. For instance, the linear programming, the most important part of the software, was coded into one 7000-line subroutine having 135 goto statements (do not tell anyone!). The new factory optimization was very immature, the data structures were too complicated, the algorithm was inefficient, and import and export were not included. The software was a 32-bit software with single precision data vectors. To allow large optimization problems, the software must be in 64-bit and in double precision. Reetta could do some minor local maintenance work. But for real improvements she should start from clean table. The code without my support provided only slightly better perspectives than a one-time exe-file.

Could the leaders of Luke be even so brave that they could admit that during their efforts to advance the interests of Luke they were actually making harm to these because they were not willing to listen the person who knew everything in this matter from the guiding ideas to dirty goto statements?

Rewriting the software

Open **Jlp22** was published 22.4.2022 in a web-seminar, and it has been distributed in Github since then. It contained many errors, but I wanted to get the open J started. After my retirement I have rewritten completely the software, the most part after the agreement in 7.10.2021. Only the skeleton and innermost loops in the optimization come from the time I worked for Metla and Luke. The following manual tells what **Jlp22** can do now. The factory optimization is under

development, and I will be published it later. Reetta has participated in testing, in addition to teaching the use of Github.

Book: Linear and nonlinear programming methods

I signed in Dec 15 2022 with Chapman & Hall the author agreement that I will write a book with title: 'Linear and nonlinear programming methods for joint analysis of forestry and factories: **Jlp22** approach'.

The book will be published with Open Access if I pay 16500 Euro when the book is ready. I want it be OA as it is utilizing a software which I was allowed to publish as Open Source after a long and painful fight. Alongside with the book, there will be a script file so that the readers can repeat computations just writing the name of the example, similarly as the users of **Jlp22** can compute the examples in this manual. So I need data which I can utilize for such OA computations. My current agreement with Luke does not allow such utilization of Luke's data. Such cooperation with Luke would allow a peaceful phase to our problematic 9 year relationship.

Acknowledgements

I acknowledge the positive contribution of Even Bergseng and Victor Strimbu from NMBU for co-operation in the development of **J**, Kyle Eyvindson from NMBU/Luke for providing me access to CSC supercomputer, Hannu Salminen for co-operation. Hannu Hirvelä provided me Mela data, and Pekka Hyvönen factory data. Lauri Mehtätalo was building with me the links between **J** and R. Ron Shepard advised in Fortran Discourse to make expansion of allocated vectors faster, in addition to advising to change the name of **J** software. I thank Reetta Lempinen from Luke for being a loyal colleague for a long time.

I thank my grand daughter Ella for the permission to use the portrait she drew for my 70 yr birthday in 2021.

Suonenjoki 3.12.2022 Juha Lappi

2 Recent changes

After renaming the software to **Jlp22**, this chapter starts to describe changes in new versions. The corrections of errors are not described in detail. The first version of **Jlp22** contains so many new properties that also old users should look at the manual. All the examples of the manual should now go through using ALL in running jexamples.inc.

I (in this manual 'I' refers to the first author) found recently a bug in Fletchers code. When after some pivot steps only residual variables are in the basis, the code computed wrong shadow prices, and the objective was getting worse. This situation will not happen in ordinary linear programming problems. When hunting the bug, I developed new debugging tools, so I hope that all users would now send problematic runs to me.

Version Dec 20 2022 provides simple data formats for storing schedules so that in the simulation tree only those nodes after branching are stored. See `keepopen->` and `continue->` options in `data()`. Function `joindata()` is used to build the schedules from their components. Function `splitdata()` can be used to split data containing whole schedules into these new component data. `splitdata()` can be used to convert data generated with previous simulators into this new format. It is recommended that a simulator generating data for **Jlp22** starts to write directly into this new format.

Now the variable telling the number of observations in `DATA datab` is always `datab%obs`. Similarly the variable telling how many children that observation has in the lower level is now always `datab%nobsw` and it must be the telling how many children that observation has in the lower level is now always `datab%nobsw` and it must be the first variable in the list of variables. This new legislation was necessary to keep the new multilevel data in order.

Version Dec 20 2022 gives possibility to change fonts in figures.

3 Introduction

Jlp22 can be used as is, i.e. using exe files. The User's guide concentrates on using binary files, but some reference is also made to additional possibilities offered by the open **Jlp22** code.

3.1 Using Jlp22 exe files

Jlp22 is a general program for many different tasks. In one end, **Jlp22** is a programming language which can be used to program several kind of applications and tasks, starting from computing 1+1, either at `sit->` prompt or inside a transformation object. In the other end, it contains many functions which can do several tasks in statistics, plotting figures, deterministic and stochastic simulation and linear optimization. Forest planning with factories using `jlp()` function can take several hours. The general **Jlp22** functions and **Jlp22** transformations can be combined in many ways.

There are several alternatives for doing general mathematical and statistical computations available in **Jlp22**, most prominent being R. For users of R, the most interesting functions in **Jlp22** are evidently the linear programming functions which utilize the structure of typical forest management planning problems. The forest management planning can now in principle

be combined with factories. Just now a completely new version of factory optimization is under development, and thus it is not usable. R users can do general data management in R and use **Jlp22** only for linear programming. But after learning basics of **Jlp22**, it may be more straightforward to do also data management in **Jlp22**.

Jlp22 can now be used for general matrix computations. I have included in **Jlp22** all matrix functions of Matlab which I found useful in a consulting project. **Jlp22** uses Gnuplot for making figures. It is straightforward to extend these graphics functions. **Jlp22** can be used an interface to Gnuplot graphics. **Jlp22** contains many tools to deal with classified data.

The current binary versions of **Jlp22** are developed using Gfortran Fortran 90 compiler in MSYS2 MINGW 64-bit environment under Windows 10. Binary versions are ordinary console applications. It is recommended that **Jlp22** is used in command prompt window, so that if execution of **Jlp22** terminates unexpectedly, the error debugging information remains visible. With the debug version the problematic line is indicated. See chapter 37 for more information of error handling.

3.2 Developing own Jlp22 functions in Fortran

The user's of **Jlp22** can utilize the open source of **Jlp22** in principally two different ways. Either the user can develop new versions of existing **Jlp22** functions or the user can make new functions. In both cases the user should make new developments using so called own functions, which can be independently of the main **Jlp22** functions. When modifying an existing **Jlp22** function, the user should make a copy of the function under a different name. Then the old and new versions can exist simultaneously in the function space of **Jlp22**. It is very easy to add new functions in **Jlp22** and even more easy to add new options.

When developing a new methods in **Jlp22**, it is possible to first use the **Jlp22** script language to make developments. Then the user can make an own function where the method is written in Fortran to make the method faster. When writing new methods in Fortran, the user can concentrate on essential parts of the method, and utilize the standard data management services provided by **Jlp22**.

See **Jlp22Development.docx** to start develop the software or to add own functions. This guide is not up to date, so all who are willing to start development shoud contact first juha.lappi.sjk@gmail.com. The development package contains, in addition to source code for the standard **Jlp22** software, program Jmanual which can be used to generate Latex code for the manual and the include file for examples. The precompiler Jpre writes necessary Fortran statements to access all global **Jlp22** data structures, makes indentations and checks if-then and do structures and gives better error messages for them than Gfortran.

4 Loading Jlp22 from Github

The Github ditribution was made under the guidance of Reetta Lempinen. This section describes the folders of the Github distribution.

4.1 Git package

The **Jlp22** package can be loaded by pressing load zip button under the green code button in the right side of the page github.com/juhalappi/Jlp22. The package contains the following files.

- LICENSE the license file
- README.m readme file

The package contains following folders:

- **JR** using **Jlp22** from R, courtesy of Lauri Mehtätalo.
 - j.par default include file for starting **Jlp22**. It contains also a LP problem and its solution.
 - JR_0.0.tar.gz File needed to use Fortran subroutines in R
 - cdat.txt
 - xdat.txt
- **Jbin** binary .exe files and dll files
 - jlp22.exe **Debug** version of **Jlp22**.
 - jlp22r.exe Release version of **Jlp22**. If the release version crashes, use the debug version to get more information of the cause.
 - jmanual.exe makes the latex code file **jmanual.tex** and the example file **jexamples.inc**.
 - jpre.exe the precompiler which generates the code for accessing variables in modules, makes indentations and gives better error messages for mixed do-loops and if-then structures than Gfortran.
 - dll: libgcc_s_seh-1.dll, libgfortran-5.dll, libquadmath-0.dll and libwinpthread-1.dll which must be available in the path. e.g., in the same folder as the exe
- **Jdocdemo** documents and include file for running examples from User's guide

- **Jlp22.pdf** This user's guide made with Latex using Overleaf <http://www.overleaf.com>.
- **jexamples.inc** include file which can be used to run all examples in the manual and which is generated with jmanual.exe
- **cdat.txt** example unit data file for small **jlp()** example in jexample.inc.
- **xdat.txt** example schedule file for small **jlp()** example
- **jlp92.pdf** Manual of old JLP which explains the theory behind the jlp algorithm
- **lappilempinen.pdf** Paper explaining the theory behing factory optimization.
- **hyvonenetal2019.pdf** A paper utilizing the factory optimization.
- **Jlp22development.docx** not up-to-date manual for developers
- **fletcher.pdf** The theory behind the subroutines of Fletcher
- **Jmanual** Source files for making Latex code for the manual and the include file for running examples
 - **jmanual.f90** source for making the Latex code and jexamples.inc
 - **jmanual.tex** Latex code generated with jmanual.exe
 - **jsections.txt** describes manual sections not in source files
 - **jsections2.txt** tells in what order sections found in jsections.txt and source files are put into the manual and what is the level of the sections
 - **main.tex** Preamble code containing Latex definitions
 - **Makefile_debug** Makefile for making jmanual.exe
- **Source** source code before precompilation
 - **fletcherd.for** Fletchers subroutines turned into double precision
 - **j.f90** code for **Jlp22** functions
 - **jlp.f90** code for linear programming
 - **j.main** main program for calling **Jlp22** when used as is, if **Jlp22** is used as a subroutine then this must be made a subroutine
 - **jmodules.f90** data structure definitions
 - **jutilities.f90** subroutines for handling objects etc.
 - **jsysdep_gfortran.f90** system dependent routines
 - **matsub.f** subroutines obtained from other sources, e.g. from Netlib
 - other subroutines for setting up users own functions

- **Source2** source code files after precompilation in addition to files in Source (such files which are not precompiled are put in both folders)
 - `makefile_debug` makefile for making debug version **Jlp22.exe**
 - `makefile_release` makefile for making release version **Jlp22r.exe**

4.2 Loading the package

The installation is here described from the viewpoint of an user who just want to use **Jlp22**, not develop it (yet).

The load zip button loads file **Jlp22-master.zip**. Copy this file into a proper folder. Let it be Jgit. Clicking the **Jlp22-master.zip** icon shows folder **Jlp22-master** in 7Zip (if this is installed). Clicking unpack 7zip unpacks it to the folder Jgit. Too many folder levels are avoided, if everything in folder **Jlp22-master** is copied directly in folder Jgit.

The `jlp22.exe` is the debug version of **Jlp22** and **Jlp22r** is the release version. The debug version should be used still used to set up a project. When everythings seems to work, the user can try the release version in production runs where the time is of some concern. Let us assume that the working folder is `jtest`.

5 Install

5.1 Install Jlp22

After loading **Jlp22** from the [Github.com/juhalappi/Jlp22](https://github.com/juhalappi/Jlp22), the folders of the exe files must be put into the environmental variable PATH. In my computer the PATH contains line `C:\jlp22` An ordinary user may use **Jlp22** and **Jlp22r** from the folder `Jgit\Jlp22bin`.

5.2 Install Gnuplot

Let us then install Gnuplot. Go to page <http://gnuplot.info>, and select there download, and in the download page select green 'download latest version', which loads 'gp543-min64-mingw.exe' (or similar), and if you let it install with usual yes-next procedures gnuplot is installed in folder `c:\program files\gnuplot` which should be placed into the environmental variable Path.

5.3 Install Rscript

If you plan to run R scripts from **Jlp22**, Rscript program mus be installed and the folder must be put into the PATH. In my computer the folder is `C:\Program Files\R\R-4.1.2\bin`

5.4 After install restart

After editing the environmental variable Path, the computer must be restarted.

6 Typographical conventions

6.1 `sin()` is a function

6.2 `xrange->` is an option

6.3 `;incl` is and input programming function

6.4 `matrixa` is an object

Names `matrixa`, `matrixb`, `proba`, `probb`, `jipa`, `jlpb` etc are common names used for matrices etc. Coloring of object names is not yet complete.

6.5 `MATRIX` is shorthand notation for a matrix object

```
if(type(matrixa).eq.MATRIX)then ..
```

7 Subroutines from other sources

The following subroutines are obtained from other sources.

- subroutine tautsp used in j_function tautspline from Carl de Boor (1978) A practical guide to splines. Springer, New York, p.310-314 No licence restrictions known. Distribution:
https://www.researchgate.net/publication/200744645_A_Practical_Guide_to_Spline, see also <http://pages.cs.wisc.edu/~deboor>
- Several subroutines from www.netlib.org/lapack with licence :
<http://www.netlib.org/lapack/LICENSE.txt>

8 Running examples

If you plan to edit the example file, copy `jexamples.inc` and `jlp22.pdf` from `jdocdemo` folder into the `Jtest` folder. It is not wise to start working in the `Jdocdemo` folder, because if you load a new version of **Jlp22** in a similar way into `Jgit` folder and allow the computer replace existing folders with the same name, you would lose the work done in `Jgit` folder.

Open the command prompt and move to the directory 'jtest' by 'cd' commands. It is possible to use **Jlp22** also directly, but its necessary to use **Jlp22** through the command prompt at this testing phase, because then, if **Jlp22** crashes, the error messages do not disappear. In first time, you may want to change the colors etc of the command prompt (color may take effect only after closing command prompt and reopening it). It may be reasonable to tick all editing properties under the properties button of the command prompt.

If you would like that when starting **Jlp22** in this folder, **Jlp22** immediately starts with examples, make file j.par to folder jtest and write to it

```
;incl(jexamples.inc)
```

It is possible to write to the first line of j.par

```
*3000
```

which would mean that **Jlp22** would generate intially 3000 named objects.

Then start **Jlp22** by giving command **Jlp22** at the command prompt. If you have not done j.par file, write at the **sit>** prompt: **;incl(jexamples.inc)**. Alternatively you can diretly start in the jexamples.inc by launching **Jlp22** by

```
Jlp22 jexamples.inc
```

Jlp22 will then print all shortcuts available. You can run examples one by one by giving example shortcuts individually, or you can run all examples by shortcut ALL. If you give shortcut ALL, **Jlp22** asks whether a **;pause** is generated after each example ('pause after each example(1/0)>'). Even if **pause()** is not generated after each example, it is generated after each plot. This can be prevented by pressing <return> when **Jlp22** asks value for fpause. Examples in the ALL section can anyhow be started at any point by putting label '**;current:**' to any point after label **;ALL:** and giving shortcut '**current**'. This is also handy when examples have errors which break the execution. If the errors are made intentionally to demonstrate error situations, the interruption of excution after these intentional errors are prevented so that the jexamples.inc have command **Continue=1** before the intentional error. Theafter the normal error handling is put on by command **Continue=0**.

It is useful to keep the manual open and follow simultaneously the manual and the execution of examples.

9 Command input and output

Jlp22 has two programming levels. First level, called input programming, generates text lines which are then transmitted to the parser which generates code which is the put into transformations sets or excuted directly. Input programming loops make it possible to generate large

number of command lines in a compact and short form. This chapter describes input programming concepts and commands.

9.1 Input record and input line

Jlp22 reads input records from the current input channel which may be the console, file or a text object. When **Jlp22** interprets input lines, spaces between limiters and function or object names are not significant. In input programming, functions start with ';' which is part of the function name (and there can thus be no space immediately after ';'). If a line (record) ends with ',', '+', '*', '-', '(', '=' or with '>', then the next record is interpreted as a continuation record and the continuation character is kept as a part of the input line. If a record ends with '' and the next record starts also with '', only one '' is obtained. If a line ends with '>>', then the next line is also continuation line, and '>>' is ignored. All continuation records together form one input line. In previous version input programming functions operated on input lines but now they operate on recors. One input record can contain 4096 characters, and an input line can contain also 4096 characters (this can be increased if needed). There can be comment lines within a command line.

When entering input lines from the keyboard, the previous lines given from the keyboard can no more be accessed and edited using the arrow keys owing to MSYS2 MSYS environment used to build the exe-file. To copy text from the **Jlp22** window into the clipboard right-click the upper left icon, select Edit, and then select Mark. Next click and drag the cursor to select the text you want to copy and finally press Enter (or right-click the title bar, select Edit, and in the context menu click Copy). To paste text from the clipboard into the **Jlp22** command line right-click the title bar, select Edit, and in the context menu click Paste. Console applications of Intel Fortran do not provide copy and paste using <cntrl>c and <cntrl>v. An annoying feature of the current command window is that it is possible All input lines starting with '*' will be comments, and in each line text starting with '!' will also be interpreted as comment (!debug will put a debugging mode on for interpretation of the line, but this debug information can be understood only by the author). If a comment line starts with '!*', it will be printed.

9.2 Input Paragraph

Many **Jlp22** functions parsed and executed (interpreted) at the command level need or can use a group of text lines as input. In these cases the additional input lines are immediately after the function. This group of lines is called input paragraph. The input paragraph ends with '/', except the input paragraph of text function **text()** and **txt()** end with '//' as a text object can contain ordinary input paragraphs. It may be default for the function that there is input paragraph following. When it is not a default, then the existence of the input paragraph is indicated with option **in->** without any value. For many functions, the input paragraph can contain input programming commands. The resulting text lines are transmitted to the function which interprets the input

paragraph either using the parser (e.g. `trans()` function) or by other means (e.g `problem()`).

Example 9.1 (inpuparag). Example of inputparagraph

```
transa=trans()
a=log(b)
write($, '(~sinlog is=~ ,f4.0)', sin(a))
/
b=matrix(2,3,in->)
1,2,3
5,6,7
/
```

9.3 Shortcuts

Command shortcuts are defined by defining character variables. When entering the name of a character variable at `sit>` prompt or from an include file, **JIp22** executes the command. The command can be either input programming command or one-line command. The file `jexamples.inc` shows an useful way to organize shortcuts and include files.

Example 9.2 (shortex). Example of using shortcuts and include files

```
short1='sin(Pi)+cos(Pi);'
short1
te=text()
this=thisfile()
ju1=';incl(this,from->a1)'
ju2=';incl(this,from->a2)'
;return
;a1:
!! greetings from a1
;return
;a2:
** here, jump to a1
ju1
*! back here, return to sit> or next example in ALL
;return
//write('shortex.txt',$,te)
close('shortex.txt')
;incl(shortex.txt)
ju1
ju2
delete_f('shortex.txt')
te=0!delete also text object te
```

9.4 Input programming

The purpose of the input programming is to read or generate **Jlp22** commands or input lines needed by **Jlp22** functions. The names of input programming commands start with semicolon ';'. There can be no space between ';' and the following input programming function. The syntax of input programming commands is the same as in **Jlp22** functions, but the input programming functions cannot have an output. There are also control structures in the input programming. An input paragraph can also contain input programming structures.

9.5 Labels in input programming

The included text files can contain labels. Labels define possible starting points for the inclusion or jump labels within an include file. A label starts with semicolon (;) and ends with colon (:). There can be text after the label and the text is printed but otherwise ignored.

;ad1: At this point we are doing thit and that

Note 9.5.1. The definition of a transformations object can also contain labels. These labels start with a letter and end also with colon (:). When defining a transformation object with `trans()` function, the input paragraph can contain input programming labels and code labels. It is up to input programming what code alabels become part of the transformation object.

9.6 Changing "i" sequences

If an original input line contains text within quotation marks, then the sequence will be replaced as follows. If a character variable is enclosed, then the value of the character variable is substituted: E.g. `directory='D:/J/ñame='area1' extension='svs'` then `in->"directory""name"."extension"` is equivalent to `in->'D:/J/1.svs'` If the "-expression is not a character variable then **Jlp22** interprets the sequence as an arithmetic expression and computes its value. Then the value is converted to character string and substituted into the place. E.g. if `nper` is variable having value 10, then lines

```
x#"nper+1"#"nper" = 56  
chv = 'code"nper'
```

are translated into

```
x#11#10 = 56  
chv = 'code10'
```

With " " substitution one can define general macros which will get specific interpretation by giving values for character and numeric parameters, and numeric parameters can be utilized in variable names or other character strings. In transformation sets one can shorten computation time by calculating values of expressions in the interpretation time instead of doing computations repeatedly. E.g. if there is in a data set transformation `x3 = "sin(Pi/4)*x5` Then evaluation of `sin(Pi/4)` is done immediately, and the value is transmitted to the transformation set as a real constant. If value of the expression within a "" sequence is an integer then the value is dropped in the place without the decimal point and without any spaces, otherwise its value is presented in form which is dependent on magnitude of the value. After J3.0 the format can be explicitly specified within [] before the numeric value. Eg. text can be put into a figure as `fig = drawline(5,5,mark->'y=[f5.2]coef(reg,x1)*x1+[f5.2]coef(reg,1)')` See file jex.txt and Chapter 8 for an ex

9.7 ;incl() lines from a file

Includes lines from a file or from a text object. Using the `from->` option the include file can contain sections which start with addresses like `;ad:`

and end with

`;return`

Args 0|1 Ch|Tx

file name. Default: the same file is used as in the previous `;incl()`.

`from` N|1 Ch

gives the starting label for the inclusion, label is given without starting ';' and ending ':'.

`wait` N|0

Jlp22 waits until the include file can be opened. Useful in client server applications. See chapter **Jlp22** as a server.

Note 9.7.1. Include files can be nested up to 4 levels.

Note 9.7.2. In the current version of **Jlp22**, the file name and the address can be without apostrophes '', but the previous names with apostrophes are allowed.

Note 9.7.3. It is possible to start reading the script from the same file. In that case `;return` returns the reading of the script after the `;incl-` line.

Note 9.7.4. `;goto(adr)` and `;incl(from->adr)` go to the same line in the include file but after `;goto`

the ;return-command closes the include file but after ;incl() the ;return-command returns the control to the calling point.

Note 9.7.5. See Chapter Defining a text object with text function and using it in ;incl how to include commands from a text object.

Note 9.7.6. When editing the include file with Notepad ++, it is reasonable to set the language as Fortran (free form).

Example 9.3 (inpuincl). Example of ;incl()

```
file=text()
** File start
i=1;
;goto(ad1)
** Never here
i=2;
;ad1:i=66;
**After ad1
;goto(ad2,ad3,2) !select label from a label list
;ad2:
** After ad2
i=3;
;ad3:
** After ad3
i=4;
;ad4:
** After ad4
i=5;
;ad5:
** After ad5
i=6;
//
file;
;if(exist_f('file.txt'))delete_f('file.txt')
write('file.txt',$,file)
close('file.txt')
;incl(file.txt)
;incl(file.txt,from->ad2)
```

Note 9.7.7. The adress line can contain comment starting with '!'.

9.8 ;goto()

Go to different adress in ;incl() file.

Args	1	CHAR
------	---	------

The label from which the reading continues. With ;**goto**(adr1) the address line starts ;adr1:

Example 9.4 (inpugotoex). Example of ;**goto**() and ;**incl**()

```
gototxt=text()
!! Start jumping
;goto(ad2)
;ad1:
!!Greetings from ad1
;return
;ad2:
!!Greetings from ad2
;goto(ad1)
//  
print(gototxt)
if(exist_f('goto.txt'))delete_f('goto.txt')
write('goto.txt',gototxt)
close('goto.txt')
print('goto.txt')
;incl(goto.txt)
;incl(goto.txt,from->ad1)
delete_f('goto.txt')
```

Note 9.8.1. In the previous versions the address had to be within apostrophes '' , but now this is not necessary even if it is possible.

9.9 ;**do()** input records in a loop.

Args 3|4 Var, Num..

Arguments are: iteration index, starting limit, final limit and step. First argument must be a variable name and others can be **REAL** variables or numeric constants.

Example 9.5 (inpudoex). Examples of ;**do**()

```
;do(i,1,2)
x"i"="i"*10
print('Greetings from iteration "i"')
;enddo
print(x1,x2)
varlist=list(x0,y0,
;do(i,1,3)
x"i",y"i",
;enddo
x4,y4);
```

```
<print('Greetings from iteration 1')
'Greetings from iteration 1'
<print('Greetings from iteration 2')
'Greetings from iteration 2'
sit< print(x1,x2)
<print(x1,x2)
x1=    10.00000000000000
x2=    20.00000000000000
```

9.10 ;sum() sums into input

JIp22 can generate text of form part1+part2+...partn into input line using input programming function ;sum(). The syntax of the function is as follows:

;sum(i,low,up,step)(text)

or

;sum(i,low,up)

Arguments low, up and step must be integers (actually from nonintger values, the integer part is used) or REAL variables. Thus te valuse cannot be obtained from arithmetic operations. Sum is useful at least in problem() function.

Example 9.6 (inpusumex). Example of ;sum()

```
prob=problem()
;sum(i,1,5)(a"i"*x"i")==max
;sum(i,1,3)(a"i"*x"i")<8
/
```

Note 9.10.1. ;dif() works similarly for minus

9.11 ;dif() differences into input

JIp22 can generate text of form part1-part2-...partn into input line using input programming function ;dif(). The syntax of the function is as follows:

;dif(i,low,up,step)(text)

or

;dif(i,low,up)

Arguments low, up and step must be integers (actually from nonintger values, the integer part is used) or REAL variables. Thus te valuse cannot be obtained from arithmetic operations. ;dif() is useful at least in problem() function.

Note 9.11.1. ;sum()() works similarly for plus. See ;sum() for examples.

9.12 ;pause in script processing

Including input from an include file can be interrupted using an input programming command ;pause prompt or the JIp22 function pause('<prompt>'). In both cases the user can give JIp22 commands, e.g., print objects, change the value of Printdebug etc. The difference is that pause('<prompt>') goes first through the interpreted and the interpreted code is transmitted to the JIp22 function driver. In the ;pause- pause it is possible to use input programming commands while in pause()- pause it is not possible. In both cases, when an error occurs, the control remains at the pause prompt. If the user is pressing <return> JIp22 continues in the include file. If pause() is part of a transformation object, pressing <return>, the function driver continues in the transformation object. If the user gives command 'e' or 'end', then JIp22 procees similarly as if an error had occurred, i.e. print error messages and returns control to sit>-prompt.

9.13 ;return from ;incl

;return in an input file means that the control returns to the point where a jump to an label was found. Two different cases need to be separated:

- The conrol came to the starting label or to the beginning of the include file from outside the current include file using a ;incl command. Then ;return returns the control to upper level include file or to the sit> prompt.
- The control came to the starting label from within the same include file using an explicit ;incl or ;incl is generated with command shortcut.

9.14 ;where the current lines in ;incl -files

9.15 Access using part of the name

The subobjects generated with a function can be seen according to the following example. The second example shows how objects having a common part in the name can be printed.

Example 9.7 (subobjex). Seeing subobjects

```
dat=data(in->,read->(x,y))
1,2
3,4
/
dat%?; !prints subobjects
subob=;list(dat%)! makes the list of subobjects and prints it
@subob; ! prints the subobjects
```

Example 9.8 (relativesex). Seeing relatives

```
x1a...x3a=3...5  
x?a;  
rel=;list(x?a);  
@rel;
```

9.16 @List(index) Gets a name from a LIST

The name of an object in a LIST can be obtained into the input using the following example.

Example 9.9 (inpulistelem). Getting name from list

```
lis=list(c2...c5);  
@lis=2...5;  
@lis(2)=6;  
@lis(4)=@lis(1);  
@lis(2)%@lis(4)=66;
```

9.17 @List expands a LIST

If a LIST is generated explicitly with list() function or as a byproduct of an other function, then all elements of the list can put into the code using @-sign in the front of the name of the list. The code then works similarly as if all the object names had been written consecutively and separated with commas.

Note 9.17.1. A function or an option can have several parts in the arguments generated with @

Note 9.17.2. In the earlier versions of the software, expanding lists with @ was implemented during the generation of the input line similarly as in the input programming proper. This was stupid. It is more simple and more efficient to implement the expanding of lists during the code parsing stage. This is presented here because, @-sign works as if it were part of input programming.

Example 9.10 (expandex). Example of expanding lists with @

```
list0=list(site,altitude)  
list1=list(  
;do(i,1,3)  
vol"i",ba"i",  
;enddo  
vol4,ba4);  
dat=data(in->,read->(@list0,@list1))
```

```
1,2,3,4,5,6,7,8,9,10  
2,3,4,5,6,7,8,9,10,11  
/  
stat()
```

9.18 ... sequences

It is often natural to index object names, and often we need to refer object names having consecutive index numbers or index letters. In **Jlp22** versions before version 3.0 it was possible to generate object lists using ... -construct which replaced part of the input line with the names of objects being between the object name before ... and after Now the dots construct is no more done as part of the input programming but in the interpret subroutine which interprets the input line and generates the integer vector for function and argument indices. But as dots work as if it would be part of the input programming, it is presented in this section. Currently also sequences of integer constants can be generated with dots and sequences can be from larger to smaller.

Example 9.11 (dotsex). Example of dots construct

```
dat=data(read->(x4...x7),in->)  
1,2,3,4  
11,12,13,14  
/  
stat(min->,max->,mean->)  
x3%mean...x7%mean;  
A...D=4...1;  
Continue=1 !demo of error in data()  
dat=data(read->(x3...x7),in->)  
1,2,3,4  
11,12,13,14  
/  
Continue=0
```

10 Jlp22 objects

Jlp22 objects have a simple yet efficient structure. Each object is associated with two integer vectors, one single precision vector, one double precision vector, one vector of characters and one vector of text lines. All vectors are allocated dynamically. There are several object types which store data differently in these vectors. Object can be either simple or compound objects. Compound objects are linked to other objects which can be used also directly utilizing the standard naming conventions. All objects are global, i.e. also users can access all objects. Some predefined objects are locked so that users cannot change them.

There are three types of objects

- Named objects. The number of named objects is specified at the initialization, and it cannot be changed later. Deleting an object means deallocating all the allocated vectors associated with the objects.
- Temporary objects used to store intermediate results.
- Temporary objects used to store the partial derivatives when computing the derivatives using the derivations rules.

Alongside the objects there is a vector of double precision values, call j_v-vector. When an object is called a **REAL** object or variable, this vector is referenced. After the parts corresponding to named objects and those two sets of temporary objects, there is an area used to store numeric constants. If a **REAL** variable `a` has object number of 100 and constant 7 is in the position 7000 in the v-vector, then `a+7` can be presented as `j_v(100)+j_v(7000)`. Thus after parsing, all arithmetic computations can be done without reference to whether a variable is in the named part or constant part of the j_v-vector. Because the numeric constants are at the end section of the j_v-vector, new space can be added for the numeric constants without mixing up parsed transformations.

10.1 Object names

Object names start with letter or with `$#`. Object names can contain any of symbols `#%$/`. **JIp22** is using '%' to name objects related to some other objects. E.g. function `stat(x1,x2,mean->)` will store means of variables `x1` and `x2` into variables `x1%mean` and `x2%mean`. Objects with name starting with '\$' are not stored in the automatically created lists of input and output variables when defining transformation objects. The variable `Result` which is the output variable, if no output is given, is not put into these lists. Object names can contain special characters (e.g. `+-*=()`) if these are closed within '[' and ']', e.g. `a[2+3]`. This possibility to include additional information is borrowed from Markku Siionen, the developer of Mela software. If a transformation object is created with `trans()` function, and the intended global arguments are given in the list of arguments, then a local object is created e.g. with transformation object `tr` have prefix `tr/` yielding `tr/`. Actually also these objects are global, but their prefix protects them so that they do not intervene with objects having the same name in the calling transformation object. There are many objects initialized automatically. Some of these are locked so that the users cannot change them. In transformation objects there can be objects which are intended to be used only locally. These are protected by putting an invisible prefix to the object names, but these can be anyhow accessed by writing the prefix. **Names** of objects having a predefined interpretation start with capital letter. The user can freely use lower or upper case letters. **JIp22** is case sensitive. All objects known at a given point of a **JIp22** session can be listed by command: `print(Names)`

10.2 Object types

The following description describes shortly different object types available in J. More detailed descriptions are given in connection of **Jlp22** functions which create the objects and in Developers' guide.

10.2.1 Real variables and constants

A **REAL** variable is a named object associated with a single double precision value. Before version J3.0 the values were in single precision, and thus this objecttype is still called **REAL**. The value can be directly defined at the command level, or the variable can get the value from data structures. E.g. `stat(D,H,min->,max->)` ! Here arguments must be variable names `a = sin(2.4)` ! argument is in radians `sind()` is for degrees `h = data(read->(x1...x4))` ! `x1, x2 ,x3, x4` are variables in the data set, and get their values when doing operations for the data.

Note 10.2.1. All objects have also an associated **REAL** value. In order to make arithmetic operations fast, the argument types in simple arithmetic functions are not checked. If a general object is used as an argument in an arithmetic operation, then the **REAL** value associated with the object is used. This will usually prevent the program to stop due to Fortran errors, but will produce unintended results.

Note 10.2.2. In this manual 'variable' refers to a **Jlp22** object whose type is **REAL**.

10.2.2 Character constants and variables

Character constants are generated by closing text within apostrophe signs ('). Apostrophe character (') within a character constant is indicated with (~) (if the character ~ is not present in the keyboard, it can be produced by <Alt>126, where numbers are entered from the numeric keyboard) Character constants are used e.g. in I/O functions for file names, formats and to define text to be written. , e.g `a = data(in->'file1.dat', read->(x1,x2))`

`write('output.txt', ('~kukkuu=~4f7.0'), sqrt(a))` Character variables are pointers to character constants. An example of a character variable definition:

`cvar='file1.dat'` After defining a character variable, it can be used exactly as the character constants.

Note 10.2.3. The quotation mark ("") has special meaning in the input programming. See Input programming how to use character constants within character constants.

10.2.3 Logical values

There is no special object type for logical variables. Results of logical operations are stored into temporary or named real variables so that 0 means False and 1 means True. In logical tests all non-zero values will mean True. Thus e.g. `if(6)b=7` is legal statement, and variable `b` will get value 7. E.g. `sit>h=a.lt.b.and.b.le.8 sit>print(h)` `h= 1.00000`

10.3 Predefined objects

The following objects are generated during the initialization.

<code>Names</code>	<code>Text</code>	Text object containing the names of named objects
<code>Pi</code>	<code>REAL</code>	The value of <code>Pi</code> (=3.1415926535897931)
<code>\$Cursor\$</code>	<code>TRANS</code>	The transformation object used to run <code>sit> prompt</code>
<code>\$Cursor2\$</code>	<code>TRANS</code>	Another transformation object used to run <code>sit> prompt</code>
<code>Val</code>	<code>TRANS</code>	Transformation object used to extract values of mathematical statements, used,
<code>Round</code>	<code>REAL</code>	<code>jlp()</code> : The current round through treatment units in <code>jlp()</code> function.
<code>Change</code>	<code>REAL</code>	<code>jlp()</code> : The change of objective in <code>jlp()</code> in one round before finding feasible and thereafter
<code>Imp</code>	<code>REAL</code>	<code>jlp()</code> : The number of improvements obtained from schedules outside the current active
<code>\$Data\$</code>	<code>List</code>	Default data set name for a new data set created by <code>data()</code> -function.
<code>Obs</code>	<code>REAL</code>	The default name of variable obtaining the the number of
<code>Maxnamed</code>	<code>REAL</code>	The maximum number of named objects. Determined via <code>j.par</code> in
<code>Record</code>	<code>REAL</code>	The name of variable obtaining the the number of
<code>Subecord</code>	<code>REAL</code>	The name of variable obtaining the the number of
<code>Duplicate</code>	<code>REAL</code>	A special variable used in <code>data()</code> function when duplicating observations
<code>LastaData</code>	<code>List</code>	A list object referring to the last data set made, used as default data set.
<code>\$Buffer</code>	<code>Char</code>	A special character object used by the <code>write()</code> function.
<code>\$Input\$</code>	<code>Text</code>	Text object used for original input line.

1\$Input1\$	Text	Text object for input line after removing blanks and comments.
Data	List	List object used to indicate current data setsDat
\$ ing	REAL	Object name used to indicate console and '*' format in reading and writing
x#	REAL	Variable used when drawing functions.
Selected	REAL	Variable used to indicate the simulator selected in simulations
Printinput	REAL	Variable used to specify how input lines are printed. Not properly used.
Prinoutput used.	REAL	Variable used to indicate how much output is printed. Not properly
\$Debug	REAL	Variable used to put debugging mode on.
Accepted	REAL	The number of accepted observations in functions using data sets.
Arg function.	REAL	The default argument name when using transformation object as a
Continue	REAL	If Continue has nonzero value then the control does not return to the
Err	REAL	If Continue prevents the control from returning to sit> prompt
Result	?	The default name of output object.

11 Jlp22 functions

The structure of **Jlp22** functions is easiest to explain using an example. For instance a data object can be created with

```
data2=newdata(matrx,matrz,read->(x1...x3,z1...z4),maketrans->mt)
```

Here **data2** is the output, **matrx** and **matrz** are matrices having equal number of rows. Matrix **matrx** has 3 columns, **matrz** 4. **read->** is an option which tells what are the variable names in the data. **x1...x3** is equivalent to **x1,x2,x3**. Option **maketrans->mt** tells that for each observation the trasformations defined in the trasformation object **mt** are computed from variables **x1...x3** and **z1...z4**. The output variables whose names do not start with \$ are included in the **DATA** object.

A function call obtained from the input programming can have the following components separated with commas.

11.1 Output of a function

There are the following cases with respect to the output of the function

- The function appears in a code line looking like

`Output=func()`

Then the function produces an object `Output`. The type of the `Output` depends on the function. Several functions produce additional objects whose name start with `]Output%[`. The object `Output` may or may not store links to these object. If such links are stored then the output is a compound object. An objects to which there is a link, is called a subobject. Objects without such links are called side objects. For instance linear programming function `jlp()` does not produce any object with name `Output` just several side objects.

- The expression

`func()`

is equivalent to

`Result=func()`

- If code line is `Output=func();` or `func();` the `Output` or `Result` are printed if variable `Printvalue` has value 1 or 3. If code line is `Output=func();;` or `func();;` if variable `Printvalue` has value 2 or 3.
- `Output` is a temporal object. If a function is part of arithmetic computations, then the intermediate results are stored into temporary objects according to the parse tree. Thus in the expression `y=sin(x)+cos(x)`, `sin(x)` produses first a temporary object and `cos(x)` another temporary object.
- `Output` is a submatrix of a `MATRIX` object. If `A` is a 4x4 matrix, and `B` is a 3x3 `MATRIX`,then expression
`A(2,-4,1,-3)=B`
 puts `MATRIX B` into `A`.

11.2 Function names

Function name can be any of the four cases.

- A standard **Jlp22** function,
- An arithmetic or logical function obtained when translating the code into the polish notation. nslated first into Thus
`if(region.eq.sav0)c=2*3+4;`
 is translated into
`if(EQ(region,sav0))c=PLUS(MULT(2,3),4);`
 The user can try directly the above translated form
- An own-function of the user included in the function space.

- Implicit function generated with the parser. For instance, options are implemented using `setoption()` function.
- `JIp22` object which can be used as if it were a function. Currently there are four such cases

11.2.1 `MATRIX` as a function

If `matrixa` is a `MATRIX` then expression `matrixa()` can be both in the input side or output side to indicate a submatrix or element of the matrix. See matrix chapter.

11.2.2 `REAL` as a `MATRIX`

Often in matrix computations, a `REAL` is a limiting value of a sequence of matrices. To facilitate such computations, `matrixa(1)` and `matrixa(1,1)` are legal ways to refer to `matrixa` even if it is `REAL`. If `matrixa` is `REAL`, then expression `matrixa(3)` is causing error:

`matrixa` is `REAL`, ranges 3 are illegal, only (1) or (1,1) are allowed

11.2.3 `DATA` as a function

If `Data` is `DATA` then `Data(var1,..,varn)` indicates a matrix obtained by picking the columns of the data matrix corresponding the argument variables.

11.2.4 Using a transformation object as a function

It is now possible to use a transformation object as a function which computes new objects when generating arguments for functions or options, or values of code options, or in any place within a transformation object. If `tr` is a transformation and the transformation computes an object `A` then `tr(A)` is first calling transformation `tr` and provides then object `A` into this place. As the transformation computes also other objects which are computed within it, also these objects are available. At this point it is important to note that arguments of a transformation line are computed from right to left, because options must be computed before entering into a function.

Example 11.1 (`transfunc`). Transformation as a function

```
delete_o(a,c)
transa=trans()
a=8;
c=2;
/
transb=trans()
a=5;
c=1;
/
c=2
```

```
a=c+transb(a)+c+transa(a);
```

11.2.5 REGR as a function

If `Regr` is a regression object produced with `regr`, then `Regr()` produces the value of the regression function as explained for `regr()`. The values of arguments can be given in the calling code or the existing values can be used.

11.2.6 Cannot produce -error

If the code looks like a function, the control goes to `j_getelem` function which computes the results for the above mentioned object types. But if the object cannot produce anything, there will be an error message:

produce but it is not a function or object which can provide something then there will be an error message:

* (object name) cannot produce anything

11.2.7 is REAL ranges .. illegal -error

If the object is `REAL` then the error message can be

`matrixa` is `REAL`, ranges 5 are illegal, only (1) or (1,1) are allowed

A `REAL` can be treated as a 1x1 `MATRIX`, so for `REAL var var(2,2)` means illegal dimensions.

11.3 Arguments of a function

Arguments separated with commas. Arguments can be a combination of the following types

- object name
- numeric constant
- A code which produces a temporary object generated with any `JIp22` functions
- a sequence of object names generated with ... as `x1...x3` above.
- @List where `List` is a `LIST`. If `List` is obtained with `List=list(x1...x3)`, then `@List` is equivalent to `x1...x3` which is equivalent to `x1,x2,x3`.

`a = sin(cos(c)+b)` ! Usual arithmetic functions have numeric values as arguments. here the value of the argument of cos is obtained by 'computing' the value of real variable `c`. `stat(D,H,min->,max->)` ! Here arguments must be variable names `plotyx(H,D,xrange->(int(D%min,5), ceiling(D%max,5)))`

!arguments of the function are variables, arguments of option `xrange->` are numeric values `c = inverse(h+t(g))` ! The argument can be intermediate result from matrix computations. If it is evident if a function or option should have object names or values as their arguments, it is not indicated with a special notation. If the difference is emphasized, then the values are indicated by `val1,...,valn`, and objects by `obj1,...,objn`, or the names of real variables are indicated by `var1,...,varn`. There are some special options which do not refer to object names or values. Some options define a small one-statement transformation to be used to compute something repeatedly.

11.4 Options of a function

Options give additional arguments to the function.

11.4.1 Option structure

An option starts with the option name followed with '`->`' after which there can be

- Nothing. In this case the option indicated that the option is put 'on'. E.g. `continue->` in a graphics function indicates that no `pause()` is generated after plotting the figure.
- Numeric value, e.g. `continue->fcont` in a graphics function indicates that no `pause()` is generated if a `REAL` object `fcont` has a nonzero value.
- Object name.
- Function name followed by the arguments within parenthesis, e.g., `xrange->(0,ask('xmax'))` where `ask()` is the function which asks a numeric value from the user.
- Arguments of the option expressed in the same way as the arguments of the function, i.e., using a code which is producing a temporary object.

11.4.2 Codeoptions

Options are grouped into two groups: code options and regular options. Code options define a small one-statement transformation to be used to compute something repeatedly. As these one-statement can use transformation objects as functions, the code option can actually execute long computations. For instance

`stat(D,H,filter->(region.eq.sav0))`

only those observations are accepted which pass the filter.

`draw(func->(sin($x)+1),x->$x,xrange->(0,10,1),continue->fcont)`

`func->` option transmits the function to be drawn not a single value.

12 Arithmetic and logical functions and operations

JIp22 has all the standard arithmetic and logical operations and functions. The arithmetic and logical functions return single **REAL** value or a **MATRIX**.

12.1 Functions **sqrt()**, **sqrt2()**, **exp()**, **log()**, **log10()**, **abs()**

!

- **sqrt(x)** square root, **sqrt(0)** is defined to be 0, negative argument produce error. If x is matrix, then an error occurs if any elemet is negative.
- **sqrt2(x)** If x or an element of x is negative then $\$sqrt2()=-sqrt()\$$. Actually **sqrt2()** might be a useful sigmoidal function in modeling context.
- **exp(x)** \$e\$ to power x. If $x>88$, then JIp22 produces error in order to avoid system crash.
- **log(x)** natural logarithm
- **log10(x)** base 10 logarithm
- **abs(x)** absolute value

12.2 Trig **sin()**,**sind()**,**cos()**,**cosd()**,**tan()**,**tand()**,**cotan()**,**cotand()**

In **sin()**, etc, argument is in radians, in **sind()**, etc in degrees

- **sin()**
- **sind()**
- **cos()**
- **cosd()**
- **tan()**
- **tand()**
- **cotan()**
- **cotand()** temize

12.3 arc-trig `asin()` `asind()` `acos()` `acosd()` `atan()` `atand()` `acotan()` `acotand()`

Inverse trigonometric functions. In `asin()`, etc, argument is in radians, in `asind()`, etc in degrees

- `asin()`
- `asind()`
- `acos()`
- `acosd()`
- `atan()`
- `atand()`
- `acotan()`
- `acotand()` temize

12.4 Hyperbolic `sinh()` `cosh()` `tanh()`

- `sinh()`
- `cosh()`
- `tanh()`

12.5 Functions `mod()` `fraction()`

- `mod()`
- `fraction()`

12.6 Conversion to integer

- `nint(x)` nearest integer value
- `nint(x,modulo)` returns modulo*`nint(x/modulo)` ,e.g.`nint(48,5)=50;` `nint(47,5)=45;`
- `int(x)` integer value obtained by truncation
- `int(x,modulo)` returns modulo*`int(x/modulo)`, e.g. `int(48,5)=45`
- `ceiling(x)` smallest integer greater than or equal to x.
- `ceiling(x,modulo)` returns modulo*`ceiling(x/modulo)`, e.g. `ceiling(47,5)=50.`
- `floor(x)` greatest integer smaller than or equal to x.
- `floor(x,modulo)` returns modulo*`floor(x/modulo)`, e.g. `floor(47,5)=45.`

12.7 `min()` and `max()`

Functions `min()` and `max()` behave in a special way, `max()` behaves similarly as `min()` here:

- `min(x1,x2)`:: minimum of two `REAL`
- `min(MATRIX,REAL)`:: each element is `min(elem,REAL)`
- `min(MATRIX)`:: row vector having minimums of all columns
- `min(MATRIX,any->)`:: minimum over the whole matrix

12.8 `sign(A,B)`

`sign(A,B)` returns the value of `A` with the sign of `B`.

12.9 Numeric operations - , + , * , ** , *** , / , *. , ./.

An arithmetic expression consisting of ordinary arithmetic operations is formed in the standard way. The operations are in the order of their precedence.

- - unary minus
- *** integer power
- ** or ðreal power
- * multiplication
- / division
- + addition
- - subtraction

The reason for having a different integer power is that it is faster to compute and a negative value can have an integer power but not a real power.

In matrix computations there are two additional operations.

- *. elementwise product (Hadamard product)
- /. elementwise division

The matrix operations are explained in section ?. Their operation rules extend the standard rules.

12.10 Logic and relation .eq. .ne. .gt. .ge. .lt. .le. .not. .and. .or. .eqv. .neqv.

There are following relational and logical operations. The first alternatives follow Fortan style:

Note 12.10.1. Testing equivalence can be done also using 'equal to' and 'not equal', as the same truth value is expressed with the same numeric value.

Note 12.10.2. when the truth value of an expression is tested with `if()`, then all nonzero real values means that the expression is true.

13 Operation of Jlp22

In this section the main structure of the operation of **Jlp22** and tools in code development in a project are presented. The two operation modes are interactive operation and batch operation.

13.1 Looping between j_getinput, j_parser and dotrans

There are three key subroutines in **Jlp22** operation.

- `j_getinput` gets a new command line from the console, an include file. `j_getinput` can read several records to make one command line, and it can edit or duplicate the input with special **input programming** tools. Jlp prints `sit>` prompt when reading from the console. Input programming lines are indicated with initial %.
- If the obtained input line is not an input programming command or if it is not captured by some function which is utilizing `j_getinput`, the line goes to `j_parser` which generates an integer vector.
- The integer vector produced by the `j_parser` is interpreted ('executed' in this manual) with `dotrans` subroutine.
- `trans()` function packs several lines generated in `j_getinput` - `j_parser` loops into a transformation (**TRANS**) object, which can be called from different functions.
- `dotrans` subroutine executes a single line command which is not part of an **TRANS** object. **Jlp22** writes '#' in front of the line.

13.2 Printing of Jlp22

Jlp22 prints information of the proceeding of the control. There are different ways to control the output. Finetuning is needed in the output. There are three logical stages in the flow of the control. The output indicates these as follows.

13.2.1 % -lines are printed from input programming

The input programming lines are printed starting with %. The amount of printing is controlled with `Printinput` variable. the default is `Printinput=1`. A problem in printing the input is how much should be printed when many input lines are produced with `;do()`

13.2.2 # -lines are printed in one-line commands.

The input lines which go directly to execution are printed starting with #.

13.2.3 Comments starting with !!, !*, ** or *! are printed

The first non blank character in a command line is '!' or '*'. If there are two consecutive comment characters, the line is printed, dropping the first character.

Note 13.2.1. There can be comment lines between continuation lines.

13.2.4 Printoutput guides printing of functions.

The amount of printing in functions is guided with variable [Printoutput]. The default is

In the interactive operation, the processing of scripts can be interrupted with ;**pause**, and execution of **TRANS** can be interrupted with **pause()**. Even if they are described in 'Command input and output' and '**JIp22** transformations' chapters, descriptions are repeated here as they are useful in the interactive operation of **JIp22**.

13.2.5 ;**pause** in script processing

Including input from an include file can be interrupted using an input programming command ;**pause** prompt or the **JIp22** function **pause('<prompt>')**. In both cases the user can give **JIp22** commands, e.g., print objects, change the value of Printdebug etc. The difference is that **pause('<prompt>')** goes first through the interpreted and the interpreted code is transmitted to the **JIp22** function driver. In the ;**pause**- **pause** it is possible to use input programming commands while in **pause()**- **pause** it is not possible. In both cases, when an error occurs, the control remains at the pause prompt. If the user is pressing <return> **JIp22** continues in the include file. If **pause()** is part of a transformation object, pressing <return>, the function driver continues in the transformation object. If the user gives command 'e' or 'end', then **JIp22** proceeds similarly as if an error had occurred, i.e. print error messages and returns control to **sit>**-prompt.

13.2.6 **pause()** in a **TRANS** or in command input

Function **pause()** stops the execution of **JIp22** commands which are either in an include file or in **TRANS** object. The user can give any commands during the **pause()** except input programming commands. If the user presses <return> the execution continues. If the user gives 'e', then an error condition is generated, and **JIp22** comes to the **sit>** prompt, except if **Continue** has values 1, in which case the control returns one level above the **sit>** prompt. If **pause()** has a **CHAR** argument, then that character constant is used as the prompt.

Note 13.2.2. When reading commands from an include file, the a pause can be generated also with `;pause`, which works similarly as `pause()`, but during `;pause` also input programming commands can be given.

13.3 Batch mode

If the default main program is replaced with a program which tells that Jlp is operated in the batch mode, or if the initial `;incl`-file contains command `batch()`, the **Jlp22** is operated in the batch mode. In the batch mode, the control never starts to read commands from the console at `sit>` prompt. Using **Jlp22** from R, developed with Lauri Mehtätalo is using **Jlp22** in the batch mode.

13.4 Using shortcuts and sections in `;incl` files

It is useful to organize the project script into one script file, which contains sections starting with a label and ending with `;return`. I think that it is more difficult to have several script files. The example file `jexamples.inc` is a good example of a script file. different versions of the same script file are stored in different names, it is useful to have as first line something like `this=thisfile()`

Then it is not necessary to change anything if the file is stored in a different name. Thereafter comes the shortcut definitions for different sections. the same For instance, if the section label is

`;thistask:`

then the shortcut definition could be `thistaskh=';incl(this,from->thistask)'`

The section should end with

`;return`

After defining shortcuts for all sections, it is useful to have a shortcut as:

`again=;incl(this)`

If new sections are added, then one needs to give just shortcut

`again`

and then the new shortcuts will be defined. It does not matter if the earlier shortcuts are redefined.

The last shortcut could be

`current=';incl(this,from->current)` The label 'current' can be a floating label which is put into the section which is under development in place the problems started.

If a **Jlp22** code line, either in the input paragraph defining a transformation object or outside it, ends with ';' or ';;', the output object of the code line may be printed. The output of ';' -line is

printed if the variable `Printoutput` has value 1 or 3 at the time when the code line is computed. The output of ‘;’-line is printed if the variable `Printoutput` has value 2 or 3 at the time when the code line is computed.

If a code line within a transformation has function `pause('text')`, then a pause is generated during which the user can give any commands except input programming commands. If the user will press `<return>` then the execution continues. If the user presses ‘e’ and `<return>`, the control comes to the `sit>` prompt similarly as during an error.

If the line outside the transformation definition paragraph is `';pause'`, then a similar pause is generated except also input programming commands can be given.

If the variable `Debugtrans` has value 1, then a `pause()` is generated before each line within a transformation object is executed. If variable `Debugconsole` has value 1, a `';pause'` is generated before the line is executed. In both cases the user can give new values for `Debugtrans` and `Debugconsole`.

What happens when an error is encountered is dependent on the value of variable `Continue`. If `Continue` has value 0 (the default case), the control comes into `sit>` prompt when an real error occurs or if an artificial error condition is generated with `errexit()`. If `Continue` has value 1 then the computation continues in the same script file where the error occurred. This property is used in file `jexamples.inc` to demonstrate possible error conditions so that the computation continues as if no error had occurred.

13.5 end ends Jlp22

To exit `Jlp22` program and close console window, just give end command:

`sit>end`

14 Functions for handling objects

The following functions can handle objects.

14.1 Copying object: `a=b`

A copy of object can be made by the assignment statement `a=b`.

14.2 `type()` Type of an object or all available types

The type of any object can be accessed by `type(object)`. If the argument is a character variable or character constant referring to a character constant, and there is `content->` option, and the

character is the name of an object , the `type()` returns the type of the object having the name given in the argument. If there is no object having that name, then `type()` returns -1 and no error is generated.

Example 14.1 (typeex). Example of type

```
ttt=8; !REAL
type(ttt);
type('ttt'); !type is CHAR
type('ttt',content->);
cttt='ttt',
type(cttt);
type(cttt,content->);
```

14.3 `delete_o()` Deletes objects

The function `delete_o()` deletes all the argument objects, which means that the associated allocated vectors are deallocated, and the object will be `REAL`.

Note 14.3.1. Note that `delete_o()` is actually needed only for matrices, because objects can be deleted with `Object=0`. When `Object` is a matrix, then `Object=0` puts all elements into zero.

Example 14.2 (deleteoex). Delete object

```
a=matrix(2,3,do->);
b=t(a);
delete_o(a,b)
a,b;
```

14.4 `exist_o()`: does an object exist

looks whether an object with the name given in the character constant argument exists.

Note 14.4.1. In the previous versions of **JIp22** same function was used for files and objects.

14.5 `name()`: writes the name of an object

The argument gives the index of the object. This function may useful if **J** prints in problem cases the object indices.

15 JIp22 transformations

Most operation commands affecting **JIp22** objects can be entered directly at the command level or packed into transformation object. In both cases the syntax and working is the same. A command line can define arithmetic operations for real variables or matrices, or they can include functions which operate on other **JIp22** objects. General **JIp22** functions can have arithmetic statements in their arguments or in the option values. In some cases the arguments must be object names. In principle it is possible to combine several general **JIp22** functions in the same operation command line, but there may not be any useful applications yet, and possibly some error conditions would be generated. Definition: A numeric function is a **JIp22** function which returns a single real value. These functions can be used within other transformations similarly as ordinary arithmetic functions. E.g. `weights()` is a numeric function returning the number of schedules having nonzero weight in a JLP-solution. Then `print(sqrt(weights())+Pi)` is a legal transformation.

15.1 Transformation object

A transformation object groups several operation commands together so that they can be used for different purposes by **JIp22** functions and **JIp22** objects. A transformation object contains the interpreted transformations. For more details see **JIp22** function for defining transformation objects: `trans()`. Transformation objects can be called using `call()` function, so that all transformations defined in the object are done once. Function `result()` also calls transformations but is also returning a value. When transformation objects are linked to data objects, then the transformations defined in transformation object are done separately for each observation. There is an implicit transformation object `$Cursor$` which is used to run the command level. The name `$Cursor$` may appear in error messages when doing commands at command level. Another transformation object `Val` which is used to take care of the substitutions of "-sequences in the input programming. Some **JIp22** functions use also implicitly transformations object `$Cursor2$`.

15.2 `trans()` Creates a **TRANS** (transformation) object

`trans()` function interprets lines from input paragraph following the `trans()` command and puts the interpreted code into an integer vector, which can be executed in several places. If there are no arguments in the function, the all objects used within the transformations are global. This may cause conflicts if there are several recursive functions operating at the same time with same objects. **JIp22** checks some of these conflict situations, but not all. These conflicts can be avoided by giving intended global arguments in the list of arguments. Then an object 'ob'

created e.g. with transformation object `tr` have prefix `]tr/`

yelding]tr/[.Actually also these objects are global, but their prefix protects them so that they do not intervene with

Each line in the input paragraph is read and interpreted and packed into a transformation object, and associated `tr%input` and `tr%output` lists are created for input and output variables. Objects can be in both lists. Objects having names starting with '\$' are not put into the input or output lists. The source code is saved in a text object `tr%source`. List `tr%arg` contains all arguments. ! If a semicolon ';' is at the end of an input line, then the output is printed if `REAL` variable `Prindebug` has value 1 or value>2 at the execution time. If the double semicolon '::' is at the end then the output is printed if `Printresult`>1. If there is no output, but just list of objects, then these objects will be printed with semicolons.

!

Output	1	Data
--------	---	------

The `TRANS` object generated.

Args	N 1-
------	------

Global objects.

Note 15.2.1. Options `input->`, `local->`, `matrix->`, `arg->`, `result->`, `source->` of previous versions are obsolete.

Note 15.2.2. The user can intervene the execution from console if the code calls `read($)`, `ask()`, `askc()` or `pause()` functions. During the pause one can give any command excepts such input programming command as `;incl`.

Note 15.2.3. The value of `Printresult` can be changed in other parts of the transformation, or in other transformations called or during execution of `pause()`.

Note 15.2.4. Output variables in `maketrans->` transformations whose name start with \$ are not put into the new data object.

Example 15.1(`transex`). Demonstrates also error handling

```
transa=trans()
$x3=x1+3
x2=2/$x3;
/
transa%input,transa%output,transa%source;
x1=8
call(transa)
transb=trans(x1,x2)
```

```

$x3=x1+3
x2=2/$x3;
x3=x1+x2+$x3;
/
transb%input,transb%output,transb%source;
call(transb)
transb|x3; !x3 is now local
transc=trans()
x1=-3
call(transb)!this is causing division by zero
/
Continue=1 ! continue after error
call(transc)

```

```

sit>transex
<;incl(exfile,from->transex)
```

```

<transa=trans()
<$x3=x1+3
<x2=2 | $x3;
</
<transa%input,transa%output,transa%source;
transa%input is list with           2 elements:
x1 $x3
transa%output is list with          1 elements:
x2
transa%source is text object:
1 $x3=x1+3
2 x2=2/$x3;
3 /
///end of text object

<x1=8
```

```

<call(transa)
x2=0.18181818
```

```

<transb=trans(x1,x2)
<$x3=x1+3
```

```
<x2=2/$x3;
<x3=x1+x2+$x3;
</
<transb%?;

<call(transb)

<transc=trans()
<x1=-3
<call(transb)
</
<Continue=1
<call(transc)
*division by zero
*****error on row           2  in tr%source
x2=2/$x3;
recursion level set to      3.000000000000000

*****error on row           2  in transc%source
call(transa)
recursion level set to      2.000000000000000

*err* transformation set=$Cursor$
recursion level set to      1.000000000000000
***cleaned input
call(transc)
*Continue even if error has occured
<;return
```

15.3 `call()` executes `TRANS` object

Parsed transformations in a TRANSobject can be automatically executed by other **Jlp22** functions or they can be executed explicitly using `call()` function.

Arg 1 **TRANS**
The transformation object executed.

Note 15.3.1. A transformation objects can be used recursively, i.e. a transformation can be called from itself. The depth of recursion is not controlled by **J**, so going too deep in recursion will eventually lead to a system error.

Note 15.3.2. Professional programmers would probably say that the integer vector produced with the parser is interpreted and not executed. An amateur programmer can be more flexible with terms.

Example 15.2 (recursion). Recursion produces system crash.

```
transa=trans() !level will be initialized as zero
level;
level=level+1
call(transa)
/
Continue=1 !error is produced
call(transa)
Continue=0
```

15.4 pause() in a TRANS or in command input

Function **pause()** stops the execution of **Jlp22** commands which are either in an include file or in **TRANS** object. The user can give any commands during the **pause()** except input programming commands. If the user presses <return> the excution continues. If the user gives 'e', then an error condition is generated, and **Jlp22** comes to the **sit>** promt, except if **Continue** has values 1, in which case the control returns one level above the **sit>** promt. If **pause()** has a **CHAR** argument, then that character constant is used as the prompt.

Note 15.4.1. When reading commands from an include file, the a pause can be generated also with **;pause**, which works similarly as **pause()**, but during **;pause** also input programming commands can be given.

16 Special implicit functions

The special functions are such that the parser uses these functions for special operations. Only **list2()** is function which also the user can use, but the parser is is using it implicitly.

16.1 setoption(): set option on

When a function has an option then the parser generates first code **setoption(...)** where the arguments of the option are interpred in the similar way as arguments of all functions. Then the

parser generates the code for `setoption()` function in a special way.

16.2 Get or set a matrix element or submatrices

Matrix elements or submatrices can be accessed using the same syntax as accessing `JIp22` functions.

One can get or set matrix elements and submatrices as follows. If the expression is on the right side of '=' then `JIp22` gets a `REAL` value or submatrix, if the expression is on the left side of '=', the `JIp22` sets new values for a matrix element or a submatrix. In the following formulas `C` is a column vector, `R` a row vector, and `M` is a general matrix with m rows and n columns. If `C` is actually `REAL` it can be used as if it would 1×1 `MATRIX`. This can be useful when working with matrices whose dimensions can vary starting from 1×1 . Symbol `r` refers to row index, `r1` to first row in a row range, `r2` to the last row. The rows and columns can be specified using `ILIST` objects `i1` and `i2` to specify noncontiguous ranges. It is currently not possible to mix `ILIST` range and contiguous range, so if `ILIST` is needed for rows (columns), it must be used also for columns (rows). `ILIST` can be specified using explicitly `ilist()` function or using `construction`. Similarly columns are indicated with `c`. It is always legal to refer to vectors by using the `M` formulation and giving `c` with value 1 for column vectors and `r` with value 1 for row vectors.

Args	0-4	<code>REAL ILIST</code>
------	-----	---------------------------

row and column range as explained below.

<code>diag</code>	<code>N </code>
-------------------	-----------------

Get or set diagonal elements

<code>sum</code>	<code>N 0 1</code>
------------------	--------------------

When setting elements, the right side is added to the current elements. If the `sum->` option has argument, the right side is multiplied with the argument when adding to the current elements.

Row and column ranges can be specified as follows.

- `M(r,c)` Get or set single element.
- `C(r)` Get or set single element in column vector.
- `R(c)` Get or set single element in column vector.
- `M(RANGES)` Get or set a submatrix, where RANGES can be. For a column vector, the column range need not be specified.
 - `r1,-r2,c1,-c2`

- $r,c1,-c2$ part of row r
 - $r1,-r2,c$ part of column c
 - $r1,-r2,All$ All columns of the row range
 - $All,c1,-c2$ All rows of the column range
 - $r1,...rm,c1,...,cn$ Given rows and columns
 - $r1,...rm$ Given rows for column vector
 - $il1,il2$ for matrix with several columns
 - $il1$ for column vector
- When $r2= m$, then $-r2$ can be replaced with `Tolast`.
 - When $c2= n$, then $-c2$ can be replaced with `Tolast`.

If option `diag->` is present then

- $M(diag->)$ Get or set the diagonal. If M is not square matrix, and error occurs.
- $M(r1,-r2,diag->)$ (Again $-r2$ can be `Tolast`.)

Note 16.2.1. Note When setting values to a submatrix the the values given in input matrix are put into the outputmatrix in row order, and the shape of the input and output matrices need not be the same. An error occurs only if input and output contain different number of elements.

Example 16.1 (getset). Get or set submatrices

```
A=matrix(3,4,do->);  
B=A(1,-2,3,-4);  
A(1,-2,3,-4)=B+3;  
A(1,-2,3,-4,sum->)=-5;  
A(1,-2,3,-4,sum->2)=A(2,-3,1,-2);  
C=A(1,3,4...2);  
H=matrix(4,4,diag->,do->3);  
H(3,-4,diag->)=matrix(2,values->(4,7));
```

Note 16.2.2. When giving range, the lower and upper limit can be equal.

16.3 `getelem()`: extracting information from an object

The origin of this function is the function which was used in previous versions to take an matrix element, which explains the name. Now it is used to extract also submatrices (e.g. $a(1,-3,All)$) , or to get value of an regression function or to compute a transformation and then take argument object as the result. E.g. if `tr` is a transformation then the result of `tr(a)` is object `a` after calling `tr`.

Note 16.3.1. If someone starts to use the own function property of the open source **J**, she/he

probably would like to get the possibility to extract information from her/his object types also. To implement this property requires some co-operation from my side.

16.4 `setelem()`: Putting something into an object.

The origin of this function is the function which was used in previous versions to set an matrix element, which explains the name. Now it is used to replace values of submatrices when submatrix expression is on the output side (e.g. `a(1,-3,All)=..`).

Note 16.4.1. If someone starts to use the own function property of the open source **J**, she/he probably would like to get the possibility to put information into from her/his object types also. To implement this property requires some co-operation from my side.

Note 16.4.2. In effect the `getelem()` and `setelem()` functions are excuted in the same `getelem()` subroutine, because bot functions can utilize the same code.

16.5 `list2()`

The interpreted utilizes this to separate when spearating output and input objects. See Section ?? hw user can use this function

16.6 `setcodeopt()`: Initialization of a code option

This function initializes an code option for a function which has the option.

16.7 `o1_funcs()`, `o2_funcs()` and `o3_funcs()` calls own functions

The users of open **Jlp22** can define their own functions using three available own-function sets. In addition to own functions open **Jlp22** is ready to recognize also own object types and options which are defined in the source files controlled by the users. The main **Jlp22** does not know what to do with these own object types and options, they are just transmitted to the own-functions. In the main **Jlp22** the control is transmitted to the own functions using implicit **Jlp22** functions `o1_funcs()`, `o2_funcs()` and `o3_funcs()`.

17 Transformation objects

The code lines generated by the input programming can be either executed directly after interpretation, or the interpreted code lines are packed into a transformation object, which can be excuted with `call()` which is either in the code generated with the input programming or inside

the same or other transformation object. Recursive calling a transformation is thus also possible. Different functions related to transformation object are described in this section.

18 Loops and control structures

This section describes nonstandard functions.

18.1 do() loops

The loop construction in **JIp22** looks as follows: **do(i,start,end[,step]) enddo**

Note 18.1.1. cycle and exit are implemented in the current **JIp22** version with **goto()** Within a do-loop there can be cycle and exit statements

Note 18.1.2. There can be 8 nested loops. do-loop is not allowed at command level.

Example 18.1(doex). do-loop

```
!!begin
transa=trans()
do(i,1,5)
i;
ad1: if(i.eq.3)goto(cycle)
i;
if(i.eq.4)goto(jump)
cycle: enddo
jump:i;
/
call(transa)
```

18.2 if()

if()j_statement...

The one line if-statement.

18.3 if() elseif() else endif

There can be 4 nested **if()then** structures. If-then-structures are not allowed at command level.

if()then **elseif()then** ... **else** **endif**

18.4 output=input

There are two assignment functions generated by '=', when the line is of form `output=func[]input()`, then the output is directly put to the output position of the function without explicitly generating assignment. When the codeline is in form `output=input` then the following cases can occur

- `output` is **MATRIX** and `input` is scalar, then each element of **MATRIX** is replaced with the `input` in `assone()` function.
- `output` is submatrix expression, then the elements of the submatrix are assigned in `setelem()` function whether `input` is **MATRIX** or submatrix expression, scalar or **LIST**.
- `output` is **MATRIX** and on input side is a random number generation function, the random numbers are put to all elements of the matrix.
- If on output side are many object names, and input side is one **REAL** value, this is put to all variables.
- If on output side are many object names, and input there are several variables then both sides should have equal numbers of object names, then then copies of the input objects are put into output objects.

Example 18.2 (assignex). Examples of assignments

```
a=matrix(2, 3);  
a=4;  
a=rann();  
v1...v5=2...6;  
v1...v5=77;  
Continue=1 ! ERROR  
v1..v3=1, 5;  
v1..3=1...3 ! v is missing from the front of 3  
Continue=0
```

18.5 which() Value based on conditions

Usage:

```
output=which(condition1,value1,...,conditionn,value)n)
```

or

`output=which(condition1,value1,...,conditionn,value,n,valuedefault)` Where conditionx is a **REAL** value, nonzero value indicating TRUE. Output will get first value for which the condition is TRUE. When the number of arguments is not even, the the last value is the default value.

Example 18.3 (whichex). Example of `which()`

```
c=9  
which(a.eq.3.or.c.gt.8,5,a.eq.7,55);
```

```
a=7
which(a.eq.3.or.c.gt.8,5,a.eq.7,55);
a=5
which(a.eq.3.or.c.gt.8,5,a.eq.7,55);
which(a.eq.3.or.c.gt.8,5,a.eq.7,55,108);
```

18.6 erexit() returns to sit>

Function `erexit()` returns the control to `sit>` prompt with a message similarly as when an error occurs.

Example 18.4 (erexitex). `erexit()` returns as if error had occurred

```
transa=trans()
if(a.eq.0)erexit('illegal value ',a)
s=3/a; ! division with zero is tested automatically
/
a=3.7
call(transa)
transa(s); !tr can also be used as a function
a=0
Continue=1 !Do not stop in this selfmade error
call(transa)
Continue=0
```

18.7 goto() goto a label in TRANS

Control can be transferred to a label in a transformation set with `goto()`. There are two types of `goto`'s, unconditional `goto` to a given label and `goto` to a label from a group of labels based on a condition (Computed `goto` in Fortran). These are described in separate subsections. Notes common to both are presented here.

Note 18.7.1. It is not recommended to use `goto()` according to modern computation practices. However, it was easier to implement cycle and exitdo with `goto()`.

Note 18.7.2. It is not allowed to jump in to a loop or into if -then structure. This is checked already in the parser.

Note 18.7.3. Even if the labels are logically character arguments, they are not treated using CHARs. The parser handles them otherwise.

Note 18.7.4. The label lines can contain code but the labels can stand on the line also alone.

18.8 **goto(label)** Unconditional goto

An unconditional **goto()** has only one label argument.

Example 18.5 (gotoex). Example of unconditional goto

```
transa=trans()
i=0
if(i.eq.0)goto(koe)
out=99;
koe:out=88;
/
call(transa)
out;
```

18.9 **goto(index,label1...labeln)** Conditional goto

An conditional **goto()** selects the label from a group of labels.

Example 18.6 (congotoex). **transa=trans()**

```
out=999
goto(ad1)
77;
ad1:
1;
goto(2,ad1,ad3)
88;
ad2:
2;
goto(go,ad1,ad3)
out=0;
return
ad3:
3;
goto(3,ad3,ad1,ad2)
/
go=0 ! This determines the last goto
call(transa)
out;
go=4
** Now error occurs
Continue=1
call(transa)
Continue=0
;return
```

Note 18.9.1. A simulator for generating treatment schedules for forest stands can be nicely

defined using the conditional goto, as will shortly be described.

19 Arithmetic and logical operations

The logical operations follow the same rules as addition +. The following rules, extending the standard matrix computation rules apply. The same rules apply if the order of arguments is changed,

- **MATRIX + REAL** : **REAL** is added to each element
- **MATRIX1+MATRIX2** :: elementwise addition, if matrices have compatible dimensions
- **MATRIX+ column vector**: column vector is added to each column of **MATRIX** if the numbers of rows agree.
- **MATRIX+ row vector**: row vector is added to each row of **MATRIX** if the numbers of columns agree.

The same rules apply for the elementwise multiplication * and elementwise division /. as for addition +.

19.1 min() and max()

Functions **min()** and **max()** behave in a special way, **max()** behaves similarly as **min()** here:

- **min(x1,x2)**:: minimum of two **REAL**
- **min(MATRIX,REAL)**:: each element is **min(elem,REAL)**
- **min(MATRIX)**:: row vector having minimums of all columns
- **min(MATRIX,any->)**:: minimum over the whole matrix

20 Statistical functions for matrices

Functions **mean()**, **sd()**, **var()**, **sum()**, **min()** and **max()** can be used to compute statistics from a matrix. Let **mean()** here present any of these functions. The following rules apply:

mean(VECTOR) computes the mean of the vector, output is **REAL** **mean(MATRIX)** computes the mean of each column. **Result** is row vector. **mean(VECTOR,weight->wvector)** computes the weighted mean of the vector, weights being in vector **wvector**. **mean(MATRIX,weight->wvector)** computes the weighted mean of each column, weights being in vector **wvector**, result is row vector.

20.1 **mean()** Means or weighted means

See section matrixstat for details

20.2 **sd()** Sd's or weighted sd's

See section matrixstat for details

20.3 **var()** Sample variances or weighted variances

See section matrixstat for details

20.4 **sum()** Sums or weighted sums

See section matrixstat for details

21 Special arithmetic functions

JIp22 has the following arithmetic functions producing **REAL** values. These functions cannot yet have matrix arguments.

21.1 **der()** Derivatives

Derivates of a function with respect to any of its arguments can be computed using the derivation rules by using **der()** function in the previous line. The function must be expressed with one-line statement. The function can call other functions using the standard way to obtain objects from transformations, but these functions cannot contain variables for which derivatives are obtained. Nonlinear regression needs the derivatives with respect to the parameters.

Output

The **der()** function does not have an explicit output, but **der()** accompanied with the function produces **REAL** $]d[[]$ variable for each of the argument variables.

Args 1- **REAL**

$]d[[Argi]$ variable will get the value of the derivative with respect to the argument **Argi**.

Example 21.1 (derex). Derivatives with **der()**
transa=trans()

```

der(x)
f=(1+x)*cos(x)
/
fi=draw(func->transa(f
textcolor{teal}{x}),x->x,xrange->(0,10),color->Blue,continue->)
fi=draw(func->transa(f),x->x,xrange->(0,10),color->Cyan,append->,continue->fc

```

Example 21.2 (derex2). 2

```

X=matrix(do->(0,1000,10))
e=matrix(nrows(X))
e=rann(0,2);
A,Pmax,Res=0.1,20,2
A^Pmax^1000/(A^1000+Pmax);
Y=A^Pmax^X/.(A^X+Pmax)-Res+e !rectangular hyperbola used often for photosynthe

```

```

transa=trans()
der(A,Pmax,Res)
f=A^Pmax^I/(A^I+Pmax)-Res
/

```

```

fi=draw(func->(transa(f)),x->I,xrange->(0,1000),color->Orange,width->2,cont
da=newdata(X,Y,e,extra->(Regf,Resid),read->(I,P,er))
stat()
fi=plotyx(P,I,append->,show->0,continue->fcont)

```

A,Pmax,Res=0.07,17,3 !initial values

```

fi=draw(func->(transa(f)),x->I,xrange->(0,1000),color->Green,width->2,append
reg=nonlin(P,f,par->(A,Pmax,Res),var->,corr->,data->da,trans->transa)
reg%var;
reg%corr;
corrmatrix(reg%var);
fi=draw(func->(transa(f)),x->I,xrange->(0,1000),color->Violet,append->,contin

```

21.2 gamma() Gamma function

Function **gamma()** produses the value of gamma funtion for a positive argument. The function utilises gamma subroutine from library dcdflib in Netlib. For computing gamma function for a product, **loggamma()** is often needed. **loggamma()** Log of gamma function Function **gamma()** produces the value of loggamma funtion for a positive argument. ! The function utilises gamma subroutine from library dcdflib in Netlib. Loggamma is used in statistics in many cases where gamma function gets a too large value to be presented in double precision.

21.3 **logistic()** Logistic function

Returns the value of the logistic function $1/(1+\exp(-x))$. This can in principle be computed by the transformation, but the transformation will produce an error condition when the argument $-x$ of the \exp -function is large. Because the logistic function is symmetric, these cases are computed as $\exp(x)/(1+\exp(x))$. Because the logistic function can be needed in the nonlinear regression, also the derivatives are implemented. Note, to utilize derivatives the function needs to be in a **TRANS** object. Eg when $f=\text{logistic}(a*(x-x_0))$, then the derivatives can be obtained with respect to the parameters a and x_0 by

Example 21.3 (logisticex). Example of logistic function

```
transa=trans()
der(a,x0)
f=logistic(a*(x-x0));
/
x,x0,a=10,5,0.1
call(transa)
```

Note 21.3.1. In the previous example $\text{tr}(d[x_0])$ has the effect that **TRANS** tr is first called, which makes that also $d[a]$ and $d[x]$ have been computed. Remember that the parse tree is computed from right to left.

21.4 **npv()** Net present value

npv([interest,income1,...,incomen,time1,...,timen])// Returns net present value for income sequence income1,...,incomen, occurring at times time1,...,timen when the interest percentage is **interest**.

22 Probability distributions

There are currently the following functions relate to probability distributions.

Note 22.0.1. function **density()** can be used define density or probability function for any continuous or discrete distribution which can then be used to generate random numbers with **random()** function.

22.1 **pdf()** Normal density

Output	1	REAL
--------	---	------

the value of the density.

Args	0-2	REAL
Arg1 is the mean (default 0), Arg2 is the standard deviation (default 1). If sd is given, the mean must be given explicitly as the first argument.		

Note 22.1.1. See example drawclassex for an utilization of **pdf()**

22.2 **cdf()** Cumulative distribution for normal and chi2

Output	1	REAL
The value of the cdf.		
Args	1-3	REAL
Arg1 the upper limit of the integral. When chi2-> is not present, then Arg2 , if present is the mean of the normal distribution (default 0), and Arg3 , if present, is the sd of the distribution. If chi2-> is present, then obligatory Arg2 is the number of degrees of freedom for chi2-distribution.		
chi2	N 0	
chi2	N 0	

22.3 **bin()** Binomial probability

bin(k,n,p)= The binomial probability that there will be **k** successes in **n** independent trials when in a single trial the probability of success is **p**.

22.4 **negbin()** Negative binomial

negbin(k,myy,theta)= The probability that a negative binomial random variable has value **k** when the variable has mean **myy** and variance **myy+theta*myy**2**.

Note 22.4.1. **negbin(k,n*p,0)= bin(k,n*p).**

Note 22.4.2. Sorry for the parameter inconsistency with **rannegbin()**.

22.5 **density()** for any discrete or continuous distribution

Make density for random numbers either with a function or histogram generated with **classify**.

Args	0-1	MATRIX
		MATRIX generated with classify()
func	N 1	
		codeoption defining the density. The x -variable is \$.
xrange	0 2	REAL
		Range of x -values
discrete	-1 0	
		Presence implies the the distribution is discrete

Note 22.5.1. Actually the function generates a matrix having two rows which has values for the cumulative distribution function.

Note 22.5.2. When defining the density function, the user need not care about the scaling constant which makes the integral to integrate up to 1.

Example 22.1 (densityex). Example of distributions

```

ber=density(func->(1-p+(2*p-1) * $),xrange->(0,1),discrete->); Bernoulli
bim=matrix(100)
bim=random(ber)
mean(bim);
p*(1-p); !theoretical variance
var(bim);
pd=density(func->exp(-0.5*$*$),xrange->(-3,3)) !Normal distribution

ra=random(pd);
f=matrix(1000)
f=random(pd)
da=newdata(f,read->x)
stat(min->,max->)
cl=classify(x->x,xrange->);
fi=drawclass(cl,continue->fcont)
fi=drawclass(cl,area->,continue->fcont)

fi=draw(func->pdf(x),x->x,xrange->,append->,continue->fcont)
f=matrix(1000)
f=rann()
da=newdata(f,read->x)
stat(min->,max->)
cl=classify(x->x,xrange->)

```

```
fi=drawclass(cl,histogram->,classes->20,continue->fcont)
den=density(cl);
fi=drawline(den,continue->fcont)
```

23 Random number generators

Random number generators are taken from Ranlib library of Netlib. They can produce single **REAL** variables or random **MATRIX** objects. Random matrices are produced by defining first a matrix with **matrix()** function and putting that as the output.

23.1 **ran()** Uniform

Uniform random numbers between 0 and 1 are generated using Netlib function ranf.

Output 1 **REAL|MATRIX**

The generated **REAL** value or **MATRIX**. Random matrix can be generated by defining first the matrix with **matrix()**.

Example 23.1 (ranex).
ran();
ran();
cpu0=cpu()
A=matrix(10000, 5)
A=ran()
mean(A);
mean(A,any->) ! mean over all elements
mean(A(All,2));
sd(A);
sd(A,any->);
min(A);
min(A,any->);
max(A);
cpu()-cpu0;

23.2 **rann()** Normal

Computes normally distributed pseudo random numbers into a **REAL** variable or into **MATRIX**.

Output 1 **REAL|MATRIX**

The matrix to be generated must be defined earlier with **matrix()**.

Args 0-2 num

rann() produces N(0,1) variables, **rann(mean)** will produce N(mean,1) variables and **rann(mean,sd)** produces N(mean,sd) variables.

Example 23.2 (rannex). Random normal variates, illustrating also find

```
rx=rann(); !Output is REAL
rm=matrix(1000)
rm=rann()
rm(1,-5);
print(mean(rm),sd(rm),min(rm),max(rm))
Continue=1!an error
large=find(rm,filter->($.ge.2),any)
Continue=0
large=find(rm,filter->($.ge.2),any->)
100*nrows(large)/nrows(rm);
cpu0=cpu()
rm2=matrix(1000000)
rm2=rann(10,2) !there cannot be arithmetic operations in the right side
cpu()-cpu0;
mean(rm2),sd(rm2),min(rm2),max(rm2);
large=find(rm2,filter->($.ge.14),any->)
100*nrows(large)/nrows(rm2);
!
```

Note 23.2.1. When generating a matrix with random numbers, there cannot be arithmetic operations on the right side. That means that code:

```
rm=matrix(100)
rm=2*rann()
would produce a REAL value rm.
```

23.3 **ranpoi()** Poisson

ranpoi(myy// returns a random Poisson variable with expected value and variance **myy**

23.4 **ranbin()** Binomial

Binomial random numbers between 0 and n are generated using Netlib **ignbin(n,p)**. Random matrix can be generated by defining first the matrix with **matrix()**.

Output 1 **REAL |MATRIX**

The generated **REAL** value or **MATRIX** with number of successes. (**Jip22** does not have explicit integer type object).

Args 2 **REAL**

Arg1 is the number of trials (n) and **Arg2** is the probability of success in one trial.

!

Example 23.3 (ranbinex). Random binomial

```
ranbin(10, 0.1);
ranbin(10, 0.1);
A=matrix(1000, 2)
Continue=1
A(A11, 1)=ranbin(20, 0.2)
Continue=0
A=matrix(1000)
A=ranbin(20, 0.2)
B=matrix(1000)
B=ranbin(20, 0.2)
da=newdata(A, B, read->(s1, s2))
stat(min->, max->)
cl=classify(1, x->s1, xrange->)
fi=drawclass(cl, histogram->, color->Blue, continue->fcont)
cl=classify(1, x->s2, xrange->)
fi=drawclass(cl, histogram->, color->Red, append->, continue->fcont)
```

23.5 ranegbin() Negative binomial

The function returns random number distributed according to the negative binomial distribution.

Output 1 **REAL | MATRIX**

the number of successes in independent Bernoul trials before r'th failure when p is the probability of success. **ranbin**(r,1)returns 1.7e37 and **ranbin**(r,0)returns 0.

Note 23.5.1. there are different ways to define the negative binomial distribution. In this definition a Poisson random variable with mean \$\$ is obtained by letting r go to infinity and defining $p= $$/($$+r)$. The mean $E(x)$ of this definition is $p*r/(1-p)$ and the variance is $V=p*r/(1-p)^2$. Thus given $E(x)$ and V , r and p can be obtained as follows: $p=1- E(x) /V$ and $r= E(x)^{**2}/(V- E(x))$. This is useful when simulating 'overdispersed Poisson' variables. Sorry for the (temporary) inconsis-

tency of parameters with function `negbin()`.

Note 23.5.2. can also have a noninteger values. This is not in accordance with the above interpretation of the distribution, but it is compatible with interpreting negative binomial distribution as a compound gamma-Poisson distribution and it is useful when simulating overdispersed Poisson distributions.

23.6 `select()` Random selection

Output 1 **MATRIX**

column vector with n elements indicating random selection of k elements out of n elements. The selection is without replacement, thus elements of the output are 1 or 0..

Args 2 **REAL**

`k=Arg1` and `n=Arg2`.

Example 23.4 (`selectex`). Random selection

```
** select 500 numbers without replacement from 10000
** output is vector of 10000 rows containing 0 or 1
S=select(500,10000)
nrows(S),mean(S),sum(S),500/10000;
```

23.7 `random()` Any distribution

usage `random(dist)` where `dist` is the density defined in `density()`. See `density()` for examples.

24 Interpolation

The following functions can be used for interpolation

24.1 `interpolate()` Linear interpolation

Usage:// `interpolate(x0,x1[,x2],y0,y1[,y2],x)`// If arguments `x2` and `y2` are given then computes the value of the quadratic function at value `x` going through the three points, otherwise computes the value of the linear function at value `x` going through the two points.

Note 24.1.1. The argument `x` need not be within the interval of given `x` values (thus the function also extrapolates).

24.2 `plane()` Interpolates an a plane

Usage:

```
plane(x1,x2,x3,y1,y2,y3,z1,z2,z3,x,y]
```

The function computes the equation of plane going through the three points (`x1,y1,z1`), etc and computes the value of the `z`-coordinate in point (`x,y`). The three points defining the plane cannot be on single line.

24.3 `bilin()` Bilinear interpolation

Usage:

```
bilin(x1,x2,y1,y2,z1,z2,z3,z4,x,y]
```

`z1` is the value of function at point (`x1,y1`), `z2` is the value at point (`x1,y2`), `z3` is the value at (`x2,y1`) and `z4` is the value at (`x2,y2`): the function is using bilinear interpolation to compute the value of the `z`-coordinate in point (`x,y`). The point (`x,y`) needs not be within the square defined by the corner points, but it is good if it is. See Press et al. ? (or Google) for the principle of bilinear interpolation

25 List functions

The following list functions are available

25.1 Object lists

An object list is a list of named **JIp22** object. See Shortcuts for implicit object lists and List functions for more details. Object lists can be used also as pointers to objects, see e.g. the selector option of the simulate() function.

25.2 `list()` Creates LIST

Output	1	LIST
--------	---	------

The generated `LIST` object.

Args	0-
------	----

named objects. If an argument is **LIST** it is expanded

mask N|1- REAI

Which object are picked from the list of arguments. value 0 indicates that the object is dropped, positive value indicates how many variables are taken, negative value how many objects are dropped (thus 0 is equivalent to -1). mask-option is useful for creating sublists of long lists.

Note 25.2.1. The same object may appear several times in the list. (see **merge()**)

Note 25.2.2. There may be zero arguments, which result in an empty list which can be updated later.

Note 25.2.3. The index of object in a **LIST** can be obtained using **index()**.

```
li=list(x1...x3); index(x2,li); Continue=1 index(x4,li); ! error Continue=0
```

Example 25.1 (list2ex). x

```
all=list(); ! empty list
sub=list();
nper=3
;do(i,1,nper)
period#"i"=list(ba#"i",vol#"i",age#"i",harv#"i")
sub#"i"=list(@period#"i",mask->(-2,1,-1))
all=list(@all,@period#"i") !note that all is on both sides
sub=list(@sub,@sub#"i")
;end do
```

25.3 **merge()** Merges LISTs

merge() will produce of list consisting of separate objects in argument lists and argument objects.

Output 1 **LIST**

A list which is produced by first putting all elements of argument lists and non-list arguments into a vector, and then duplicate objects are dropped.

Args 2- **LIST|OBJ**

LIST and separate non-list objects.

Example 25.2 (mergex). Merging list

```

x1...x3=1,2,3
mat=matrix(3,values->(4,5,6))
lis0=list(x2,x1)
lis2=merge(x1,mat,lis0)
print(lis2)

<print(lis2)
lis2 is list with           3   elements:
x1 mat x2

```

25.4 difference() Difference of LISTs

difference() removes elements from a **LIST**

Output 1 **LIST**

the generated **LIST**.

Args 2 **LIST|OBJ**

The first argument is the **LIST** from which the elements of the are removed
If second argument is **LIST** then all of its eleemts are remove, other wise it is assumed that the second argument is an object which is remote from the list.

Example 25.3 (diffex). fex

```

lis=list(x1...x3,z3..z5);
lis2=list(x1,z5);
liso=difference(lis,lis2);
liso2=difference(liso,z3);
Continue=1
lisoer=difference(lis,z6); ! error occurs
liser=difference(Lis,x3); !error occurs
Continue=0

```

25.5 index() Index in a **LIST**

To be documented later

25.6 len() Length of **LIST**, **ILIST** or **MATRIX**

len(arg) Lenghts for the following argument types

- **arg** is **MATRIX** => **len**=the size of the matrix, i.e. **nrows(arg)*ncols(arg)**

- `arg` is TEXT => len=the number of character in TEXT object
- `arg` is LIST => len=the number of elements in LIST
- `arg` is ILIST => len=the number of elements in ILIST

If `arg` does not have a legal type for `len()`, then `len(arg)=-1` if `len()` has option `any->`, otherwise an error is produced.

25.7 `ilist()` ILIST of integers

Generates a list of integers which can be used as indexes.

Output	1	ILIST
		The generated ILIST.
Args	0-	REAL
		Values to be put into ILIST, or the dimension of the ILIST when values are given in <code>values-></code> , or variables whose indeces in the data are put into the ILIST.
<code>data</code>	N 1	DATA
		The DATA from whose variable indeces are obtained.
<code>extra</code>	1	REAL
		Extra space reserved for later updates of the ILIST.
<code>values</code>	N 1-	REAL
		Values to be put into ILIST when dimension is determined as the only argument

Note 25.7.1. ILIST is a new object whose all utilization possibilities are not yet explored. It will be used e.g. when developing factory optimization.

Note 25.7.2. Note Using `ilist()` by giving the dimension as argument and values with `values->` option imitates the definition of a matrix (column vector). The structure of ILIST object is the same as LIST object which can be used in matrix computations.

Example 25.4 (ilistex). ILIST examples

```
1, 4, 5;
4 . . . 1;
A=matrix(4, 4)
A(1, 5, 3=
```

25.8 `putlist()` puts into LIST an object

Usage:

`putlist(LIST,OBJ)`

put OBJ into LIST

25.9 `table()` Crossses two LISTS

Usage:

`Output=table(rowlist,collist)`

This can be used in factory optimizations

26 TEXT and TXT text objects

There are now two object types for text.

26.1 `text()` Creates TEXT

Text objects are created as a side product by many **JIp22** functions. Text objects can be created directly by the `text()` function which works in a nonstandard way. The syntax is: `output=text()//...//`

The input paragraph ends exceptionally with '//' and not with '/'. The lines within the input paragraph of text are put literally into the text object (i.e. even if there would be input programming functions or structures included)

26.2 `txt()` Creates TXT

Works as `text()`, to be documented later. The new **TXT** object is used to implement `;incl` and Gnuplot -figures.

27 File handling

The following functions can handle files.

27.1 `exist_f(): does a file exist`

looks whether a file with the name given in the character constant argument exists.

Note 27.1.1. In the previous versions of **JIp22** same function was used for files and objects.

27.2 **delete_f()** Deletes files

The function **delete_f()** deletes all files having the names given in the arguments. The arguments can be character constants or character variables associated with character constants. After deleting a file whose name is given in character variable, the variable still refers to the same character constant.

Example 27.1 (deletfex). Deletef file

```
write('delete_fex.txt',$, 'a=matrix(2,4,do->);')
write('delete_fex.txt',$, 'delete_o(a)')
write('delete_fex.txt',$, 'a;')
close('delete_fex.txt')
;incl(delete_fex.txt)
delete_f('delete_fex.txt')
```

27.3 **print_f()** prints files

Prints the files associated with the **CHAR** arguments

maxlines-> tells the maximum number of lines to be printed, default the value of **Maxlines**

27.4 **close()** Closes a file

close(file) closes an open file where file is either a character constant or character variable associated with a file.

Note 27.4.1. No **open(9)**function is needed. An file is opened when it is first time in **write()** or **print(file->)**.

27.5 **showdir()** shows the current directory

Note 27.5.1. **showdir** is defined in the system dependent file **jsysdep_gfortran.f90**. Using other compliers it may be neccessary to change the definition

27.6 **setdir()** sets the current directory

Note 27.6.1. **setdir** is defined in the system dependent file **jsysdep_gfortran.f90**. Using other complilers it may be neccessary to change the definition

27.7 **thisfile()** Name of the current ;incl -file

The name of the current include file is returned as a character variable by: **out=thisfile()** This is useful when defining shortcuts for commands that include sections from an include file. Us-

ing this function the shortcuts work even if the name of the include file is changed. See file jexamples.inc for an application

27.8 **filestat()** Information of a file

Function **filestat**(filename) prints the size of the file in bytes (if available) and the time the file was last accessed

28 Io-functions

Theree are following io functions

28.1 **read()** Reads from file

read(file,format[,obj1,...,objn][,**eof->var**] [,**wait->**])// Reads real variables or matrices from a file. If there are no objects to be read, then a record is by-passed.// Arguments: file the file name as a character variable or a character constant// format// 'b' unformatted (binary) data // 'bn' unformatted, but for each record there is integer for the size of the record. Does not work when reading matrices. 'bis' binary data consisting of bytes, each value is converted to real value (the only numeric data type in J). This works only when reading matrices.// '(....)' a Fortran format. Does not work when reading matrices. \$ the * format of Fortran// obj1,...,objn **Jlp22** objects// Options:// eof Defines the variable which indicates the end of file condition of the file. If the end of the file is not reached the variable gets the value 0, and when the end of file is reached then the variable gets value 1 and the file is closed without extra notice.

When **eof->** option is not present and the file ends then an error condition occurs and the file is closed.// wait **Jlp22** is waiting until the file can be opened. Useful in client-server applications. See chapter **Jlp22** as a server.

Note 28.1.1. Use **ask()** or **askc()** to read values from the terminal when reading lines from an include file.

Note 28.1.2. When reading matrices, their shapes need to be defined earlier with **matrix()** hfunction.

28.2 **write()** Writes to console or to file

write(file,format,val1,...,valn[**tab->**][,**rows->**])! case[1/6] Writes real values to a file or to the console. If val1 is a matrix then this matrix (or usually vector) is written or at most as many values as given in the **values->** option. Arguments: file variable \$ (indicating the console), or the name of

the file as a character variable or a character constant, or variable \$Buffer format \$ indicates the '*' format of Fortran, works only for numeric values. A character expression, with the following possibilities: A format starting with 'b' will indicate binary file. Now 'b' indicates ordinary unformatted write, later there will be other binary formats A Fortran format statement, e.g. (~the values were ~,4f6.0), with this format pure text can be written by having no object to write (e.g. `write('out.txt','(~kukuu~)')`). For these formats, other arguments are supposed to be real variables or numeric expressions or there is a matrix argument. If they are not, then just the real value which is anyhow associated with each **JIp22** object is printed (usually it will be zero). If the val1 argument is a matrix, then all values are printed. val1,...,valn real values Options: tab if format is a Fortran format then, `tab->` option indicates that sequences of spaces are replaced by tab character so that written text can be easily converted to Ms Word tables. If there are no decimals after the decimal point also the decimal point is dropped. rows If val1 is a matrix or a vector and `rows->` has one argument then at most as many values are written as given in this option, if there are two arguments then the option gives the range of written rows in the form `rows->(row1,-row2)`. If the upper limit is greater than the number of rows, no error is produced, all available rows are just written. `write(file,'t',t1,val1,t2,val2,...,tn,valn,[tab->])` ! case[2/6] Tabulation format. positive tab position values indicate that the value is written starting from that position, negative tab positions indicate that the value is written up to that position. The values can be either numeric expressions or character variables or character constants. Tab positions can be in any order. Arguments: file variable \$ (indicating the console), or the name of the file as a character variable or a character constant, or variable \$Buffer 't' tabulation format t1,val1,t2,val2,...,tn,valn KUVAUS Options: tab option indicates that sequences of spaces are replaced by tab character so that written text can be easily converted to Ms Word tables.

28.3 `print()` Prints objects to file or console

```
print(arg1,...,argn,[maxlines->][,data->][,row->][,file->][,func->][,debug->])// Print values of variables
or information about objects.// Arguments: arg1,...,argn Options: maxlines-1|1REAL the maximum
number of lines printed for matrices, default 100. any -1|0 if the argument is the name
of a text file, then any-> indicates that the file is read to the end and the number of lines is put
into variable Accepted. data-1|1 DATA data sets. If data-> option is given then arguments must
be ordinary real variables obtained from data. row if a text object is printed, then the first value
given in the row-> option gives the first line to be printed. If a range of lines is printed, then the
second argument must be the negative of the last line to be printed (e.g. row->(10,-15)).Note
that nrows() function can be used to get the number of rows. file the file name as a character
variable or a character constant. Redirects the output of the print() function to given file. After
printing to the file, the file remains open and must be explicitly closed (close('file')) if it should
be opened in a different application. form when a matrix is printed, the format for a row can be
given as a Fortran format, e.g. form '(15f6.2)' may be useful when printing a correlation matrix.
```

debug the associated real variable part is first printed, and thereafter the tow associated two integer vectors, the real vector and the double precision vector func all functions available are printed

Note 28.3.1. For simple objects, all the object content is printed, for complicates objects only summary information is printed. `print(Names)` will list the names, types and sizes of all named **JIp22** objects. The printing format is dependent on the object type.

Note 28.3.2. `print()` function can be executed for the output of a **JIp22** command by writing ';' or ';;' at the end of the line. The excution of implied `print()` is dependent on the value of `Printoutput`. If `printoutput =0`, then the output is not printed, If `printoutput =1`, then ';' is causing printing, if `Printoutput =2` then only ';;'-outputs are printed, and if `Printoutput =3`, then both ';' and ';;' outputs are printed.

Note 28.3.3. it was earlier to print a file using this function, but now function `Print_f` must be used fro taht purpose.

28.4 `print_f()` prints files

Prints the files associated with the `CHAR` arguments

`maxlines->` tells the maximum number of lines to be printed, default the value of `Maxlines`

28.5 `ask()` Asks `REAL`

`ask([var][,default->][,q->][,exit->])`// Ask values for a variable while reading commands from an include file.// Argument:// var 0 or one real variable (need not exist before) Options: default default values for the asked variables q text used in asking exit if the value given in this option is read, then the control returns to command level similarly as if an error would occur. If there is no value given in this option, then the exit takes place if the text given as answer is not a number.

Note 28.5.1. If there are no arguments, then the value is asked for the output variable, otherwise for the argument. The value is interpreted, so it can be defined using transformations. Response with carriage return indicates that the variables get the default values. If there is no `default->` option, then the previous value of the variable is maintained (which is also printed as the `default->` value in asking)

```
Example 28.1 (askex). Examples for ask()
a=ask(default->8)
ask(a,default->8)
print(ask()+ask()) ! ask without argument is a numeric function
```

```
ask(v,q->'Give v>')
```

28.6 askc() Asks CHAR

Usage :// **askc(chvar1[,default->][,q->][,exit->])** Asks values for character variables when reading commands from an include file.

Args	0-4	REAL ILIST
------	-----	--------------

row and column range as explained below.

Args	0 1	CHAR
------	-----	------

character variable (need not exist before)

default	0 1	CHAR
---------	-----	------

default character strings

q	0 1	CHAR
---	-----	------

text used in asking

exit	-1 0	
------	------	--

if the character constant or variable given in this option is read, then the control return to command level similarly as if an error would occur.

Note 28.6.1. Note Response with carriage return indicates that the variable gets the default value. If there is no **default->** option, then the variable will be unchanged (i.e. it may remain also as another object type than character variable).

Note 28.6.2. If there are no arguments, then the value is asked for the output variable, otherwise for the arguments.

28.7 printresult() and printresult2() for ending ; and ;;

The **JIp22** interpreter translates ';' at the end of the line to a call to **printresult()** function and ';;' to a call to **printresult2()**. The output of a function is printed by writing ';' or ';;' at the end of the line. The execution of implied **print()** is dependent on the value of **Printoutput**. If **Printoutput** =0, then the output is not printed, If **Printoutput** =1, then ';' is causing printing, if **Printoutput** =2 then only ';;'-outputs are printed, and if **Printoutput** =3, then both ';' and ';;' outputs are printed.

Note 28.7.1. `printresult()` and `printresult2()` are simple functions which just test the value of `Printoutput` and then call the printing subroutine, if needed.

29 Matrix functions

JIp22 contains now the following matrix functions.

29.1 Matrices and vectors

Matrices and vectors are generated with the `matrix()` function or they are produced by matrix operations, matrix functions or by other **JIp22** functions. E.g. the `data()` function is producing a data matrix as a part of the compound data object. Matrix elements can be used in arithmetic operations as input or output in similar way as real variables. See Matrix computations.

29.2 `matrix()` Creates MATRIX

Function `matrix()` creates a matrix and puts `REAL` values to the elements. Element values can be read from the input paragraph, file, or the values can be generated using `values->` option, or sequential values can be generated using `do->` option. Function `matrix()` can generate a diagonal and block diagonal matrix. A matrix can be generated from submatrices by using matrices as arguments of the `values->` option. It should be noted that matrices are stored in row order.

Output	1	MATRIX REAL
--------	---	---------------

If a 1x1 matrix is defined, the output will be `REAL`. The output can be a temporary matrix without name, if `matrix()` is an argument of an arithmetic function or matrix function. If no element values are given in `values->` or obtained from `in->` input, all elemets get value zero.

Args	0-2	REAL
------	-----	------

The dimension of the matrix. The first argument is the number of rows, the second argument, if present, the number of columns. If the matrix is generated from submatrices given in `values->`, then the dimensions refer to the submatrix rows and submatrix columns. If there are no arguments, then the it should be possible to infer the dimensions from `values->` option. If the first argument is `Inf`, the the number of rows is determined by the number number of lines in source determined by `in->`.

in N|0|1 CHAR

The input for values. **in->** means that values are read in from the following input paragraphs, **in->file** means that the values are read from file. in both cases a record must contain one row for the matrix. If there is reading error and values are read from the terminal, **Jlp22** gives possibility to continue with better luck, otherwise an error occurs.

values N|1- REAL

values or **MATRIX** objects put to the matrix. The argument of **values->** option go in the regular way through the interpreter, so the values can be obtained by computations. If only one **REAL** value is given then all diagonal elements are put equal to the value (others will be zero), if **diag->** option is present, otherwise all elements are put equal to this value. If matrix dimensions are given, and there are fewer values than is the size the matrix, matrix is filled row by row using all values given in **values->**. If there are more values as is the size, an error occurs unless there is **any->** option present. Thus **matrix(N,N,values->1)** generates the identity matrix. If value-> refers to one **MATRIX**, and **diag->** is present then a block diagonal matrix is generated. Without **diag->**, a partitioned matrix is generated having all submatrices equal

do N|0-3 REAL

A matrix of number sequences is generated, as follows:

do-> Values 1,2,...,**arg1** x **arg2** are put into the matrix in the row order.

do->5 Values 5,6,...,**arg1** x **arg2+4** are put into the matrix

do->

Example 29.1 (matrixex). Example of generating matrices

A=matrix(3,

29.3 **nrows()** Number of rows in **MATRIX**, **TEXT** or **BITMATRIX**

can be used as:

- **nrows(MATRIX)**
- **nrows(TEXT)**
- **nrows(BITMATRIX)**

Note 29.3.1. If the argument has another object type, and error occurs

29.4 `ncols()` Number of columns in **MATRIX** or **BITMATRIX**

can be used as:

- `nrows(MATRIX)`
- `nrows(BITMATRIX)`

Note 29.4.1. If the argument has another object type, an error occurs

29.5 `t()` Transpose of a **MATRIX** or a **LIST**

`t(MATRIX)` is the transpose of a **MATRIX**. As **LIST** objects can now be used in matrix computations, `t(LIST)` is also available.

Note 29.5.1. Multiplying a matrix by the transpose of a matrix can be made by making new operation `*`.

Note 29.5.2. The argument matrix can also be a submatrix expression.

29.6 `inverse()` Inverse and condition of **MATRIX**

`inverse(matrixa)` computes the inverse of a square **MATRIX** `matrixa`. The function utilized dgesv function of netlib. If the argument has type **REAL**, then the reciprocal is computed, and the output will also have type **REAL**. An error occurs, if `matrixa` is not a square matrix or **REAL**, or `matrixa` is singular according to dgesv. If the output is a named object (i.e. not a temporary object), the condition number is stored in **REAL** with name `Output%condition`.

Note 29.6.1. The condition number is **not** put into `input%conditon` which could be more logical.

Example 29.2 (inverseex). `inverse()` and condition number

```
matrixa=matrix(4, 4)
matrixa=1
*** well conditioned matrix
matrixa(diag->)=10
matrixa;
matrixb=inverse(matrixa);
matrixb%condition;
** almost singular matrix
matrixa(diag->)=1.05
matrixb=inverse(matrixa);
matrixb%condition;
** figure of condition number
transa=trans()
matrixa(diag->)=diag
matrixb=inverse(matrixa)
/
```

```
** Note that the lower bound is equal to the dimension  
figa=draw(x->diag,xrange->(1.05,50),func->transa(matrixb%condition),  
color->Blue,continue->fcont)
```

Note 29.6.2. instead of writing `c=inverse(a)*b`, it is faster and more accurate to write `c=solve(a,b)`

29.7 `solve()` Solves a linear equation $A^*x=b$

A linear matrix equation $A^*x=b$ can be solved for `x` with code

```
x=solve(A,b)
```

Note 29.7.1. `x=solve(A,b)` is faster and more accurate than `x=inverse(A)*b`

Note 29.7.2. `solve` works also if `A` and `b` are scalars. This is useful when working with linear systems which start to grow from scalars.

29.8 `qr()` QR decomposition of `MATRIX`

Makes QR decomposition of a `MATRIX`. This can be used to study if columns of `a` are linearly dependent. `JIp22` prints a matrix which indicates the structure of the upper diagonal matrix `R` in the `qr` decomposition. If column `k` is linearly dependent on previous columns the `k`'th diagonal element is zero. If output is given, then it will be the `r` matrix. Due to rounding errors diagonal elements which are interpreted to be zero are not exactly zero. Explicit `r` matrix is useful if user thinks that `JIp22` has not properly interpreted which diagonal elements are zero. In `JIp22 qr()` may be useful when it is studied why a matrix which shoudl be nonsingular turns out to be singular in `inverse()` or `solve()`. `qr()` is using the subroutine `dgeqrf` from Netlib. An error occurs if the argument is not `MATRIX` or if `dgeqrf` produces error code, which is just printed. Now the function just shows the linear dependencies, as sho in the examples.

Args 1 `MATRIX`

A m-by-n `MATRIX`.

29.9 `eigen()` Eigenvector and eigenmatrix from `MATRIX`

Computes eigenvectors and eigenvalues of a square matrix. The eigenvectors are stored as columns in matrix `output%matrix` and the eigenvalues are stored as a row vector `output%values`. The eigenvalues and eigenvectors are sorted from smallest to larges eigenvalue. Netlib subrountines `DLASCL`, `DORGTR`, `DSCAL`, `DSTEQR`, `DSTERF`, `DSYTRD`, `XERBLA`, `DLANSY` and `DLASCL` are used.

Args 1 MAT

A square MATRIX.

29.10 sort() Sorts MATRIX

Usage:

`sort(a,key->(key1[key2]))`

Makes a new matrix obtained by sorting all matrix columns of MATRIX a according to one or two columns. Absolute value of key1 and the value of key2 must be legal column numbers. If key1 is positive then the columns are sorted in ascending order, if key1 is negative then the columns are sorted in descending order. If two keys are given, then first key dominates.

Note 29.10.1. It is currently assumed that if there are two keys then the values in first key column have integer values.

Note 29.10.2. If key2 is not given and key1 is positive, then the syntax is: `sort(a,key->key1)`.

Note 29.10.3. If there is no output, then the argument matrix is sorted in place.

Note 29.10.4. The argument can be the data matrix of a data object. The data object will remain a valid data object.

29.11 envelope() Convex hull of point

Output 1 MATRIX

(nvertex+1, 2) matrix of the coordinates of the convex hull, where nvertex is the number of vertices. The last point is the same as the first point

arg 1 MATRIX

(n,2) matrix of point coordinates

nobs -1|1 REAL

The number of points if not all points of the input matrix are used

Note 29.11.1. The transpose of the output can be directly used in frawline() function to draw the envelope

Note 29.11.2. The function is using a subroutine made by Alan Miller and found in Netlib

29.12 **find()** Finds from a MATRIX

Function **find()** can be used to find the first matrix element satisfying a given condition, or all matrix elements satifying the conditon, and in that case the found elements can be put to a vector containg element numbers or to a vector which has equal size as the input matrix and where 1 indicates that the element satifies the condition.. Remember that matrices are stored in row order. If a given column or row of matrix A should be seaeched, use A(All,column) or A(row,ALL) to extract that row or column.

Output 1 REAL|MATRIX

Without **any->** or **expand->** the first element found in row order. With **any->**, the vector of element numbers satisfying the conditon. If nothing found the output will be **REAL** with value zero. With **expand->**, the matrix of the same dimensions as the input matrix where hits are marked with 1.

Args 1 Matrix

The matrix searched.

filter 1 Code

The condition which the matrix element should be satisfied. The values of the matrix elements are put to the variable \$.

any -1|0

The filtered element numbers are put to the output vector.

expand -1|0

The filtered elements are put the output matrix

Example 29.3 (findx). Finding something from matrix

```
** Example of find, illustrating also rann() (line 6426 file c:/j3/j.f90)
** Repeating the example, different results will be obtained
rm=matrix(500)
m,s=2,3
rm=rann(m,s)
mean(rm),sd(rm),min(rm),max(rm);
m+1.96*s;
** index of first row satisfying the condition:
first=find(rm,filter->($.ge.m+1.96*s));
** indeces of all rows satisfying the condition
large=find(rm,filter->($.ge.m+1.96*s),any->);
```

```
nrows(large),nrows(large)/nrows(rm),mean(large),sd(large),min(large),max(large)
** vector of equal size as rm containing 1 or 0
large2=find(rm,filter->($.ge.m+1.96*s),expand->)
mean(large2),min(large2),max(large2);
```

29.13 **mean()** Means or weighted means

See section matrixstat for details

29.14 **sum()** Sums or weighted sums

See section matrixstat for details

29.15 **var()** Sample variances or weighted variances

See section matrixstat for details

29.16 **sd()** Sd's or weighted sd's

See section matrixstat for details

29.17 **minloc()** Locations of the minimum values

minloc(MATRIX) generates a row vector containing the locations of the minimum values in each column. **minloc(VECTOR)** is the **REAL** scalar telling the location of the minimum value. Thus the VECTOR can also be a row vector.

29.18 **maxloc()** Locations of the maximum values

maxloc(MATRIX) generates a row vector containing the locations of the maximum values in each column. **maxloc(VECTOR)** is the **REAL** scalar telling the location of the maximum value whether VECTOR is a row vector or column vector.

29.19 **cumsum()** Cumulative sums

cumsum(MATRIX) generates a **MATRIX** with the same dimensions as the argument, and puts the cumulative sums of the columns into the output matrix.

Note 29.19.1. If the argument is vector, the cumsum makes a vector having the same form as the argument.

29.20 `corrmatrix()` Correlation matrix from variance-covariance matrix

This simple function is sometimes needed. The function does not test whether the input matrix is symmetric. Negative diagonal element produces error, value zero correlation 9,99.

Output 1 **MATRIX**

matrix having nondiagonal values

`Out(i,j) = arg(i,j) = arg(i,j)/sqrt(arg(i,i)*arg(j,j)).`

Args 1 **MATRIX**

symmetric matrix

sd N|0

If `sd->` is given, then diagonal elements will be equal to `sqrt(arg(i,i))`

30 Working with DATAs

Data can be analyzed and processed either using matrix computations or using DATAs. A **DATA** is compound object linked to a data **MATRIX** and **LIST** containing variable (column) names, some other information. When data are used via **DATA** in statistical or linear programming functions, the data are processed observation by observation. It is possible to work using **DATA** or using directly the data matrix, whichever is more convenient. It is possible make new data objects or new matrices by extracting columns of data matrix, computing matrices with matrix computations. It is possible to use data in hierarchical way, This property is inherited from JLP. There are two **Jlp22** functions which create DATAs from files, `data()` and `exceldta()`. `data()` can create hierarchical data objects. Function `newdata()` creates a **DATA** from matrices, which themselves can be picked from data objects. Function `linkdata()` can link two data sets to make a hierarchical data.

Note 30.0.1. If a data file contains columns which are referred with variable names and some vectors, then it is practical to read data first into a matrix using `matrix()` function and then use matrix operations and `newdata()` to make **DATA** with variable names and matrices. See Simulator section for an example.

Note 30.0.2. `transdata()` function goes through a **DATA** similarly as statistical functions, but does not serve a specific purpose, just transformations defined in the **TRANS** object referred with `trans->` option are computed. See again the simulator section.

Note 30.0.3. In earlier versions it was possible to give several data sets as arguments for `data->` option. This feature is now deleted as it is possible to stack several data matrices and then use

`newdata()` function to create a single data set.

30.1 `data()` Making a DATA

`Data` objects are created with the `data()` function. Two linked data objects can be created with the same function call (using option `subdata->` and options thereafter in the following description). It is recommended that two linked data objects are created with one `data()` function call only in case the data is read from a single file where subdata observations are stored immediately after the upper data observation. `Data` objects can be linked also afterwards with the `linkdata()` function. A data object can be created by a `data()` function when data are read from files or data are created using transformation objects. New data objects can be created with `newdata()` function from previous data objects and/or matrices. If data objects can be created using transformation objects either with `data()` function or by creating first data matrix by transformation and then using `newdata()` to create data object.

Output	1	Data
		Output 1 Data Data object to be created. It is recommended that this default is used only when only one data object is used in the analysis. !
<code>read</code>	0 1-	REAL List
		Variables read from the input files. If no arguments are given and there is no <code>readfirst-></code> option then the variables to read in are stored in the first line of the data file separated with commas.?? Also the ... -shortcut can be used to define the variable list. If no arguments are given and there is <code>readfirst-></code> option then the variable names are read from the second line.
<code>in</code>	0-	Char
		input file or list of input files. If no files are given, data is read from the following input paragraph. If either of <code>read-></code> or <code>in-></code> option is given, then both options must be present.
<code>form</code>	-1 1	Char
		Format of the data as follows \$ Fortran format '*', the default b Single precision binary bs Single precision binary opened with access='stream' Needed for Pascal files in Windows.

B Double precision binary.

Char giving a Fortran format, e.g. '(4f4.1,1x,f4.3)'

d4 Single precision direct access for Gfortran files.

d1 Single precision direct acces for Intel Fortran files.

maketrans	-1 1	TRANS
Transformations computed for each observation when reading the data		
keep	-1 1-	REAL
variables kept in the data object, default: all read-> variables plus the output variables of maketrans-> transformations.		
filter	-1 1	Code
logical or arithmetic statement (nonzero value indicating True) describing which observations will be accepted to the data object. maketrans-> -transformations are computed before using filter. Option filter-> can utilize automatically created variable Record which tells which input record has been just read. If observations are rejected, then the Obs -variable has as its value number of already accepted observations+1.		
reject	-1 1	Code
Logical or arithmetic statement (nonzero value indicating True) describing which observations will be rejected from the data object. If filter-> option is given then reject statement is checked for observations which have passed the filter. Option reject-> can utilize automatically created variable Record which tells which input record has been just read. If observations are rejected, then the Obsvariable has as its value number of already accepted observations+1. subdata the name of the lower level data object to be created. This option is not allowed, if there are multiple input files defined in option in-> .		
keepopen	-1:1	REAL
This option tells that if nobs-> option gives the number of observations then after the current DATA is read in, the file remains open so that other DATAs can be read from the same file. This option is useful when storing schdules having the tree structure and unpacking the structure with joindata() . See also splitdata() .		

continue	-1:1	REAL
This tells that the reading continues from the file which was left open with the previous keepopen-> option.		
		subread,...,subobs sub data options similar as read->...obs-> for the upper level data. (subform->'bgaya' is the format for the Gaya system). The following options can be used only if subdata-> is present
<hr/>		
nobswcum	-1 1	REAL
A variable telling the cumulative number of subdata observations up to the current upper data observation but not including it. This is useful when accessing the data matrix one upper level unit by time, i.e., the observation numbers within upper level observation are nobswcum+1,...,nobswcum+nobsw		
<hr/>		
duplicate	-1 2	TRANS
duplicate -1 2 TRANS The two transformation object arguments describe how observations in the subdata will be duplicated. The first transformation object should have Duplicates as an output variable so that the value of Duplicates tells how many duplicates are made (0= no duplication). The second transformation object defines how the values of subdata variables are determined for each duplicate. The number of duplicate is transmitted to the variable Duplicate . These transformations are called also when Duplicate=0 . This means that when there is the duplicate-> option, then all transformations for the subdata can be defined in the duplicate transformation object, and submaketrans-> is not necessary.		
<hr/>		
oldsubobs	-1 1	REAL
If there are duplications of sub-observations, then this option gives the variable into which the original observation number is put. This can be stored in the subdata by putting it into subkeep-> list, or, if subkeep-> option is not given then this variable is automatically put into the keep-> list of the subdata.		
<hr/>		
oldobsw	-1 1	REAL
This works similarly with respect to the initial obspw variable as oldsubobs-> works for initial obs variable.		
<hr/>		
nobs	-1 1	Real
There are two uses of this option. First, a data object can be created without		

reading from a file or from the following input paragraph by using `nobs->` option and `maketrans->` transformation, which can use `Obs` variable as argument. Creation of data object this way is indicated by the presence of `nobs->` option and absence of `in->` and `read->` options. Second, if `read->` option is present `nobs->` option can be used to indicate how many records are read from a file and what will be the number of observations. Currently `reject->` or `filter->` can not be used to reject records (consult authors if this would be needed). If there are fewer records in file as given in `nobs->` option, an error occurs. There are three reasons for using `nobs->` option this way. First, one can read a small sample from a large file for testing purposes. Second, the reading is slightly faster as the data can be read directly into proper memory area without using linked buffers. Third, if the data file is so large that a virtual memory overflow occurs, then it may be possible to read data in as linked buffers are not needed. In case `nobs->` option is present and `read->` option is absent either `maketrans->` or `keep->` option (or both) is required.

<code>buffersize</code>	-1 1	Real	
			buffersize -1 1 Real The number of observations put into one temporary working buffer. The default is 10000. Experimentation with different values of <code>buffersize-></code> in huge data objects may result in more efficient <code>buffersize-></code> than is the default (or perhaps not). Note that the buffers are not needed if number of observations is given in <code>nobs-></code> .
<code>par</code>	-1 1-	Real	additional parameters for reading. If <code>subform-></code> option is 'bgaya' then <code>par</code> option can be given in form <code>par->(ngvar,npvar)</code> where <code>ngvar</code> is the number of nonperiodic <code>x</code> -variables and <code>npvar</code> is the number of period specific <code>x</code> -variables for each period. Default values are <code>par->(8,93)</code> .
<code>rfhead</code>	-1 0		When reading data from a text file, the first line can contain a header which is printed but otherwise ignored
<code>rfcode</code>	-1 0		The data file can contain also Jlp22 -code which is first executed. Note the code can be like <code>var1,var,x1...x5=1,2,3,4,5,6,7</code> , which give the possibility to define variables which describe the <code>in-></code> file.

`rfsubhead->` works for subdata similarly as `rfhead->` for data. `rfsubcode` works for subdata similarly as `rfcode->` for data

If there are both `rfhead->` and `rfcode->` then `rfhead->` is executed first. `rfhead->` and `rfcode->` replace `readfirst->` option of previous versions which was too complicated.

`time` -1|0

If `time->` is present, the cpu-time and total time in function are printed

Note 30.1.1. `data()` function will create a data object object, which is a compound object consisting of links to data matrix, etc. see `Data` object object. If `Data` is the output of the function, the function creates the list `Data%keep` telling the variables in the data and `Data%matrix` containing the data as a single precision matrix. The number of observations can be obtained by `nobs(Data)` or by `nrows(Data%matrix)`.

Note 30.1.2. See common options section for how data objects used in other **JIp22** functions will be defined.

Note 30.1.3. The `in->` and `subin->` can refer to the same file, or if both are without arguments then data are in the following input paragraph. In this case `data()` function read first one upper level record and then `nobsw->` lower level records.

Note 30.1.4. In earlier versions, the user could select the name for the variable telling the number of the observation. After version Dec 20 2022, the name for `DATA datab` is always `datab%obs`.

Note 30.1.5. When reading the data the can be used in `maketrans->` transformation and in `reject->` option and `filter->` option, and the variable `dtab%obs` refers to the number of observation in resulting data object. The variable `Record` gets the number of the read record in the input file, and can be used in `maketrans->` transformations and in `reject->` and `filter->` options. If `subdata->` option is given, variable `Subreject` gets the number of record in the sub file, and it can be used in `submaketrans->` transformations and in `subreject->` option and in `subfilter->` option.

Note 30.1.6. Options `nobs->100`, `reject->(Record.gt.100)` and `filter->(Record.le.100)` result in the same data object, but when reading a large file, the `nobs->` option is faster as the whole input file is not read.

Note 30.1.7. If no observations are rejected, `obs` variable and `Record` variable get the same values.

Note 30.1.8. If virtual memory overflow occurs, see `nobs->` option. This should not happen easily with the current 64-bit application.

Note 30.1.9. After publishing `splitdata()` and `joindata()` functions I hope to get rid of the possibility to read both the upper level and sublevel data from the same file.

Note 30.1.10. Earlier versions contained `trans->` and `subtrans->`options which associated a permanent transformation object with the data object. This feature is now deleted because it may confuse and is not really needed. If tranformations are needed in functions they can always be included using `trans->`.

Example 30.1 (dataex). `data()` generates a new data object by reading data.

```
data1=data(read->(x1...x3),in->)
1,2,3
4,5,6
7,8,9
/
```

30.2 `newdata()` Making a **DATA** from **MATRIX**s and/or **DATAs**

Function `newdata()` generates a new data object from existing data objects and/or matrices possibly using transformations to generate new variables.

Output 1 **Data**

The data object generated.

Args 1- **Data|Matrix**

Input matrices and data objects.

read N|1- **REAL**

Variable names for columns of matrices in the order of matrices.

maketrans N|1 **TRANS**

A predefined ransformation object computed for each observation.

time -1|0

If `time->` is present, the cpu-time and total time in function are printed

Note 30.2.1. If a **DATA** has a link to an upper level **DATA** obtained with `linkdata()` without output, the the upper level **DATA** is not included. You can make a link to an upper level data using `linkdata()` for the **DATA** produced with `newdata()`

Note 30.2.2. It is not yet possible to drop variables.

Note 30.2.3. An error occurs if the same variable is several times in the variable list obtained by combining variables in data sets and **read->** variables.

Note 30.2.4. An error occurs if the numbers of rows of matrices and observations in data sets are not compatible.

Note 30.2.5. Output variables in **maketrans->** transformations whose name start with \$ are not put into the new data object.

Example 30.2 (newdataex). **newdata()** generates a new data object.

```
data1=data(read->(x1...x3),in->)
1,2,3
4,5,6
7,8,9
/
matrix1=matrix(3,2,in->)
10,20
30,40
50,60
/
transa=trans()
;do(i,1,3)
;do(j,1,2)
x"i"#z"j"=x"i"*z"j"
;enddo
;enddo
/
new=newdata(data1,matrix1,read->(z1,z2),maketrans->transa)
print(new)
```

30.3 **datacase()** DATA with case names

This function will replace the properties function in factory optimizations. The function creates subobjects Output%matrix,Output%keep, and Output%case, which is a list of case names. !

Output	0 1	Data	
	Output	0 1	Data object to be created.

read	0 1-	REAL List
Variables read from the following input paragraph.		

maketrans 0|1 TRANS

Transformations made. Output variables whose names do not start with \$ are put into the data.

Example 30.3 (datacaseex). Example of datacase

```
sawmills=datacase(read->(capacity1...capacity4))  
Kotka,110,120,130,140  
Oulu,210,220,230,240  
/  
sawsub=;list(sawmills%?);  
@sawsub;  
sawmills%?;  
stat()
```

30.4 exceldata() DATA from an excel file

Generates data object from csv data generated with excel. It is assumed that ';' is used as column separator, and first is the header line generated with excel and containing column names. The second line contains information for JIp22 how to read the data. First the first line is copied and pasted as the second line. To the beginning of the second line is put '@#'. Then each entry separated by ';' is edited as follows. If the column is just ignored, then put '!' to the beginning of the entry. If all characters in the column are read in as a numeric variable, change the name to acceptable variable name in J. If the column is read in but it is just used as an input variable for maketrans-> transformations, then start the name with '\$' so the variable is not put to the list of keep-> variables. If a contains only character values then it must be ignored using '!'. If the contains numeric values surrounded by characters, the the numeric value can be picked as follows. Put '?' to the end of entry. Put the variable name to the beginning of the entry. then put the the number of characters to be ignored by two digits, inserting a leading zero if needed. The given the length of the numeric field to be read in as a numeric value. For instance, if the header line in the excel file is

Block;Contract;Starting time;Name of municipality;Number of stem;Species

and the first data line could be

MG_H100097362501;20111001;7.5.2021 9:37;Akaa;20;103;1;FI2_Spruce

then the second line before the first data line could be

##block0808?;!Contract;!Starting time;!Name of municipality;stem;species

therafter the first observation would get values block=97362501,stem=1, and species=2.

If there are several input files, the header line of later input lines is ignored, and also if the second line of later files starts with '##', then it is ignored. If any later lines in any input files start with 'jcode:', then the code is computed. This way variables describing the whole input file can be transmitted to the data. Currently jcode-output variables can be transmitted to data matrix only by using the as pseudo outputvariables in maketrans-transformations, e.g., filevar1=filevar1, if filevar1 is generated in jcode transformation. If there are several input files the file number is put into variable In before computing maketrans transformations and this variable is automatically stored in the data matrix.

Output 1 **Data**

 Data object generated

in 1- Char

 Files to read in.

maketrans N|1 trans

 Transformations used to compute new variables to be stored in the data.

30.5 **linkdata()** Links or combines hierarchical DATAs

linkdata(data->,subdata->) links hierarchical data sets. Currently linkdata can create also one flat file which can be used in **jlp()**

data 1 **DATA**

 the upper level data set object

subdata 1 **DATA**

 the lower data set object

Note 30.5.1. In versions before 20.12.2022 **nobsw->** option was needed to tell what is the number of **subdata->**-observations under the current upper level observation. When I made the data format for storing schedules having the tree structure efficiently, everything became too complicated when allowing any freedom with respect to the nobsw-variable. Thus the nobsw variable in **DATA datab** has name **datab%nosw** and it must be the first variable among the keep-variables of the **DATA**.

Note 30.5.2. In most cases links between data sets can be either made using sub-options of

`data()` function or `linkdata()` function. If there is need to duplicate lower level observations, then this can be currently made only in `data()` function. Also when the data for both the upper level and lower level data are read from the same file, then `data()` function must be used.

Note 30.5.3. When using linked data in functions, the values of the upper level variables are automatically obtained when accessing lower level observations, if option `up->` is present.

Note 30.5.4. In the current version of **Jlp22** it is no more necessary to use linked data sets in `jlp()` function, as the treatment unit index in data containing both stand and schedule data can be given in `unit->` option

Example 30.4 (linkdataex). Example for linkdata.

```

** make upper level DATA
dataa=data(read->(dataa%nobs,site),in->)
2,4
3,5
/
dataa%matrix;

** make subdata as an ordinary DATA
datab=data(read->(x1,y),in->)
1,2
3,4
5,6
7,8
6,9
/
datab%matrix;
datab%keep;
**link now DATAs
** First varaiable in the upper level dataa must be dataa%nobs
linkdata(data->dataa,subdata->datab)
listb=list(datab%?);
@listb;
** when working with subdata the upper level data is feeded in for all observa
** if up-> is present
** even if they are not part of the data matrix as seen from datab%keep.
stat()
stat(up->)

**
** Note stat() and all functions assume that the last DATA created is used
** Thus when there are several DATAs around it is safer all use data-> option
** i.e. the above could/should be stat(data->datab)
**
**

```

```

** The flat file can be created also as follows:
** when dealing with the subdata the upper level data is automatically used
transa=trans()
Unit=Unit !adds Unit and site variables from up-data to sub-data
site=site
Unit%obsw=Unit%obsw
/
** In TRANS transa, the input variables come from the upper level data, and
** outputvariables go to the new data based on DATA datab.
datac=newdata(datab,maketrans->transa)
stat()
datac%matrix;

```

30.6 **splitdata()** splits a schedules DATA into components

Each component contains variables simulated for a given period. After the function the stand data is linked to **DATA** of schedules variables during the first period.

Output 1 ?

The variable name determining the names the generated DATAs. If the output is xdata then the **splitdata()** generates DATAs xdata#1...,xdata#p for the number of periods p.

Args 1 **DATA**

Schedules data linked to an upper level stand data with **linkdata()**.

periodvars 2- **LIST**

LIST of **LISTs**, each list telling variables which are simulated for the corresponding period.

Note 30.6.1. When deciding to which period a variable belongs, the only thing which matters is at what level the variable is put into the tree. Thus variable NPV0 which is the variable telling the NPV at the beginning of the planning horizon must put to the last list in periodvars, because it can be computed only after the whole planning horizon is simulated.

Note 30.6.2. All generated matrices files can be written into one (e.g. binary) file starting from the first to the last period. These DATAS can be read in using **keepopen->** and **continue->** options of **data()**. See below in the **joindata()** section

Note 30.6.3. The first variable in **DATA** dataa is **dataa%nobsw**

30.7 joindata() Joins hierarchical DATAs

There are two different cases of `joindata()`

The call has only two arguments and is like

```
xdata2=joindata(cdata,xdata)
```

where cdata and xdata are linked and the first variable in cdata is `cdata%nobs`. Then `xdata2` will contain all variables in `cdata`, except variable `cdata%nosw` is replaced by variable `cdata%obs` which tells into which `cdata` observation the `xdata` observation belongs, in practice, into which stand the schedule belongs. The output data will not be linked to any upper level data.

In the second case the call is like

```
xdata2=joindata(cdata,xdata#1...xdata#p)
```

DATAs `xdata#1...xdata#p` contain different periods (levels) in hierarchical data and the will contain whole schedules. This new data is automatically linked to to the first argument `DATA` (`cdata`).

Note 30.7.1. In the second case: As the output will be connected to the first argument, the link from the second argument to the first argument will be lost.

Note 30.7.2. In the second case: The variable `cdata%nobs` in `cdata` is modified to correpond to the new number of children, i.e. the number of schedules in the stands.

Note 30.7.3. there are examples of the new data format after `splitdata()` function.

```
Example 30.5 (joindataex). splitting and joining period DATA
  cdata=data(in->'cdat.txt',read->(cdata%nobs,site))
  stat()
  xdata=data(in->'xdat.txt',read->(npv#0,npv#5,income1...income5),time->)
  stat()

  linkdata(data->cdata,subdata->xdata)
  stat(up->

    ;do(i,1,4)
    pv"i"=list(income"i")
    ;enddo
    pv5=list(income5,npv#0,npv#5)

    xdatap=splitdata(xdata,periodvars->(pv1...pv5))
    stat(data->cdata)

    ;do(i,1,5)
    stat(data->xdatap#"i")
    write('xdatap.txt',$,xdatap#"i"%matrix)
    ;enddo
```

```

    close('xdatap.txt')
contd=0
keepo=1
stat(data->cdata,sum->)

nobscur=cdata%nobsw%sum;

;do(i,1,5)
Pv"i"=list(xdataP#"i"%nobsw,@pv"i")
;enddo

;do(i,1,5)
;if(i.eq.5)keepo=0
xdataP#"i"=data(in->'xdatap.txt',read->(@Pv"i")),keepopen->keepo,continue->con
stat(data->xdataP#"i",sum->)
nobscur=xdataP#"i"%nobsw%sum;
contd=1
stat(data->xdataP#"i")
;enddo
stat(data->cdata)
xdatanew=joindata(cdata,xdataP#1...xdataP#5)
stat(data->xdatanew)

** Did the procedure loose any data
stat(data->xdata)
** remove the created file
delete_f('xdatap.txt')

```

** To summarize

- First there was cdata and xdata linked to it.
- Then `splitdata()` was used to pull out different levels of the simulation tree into xdatap#1...xdatap#5 DATAs.
- Each data has %nobsw variable, in addition to the original period variables, telling how many children each observation has.
- Also the variable cdata%nobsw is updated.
- Then the %matrix of each DATA was written to 'xdatap.txt' from the first to last period.
- In practice it is beneficial to use binary files. Recall that format 'b' reads and writes in single precision. The matrices are in Jlp22 in double precision but practically never double precision is needed. If insisting on double precision data storage, use format 'B'.
- Data is read in from the file period by period. Initially the sum of variable cdata%nobsw is computed using `stat(data->cdata,sum->)`. This sum tells the number of period 1 observations.
- After making a period DATA, the number of observations in next period is computed simi-

larly. It simplifies coding when the data for the last period has also %nobs variable which is zero.

- keepopen-> keeps the file open making it possible to continue reading from the same file, which is indicated with the `continue->` option. It would be possible to use keepopen also for the last period and close the file after reading all periods.
- The above procedure can be used to convert tabular form schedules data into this disk saving and fast reading format. But in long run a simulator could generate directly data in this format which is simple to implement: just write different periods to different files or collect data into different period matrices and write the directly all data into one file.

30.8 `getobs()` Obsevarion from DATA

Getting an observation from a data set: // `getobs(dataset,obs[trans->])`// Get the values of all variables associated with observation obs in data object dataset. First all the variables stored in row obs in the data matrix are put into the corresponding real variables. If a transformation set is permanently associated with the data object, these transformations are executed.

dataset 1 **DATA**

the **DATA**

obs 1 **REAL**

row number in the data matrix of the dataset

trans -1|1 **TRANS**

these transformations are also executed.

30.9 `nobs()` number of observations in DATA or REGR

`nobs(DATA)` returns the number of rows in the data matrix of **DATA**// `nobs(REGR)` returns the number of observations used to compute the regression with `regr()`.

30.10 `classvector()` Vectors from grouped DATA

Function `classvector` computes vectors from data which extract information from grouped data. These vectors can be used to generate new data object using `newdata()` function or new matrices from submatrices using `matrix()` function with `matrix->` option or they can be used in transformation objects to compute class related things. There is no explicit output for the function, but several output vectors can be generated depending on the arguments and `first->`, `last->` and `expand->` options. The function prints the names of the output vectors generated.

Args	0-	REAL
The variables whose class information is computed. Arguments are not necessary if first-> and/or last-> are present. Let $\$Arg$ be the generic name for arguments.		
class	1	REAL
	.	oindent class 1 REAL
<hr/>		
class	1	REAL
The variable indicating the class. The class variable which must be present in the data object or which is an output variable of the trans-> transformations. When the class-> variable, denoted as $\$Class$ changes, the class changes.		
<hr/>		
data	0 1	Data
Data object used. Only one data object used; extra data-> objects just ignored. The default is the last data object generated.		
<hr/>		
expand	-1 0	
If expand-> is present then the lengths output vectors are equal to the number of observations in the data object and the values of the class variables are repeated as many times as there are observations in each class. If expand-> is not present, the lengths of the output vectors are. equal to the number of classes.		
<hr/>		
first	0	
The the number of first observation in class is stored in vector $\$Class\%first$ if expand-> is present and $\$Class\%first$ if expand-> is not present.		
<hr/>		
last	0	
The the number of lastt observation in class is stored in vector $\$Class\%last$ if expand-> is present and $\$Class\%lastobject$ if expand-> is not present.		
<hr/>		
obsw	0	
If there axpnad-> option then vector $\$Class\%obsw$		
<hr/>		

ext -1|1 Char

The extension to the names of vectors generated for arguments. Let Ext be denote the extension.

mean -1|0

The class means are stored in the vectors
\$Arg#Class%mean with **expand->** and without **ext->**
\$Arg#Class%meanExt with **expand->** and with **ext->** are
\$Arg#Class%mean without **expand->** and without **ext->**
\$Arg#Class%meanExt without **expand->** and with **ext->**

sd -1|0

Class standard deviations are computed to sd vectors

var -1|0

Class variances are computed to var vectors

min -1|0

Class minimums are computed to min vectors

max -1|0

Class maximums are computed to max vectors.

Note 30.10.1. Numbers of observations in each class can be obtained by
Class%nobs=Class%last-Class%first+1 when **expand->** is present, and
Class%nobs=Class%last-Class%first+1

Example 30.6 (classdata). Hierarchical data

```
nstand=10
xm=matrix(nstand)
xm=rann(3)
ym=0.7*xm+0.1*xm
xm;
ym;
standdata=newdata(xm,ym,read->(X,Y))
stat()
ntree=6
xt=matrix(ntree*nstand)
yt=matrix(ntree*nstand)
standv=matrix(ntree*nstand)
ex=matrix(ntree*nstand)
```

```

ey=matrix(ntree*nstand)
transa=trans()
jj=0
do(i,1,nstand)
do(j,1,ntree)

    jj=jj+1
    standv(jj)=i
    ex(jj)=rann()
    ey(jj)=0.3*ex(jj)+0.3*rann()
    xt(jj)=xm(i)+ex(jj)
    yt(jj)=ym(i)+0.3*ex(jj)+0.3*rann()
enddo
enddo
/
call(transa)
treedata=newdata(standv,xt,yt,read->(stand,x,y))
stat()

!! Making class level data object from treedata
classvector(x,y,class->stand,data->treedata,mean->,min->)
standdata2=newdata(x[stand]%mean,y[stand]%mean,x[stand]%min,y[stand]%min,
read->(x,y,xmin,ymin))
stat()
classvector(x,y,class->stand,data->treedata,mean->,expand->)
ex2=treedata(x)-x

```

30.11 **values()** Different values of variables in DATA

Extracting values of class variables: **values()**.

Output	1	VECTOR
		the vector getting differen values

arg	1	REALV
		variables whose values obtained

data	1	DATA
		The data set.

Note 30.11.1. The values found will be sorted in an increasing order.

Note 30.11.2. After getting the values into a vector, the number of different values can be obtained using **nrows()** function.

Note 30.11.3. `values()` function can be utilized e.g. in generating domains for all different owners or regions found in data.

30.12 `transdata()` Own computations for `DATA`

`transdata()` is useful when all necessary computations are put into a `TRANS`, and a `DATA` is gone through observation by observation. This is useful e.g. when simulating harvesting schedules using a simulator which is defined as an ordinary `TRANS`. The whole function is written below to indicate how users' own functions dealing with `DATA` could be developed. `@@data`

```
subroutine transdata(iob,io)
call j_getdataobject(iob,io)
if(j_err)return
call j_clearoption(iob,io) ! subroutine

do iobs=j_dfrom,j_duntil
call j_getobs(iobs)
if(j_err)return
end do !do iobs=j_dfrom,j_duntil

if(j_depilog.gt.0)call dotrans(j_depilog,1)

return
```

31 Statistical functions

There are several statistical functions which can be used to compute basic statistics linear and nonlinear regression, class means, standard deviations and standard errors in one or two dimensional tables using data sets. There are also functions which can be used to compute statistics from matrices, but these are described in Section 29.2

31.1 `stat()` Basic statistics in `DATA`

Computes and prints basic statistics from data objects.

Output	0-1	<code>REAL</code>
		kokopo

Args	0-99	REAL
variables for which the statistics are computed, the default is all variables in the data (all variables in the data matrix plus the output variables of the associated transformation object) and all output		
		@@data
<hr/>		
data	-1,99	Data
data objects , see section Common options for default! weight gives the weight of each observations if weighted means and variances ar transformation or it can be a variable in the data object @@seecom		
<hr/>		
min	-1,99	REAL
defines to which variables the minima are stored. If the value is character constant or character variable, then the name is formed by concatenating the character with the name of the argument variable. E.g. <code>stat(x1,x2,min->'%pien')</code> stores minimums into variables <code>x1%pien</code> and <code>x2%pien</code> . The default value for min is '%min'. If the values of the <code>min-></code> option are variables, then the minima are stored into these variables.		
<hr/>		
max	-1,99	REAL
maxima are stored, works as <code>min-></code>		
<hr/>		
mean	-1,99	REAL
means are stored		
<hr/>		
var	-1,99	REAL
variances are stored		
<hr/>		
sd	-1,99	REAL
standard deviations are stored		
<hr/>		
sum	-1,99	REAL
sums are stored, (note that sums are not printed automatically)		
<hr/>		
nobs	-1 1	REAL
gives variable which will get the number of accepted observations, default is		

variable 'Nnobs'. If all observations are rejected due to fi

trans	-1 1	TRANS	transformation object which is executed for each observation. If there is a transformation object associated with the data object, those
filter	-1 1	Code	logical or arithmetic statement (nonzero value indicating True) describing which observations will be accepted. trans-> transformations
reject	-1 1	Code	
	reject	-1 1	Code

transafter	-1 1	TRANS	transformation object which is executed for each observation which has passed the filter and is not rejected by the reject-> -optio
------------	--------	-------	--

Note 31.1.1. 1: [stat\(\)](#) function prints min, max, means, sd and sd of the mean computed as $sd/sqrt(\text{number of observations})$

Note 31.1.2. 2: If the value of a variable is greater than or equal to $1.7e19$, then that observation is rejected when computing statistics for that variable.

Example 31.1(statex). [stat\(\)](#) computes minimums, maximums, means and std deviatons
;[if\(type\(data1\).ne.DATA\)](#)dataex
;[if\(type\(data1\).ne.DATA\)](#)dataex
[stat\(\)](#)
[stat\(data->data1,sum->x2,mean->,filter->\(x3.le.18.5\)\)](#)
li=;[list\(x2%?\)](#);
@li;
[stat\(x1,data->data1,weight->x2\)](#)
[stat\(x1,weight->\(x2**1.2\)\)](#)

31.2 cov() Covariance MATRIX

[cov\(\)](#) computes the covariance matrix of variables in DATA.

output	1	MATRIX	
			symmetric aoutput matrix.

arg 1-N **LIST** or REALV

variables for which covarianes are computed, listing individually or given as a **LIST**. @@data

weight -1|1 CODE

Codeoption for weight of each observation.

Note 31.2.1. the output is not automaticall printed, but it can be printed using ';' at the end of line.

Note 31.2.2. The covariance matrix can changed into correaltion matrix with **cormatrix()** function.

Note 31.2.3. If variable **w** in the data is used as the weigth, this can be expressed as **weight->w**

Example 31.2 (covex). Example of covariance

```
X1=matrix(200)
X1=rann()
;do(i,2,6)
ad=matrix(200)
ad=rann()
X"i"=X"i-1"+0.6*ad
;enddo
Continue=1 !error
dat=newdata(X1...X6,read->(x1...x5))
Continue=0
dat=newdata(X1...X6,read->(x1...x6))
co=cov(x1...x5);
co=cov(dat%keep);
```

31.3 **corr()** Correlation MATRIX

corr(1) works similarly as **cov()**

31.4 **regr()** Linear regression

Ordinary or stepwise linear regrwession can be computed using **regr()**.

output 1 **REGR**

sRegression object..

arg 1-N **LIST** or **REALV**

y-variable and **x**-variables variables listing them individually or given as a **LIST**.
@@data

noint -1|0

noint-> implies that the model does not include intercept

step -1|1 **REAL**

t-value limit for stepwise regression. Regression variables are droped one-by-one until the absolute value of t-value is at least as large as the limit given. intercept is not considered.

var -1|0

if **var->** is present **regr()** generated matrix **]output%var[** for the variance-covariance matrix of the coefficient estimates.

corr -1|0

if **vcorr->** is present **regr()** generated matrix **]output%corr[** for the correlation matrix of the coefficient estimates. Standard deviations are put to the diagonal.

variance -1|1 **CODE**

The variance of the residual error is proportional to the function given in this codeoption.

Note 31.4.1. If the **DATA** contains variables **Regr** and **Resid**, then the values of the regression function and residuals are put into these columns. Space for these e coluns cab reserved with **extra->** option in **data()** or in **newdata()**

Note 31.4.2. If **re** is the output of the **regr()** then function **re()** can be used to compute the value of the regression function. **re()** can contain from zero arguments up to the total number of arguments as arguments. The rest of arguments get the value they happen to have at the moment when the function is called.

Information from the **REGR** object can be obtained with the following functions. let **re** be the name of the **REGR** object.

- **coef(re,xvar)** = coefficient of variable xvar
- **coef(re,xvar,any->)** = returns zero if the variable is dropped from the equation in the stepwise

procedure of due to linear dependencies.

- `coef(re,1)` or `coef(lre,$1)` returns the intercept
- `se(re,xvar)` standard error of a coefficient
- `mse(re)` MSE of the regression
- `rmse(re)` RMSE of the regression
- `r2(re)` adjusted R². If the intercept is not present this can be negative.
- `nobs(re)` number of observations used
- `len(re)` number of independent variables (including intercept) used

31.5 `nonlin()` Nonlinear regression

To be reported later, see old manual

31.6 `varcomp()` Variance and covariance components

TO BE REPORTED LATER, see old manual

31.7 `classify()` Group means, variances and standard deviations

Classifies data with respect to one or two variables, get class frequencies, means and standard deviations of argument variables.

Output	1	Matrix	
	Output	1	Matrix
		details given below)	A matrix containing class information (details given below)

Args	1-	REAL	
	Args	1-	REAL
		computed.	Variables for which class means are computed.
	@@data		

x	1	REAL	
	The first variable defining classes.		

minobs	-1 1	REAL	
	minimum number of observation in a class, obtained by merging classes. Does not work if <code>z-></code> is given		

xrange	-1 0 2	Real
Defines the range of <code>x</code> variable. If <code>xrange-></code> is given without arguments and Jlp22 variables <code>x%min</code> and <code>x%max</code> exist, they are used, and if they do not exist an error occurs. Note that these variables can be generated with <code>stat(min->,max->)</code> . Either <code>xrange-></code> or <code>any-></code> must be present.		
any	-1 0	
Indicates that each value of the <code>x</code> -variables forms a separate class. either <code>xrange-></code> or <code>nay-></code> must be present.		
tailtofirst	-1 0	If the <code>x</code> -variable is less than the lower <code>xrange</code> , the observation is put to the first class
tailtolast	-1 0	If the <code>x</code> -variable is greater than the upper <code>xrange</code> , the observation is put to the first class
classes	-1 1	Real
Number of classes, If <code>dx-></code> is not given, the default is that range is divided into 7 classes. <code>minobs-></code> minimum number of observations in one class. Classes are merged so that this can be obtained. Does not work if <code>z-></code> is present. !		
<code>z</code>	-1 1	REAL
The second variable (<code>z</code> variable) defining classes in two dimensional classification.		
zrange	-1 0 2	Real
Defines the range and class width for a continuous <code>z</code> variable. If Jlp22 variables <code>x%min</code> and <code>x%max</code> exist, provided by <code>stat(min->,max->)</code> , they are used.		
<code>dz</code>	-1 1	Real
Defines the class width for a continuous <code>z</code> variable. mean if <code>z</code> variable is given, class means are stored in a matrix given in the <code>mean-></code> option classes number of classes, has effect if <code>dx</code> is not defined in <code>xrangedx-></code> . The default is <code>classes->7</code> . If <code>z</code> is given then, there can be a second argument, which gives the number		

of classes for `z`, the default being 7. @@@trans @@@filter @@@reject

`print` -1|1 Real

By setting `print->0`, the classification matrix is not printed. The matrix can be utilized directly in `drawclass()` function.

Note 31.7.1. If `z` variable is not given then first column in printed output and the first row in the output matrix (if given) contains class means of the `x` variable. In the output matrix the last element is zero. Second column an TARKASTA VOISIKO VAIHTAArow shows number of observations in class, and the last element is the total number of observations. Third row shows the class means of the argument variable. The fourth row in the output matrix shows the class standard deviations, and the last element is the overall standard deviation

Note 31.7.2. Variable `Accepted` gets the number of accepted obsevations.

31.8 `class()` Class of a given value

Function `class()` computes the class of given value when classifying values similarly as done in `classify()`.

`Output` 1 **REAL**

The class number.

`Args` 1 Real

The value whose class is determined.

`xrange` 2 Real

The range of values.

`dx` N|1 Real

The class width.

`classes` N|1 Real

The number of classes.

Note 31.8.1. Either `dx->` or `classes->` must be given. If both are given, `dx->` dominates.

Note 31.8.2. If `stat()` is used earlier for variables including `Var1` and options `min->` and `max->` are present, then `xrange->(Var1%min,Var1%max)` is assumed.

32 Linear programming

This chapter describes the key points of the Jlp-algorithm and the available **Jlp22** functions.

32.1 JLP linear programming algorithm

This section will later describe more closely the theoretical aspects of the linear programming functions. Now only some key concepts are listed. Now the reader is referred to the old JLP manual [jlp92.pdf](#), the description of the factory optimization in [lappilempinen.pdf](#), and an application of the factory optimization in [hyvonental2019.pdf](#)

The development of JLP algorithm !

- JLP

- The JLP algorithm was designed for forest management planning problems having the following structure. A simulator generates a large number of treatment schedules for each stand in a group of stands.
- In an optimization problem a linear combination of sums of variables (e.g. amount of harvested sawlogs during a period) produced in treatments is maximized or minimized subject to constraints which are also linear combinations of variables.
- The key point is the generalized upper bound (GUB) technique of Dantzik and Van Slyke (see [gub.pdf](#)) which I reinvented. The key idea is to remove with algebraic tricks the area constraints.
- In an optimization problem with schedules generated for each stand, there must be a area constraint for each stand telling that shares of schedules add up to one in each stand.
- In the GUB technique, the area constraints can be dropped with slight overhead cost. In a typical problem, the data can consist of 10000 stands, and an optimization problem can consist of 10 constraints for the sums of variables. Using an ordinary LP software in one iterative optimization step, a matrix consisting of 100200100 elements is updated. In JLP the equivalent step is computed by updating a matrix consisting 100 elements.
- The heuristic algorithm of Hoganson and Rose (1984) and Hoganson and Kapple (1991) leads to similar computations where a schedule in a stand is selected using shadow prices. Their shadow prices are updated heuristically but JLP algorithm updates the prices using the linear programming theory.
- The key concept in GUB is the key variable, in our case the key schedule, which is any of the schedules which has nonzero weight.
- JLP algorithm is also using the ordinary upper bound technique. If there is both lower and upper bound in a constraint, the standard theory assumes that the lower bound and

upper bound constraints are presented as different constraints. In the ordinary upper bound technique there is only one constraint, and the algorithm keeps either of the bounds as the active bound.

- JLP used own matrix subroutines which computed all the time the explicit inverse of the basis matrix.
- When a constraint is not binding, in standard algorithms, a residual variable tells the difference between the constraint row and the active bound. JLP reduced the dimension of the basis matrix, which was a feasible solution because the explicit inverse of the basis was used.
- JLP introduced domains, i.e.. subsets of stands into the problem defition. They decrease the memory needs and help to formulate more reasonable problems. Their utility to define spatial constraints is not fully utilized.
- JLP allowed to compute new variables from the simulated variables. I have suggested (in vain) since 1992 that Mela would compute only forest variables and economic variables would be feeded in JLP. This way it would not be necessary to resimulate when trying different prices.
- JLP offered the possibility to duplicate a schdedule. GAYA group has utilized this by duplicating a schdeule so tha that in one copy of a no-harvest schedule the final stae has postive net presetn value and anothe copy does not.
- JLP was written in Fortran77, which did not have dynamic allocation, pointers or own data types.
- In writing the JLP algorithm, oaly very small part of the working time went to get the algorithm work correctly mathematically. The most difficult thing was the fight against rounding errors, i.e. trying to infer whther a small number is zero or not, and whether a number is really larger than another number even if the computer values indicated that.
- JLP had a precompiler which could be used to handle compiler options and the sizes of vectors. Fortran77 did not have dynamic alloacation of vectors.
- **J**, the successor for JLP
 - Version 0.9.3 was published in 2004
 - Initially the same JLP algorithm but **J** was using matrix routines of Fletcher which were changed into double precision. Fletchcer's code was written in Fortran77.
 - **J** was written in Fortran90 which has dynamic allocation of vectors, pointers etc.
 - New tools for preprocessing of data and postprocessing of results, and these computations can be used also without LP problems.
 - Mela has not included **J** as as the optimizer, but it is possible to pull out simulated schedules from Mela and then define and solve linear programming problems using **J**. item **J** version 2.0. published in 2013 made it possible optimize simultatenously forestry

and transports to factories and factory production. Theory is published in Lappi and Lempinen 2014 Paper explaining the theory behind factory optimization.

- The generalized upper bound technique is extended for constraints which tell that all harvested timber volume in a stand is transported somewhere.
- The key idea is to have in each stand and for all harvested log types and for all periods a key factory to which some timber is transported provided that the cuttings produce that log type for that period. enditemize
- DTRAN algorithm of Hoganson is an competitor of **Jlp22** because it can deal with factories also. !

32.2 Problem definition object

Problem definition object is a compound object produced by the **problem()** function, and it is described in Linear programming.

32.3 **problem()** PROB for **jlp()** and **jlpz()**

An LP-problem is defined in similar way as a TEXT object. The following rules apply for problem rows:

- On the left there is any number of terms separated with + or -.
- Each term is either a variable name or coefficient*variable.
- A coefficient can be
 - * a number
 - * Computation code inside parenthesis. These coefficients are computed within **prob-lem()**.
 - * computation code within apostrophes. These coefficients are computed in **jlp()**, **jlpz()** or **jlpcoef()** functions.
 - * A legal name for an object.
- The variable must be a legal object name. The optimization variable can either be a **z**-variable or **x**-variable. A **x**-variable is a variable in schedules data set. In **jlpz()** all variables are **z** variables. Function **jlpz()** unpacks lists to **z**-variables.
- The right side of the first row ends either by ==min or ==max.
- On the right side for other rows there is a number or code for computing a numeric value within parenthesis or within apostrophes or a variable name. Numbers within parenthesis are computed within **problem()** but numbers within apostrophes are computed in **jlp()**, **jlpz()** or **jlpcoef()** functions. Between the left side and the right side there is

```

* >Low <Up
* >Low
* <Up
* = Value

```

Sign < means less or equal, and > means greater or equal. Pure less or greater would be meaningless in this context.

If there two different identical rows the other having '<' and the other '>', an error occurs, because the solution is obtained faster that way. If all rows have both lower limit and upper limit, the solution is obtained in half time when merging the lines.

In problems with `x`-data, there can be domain rows, which tell for what subset of the treatment units the following constraints apply. Domains are defined using c-variables, i.e. variables in the unit data, or in nonhierarchical, flat data set, the value of the c-variable is obtained from the first observation where the variable given in `unit->` gets a different value than in the previous observation. The variables in the flat data file having the same value for all observations in the same unit are called also c-variables. Later there will be variables related to factory problems. A domain definition ends with ':'. In a domain row there can be any number of domain definitions. There are three diffent kinds of domain definitions

All indicates all units. This domain is assumed to all rows before the first domain row.

c-variable, a nonzero value tells that the unit belongs to the domain.

A piece of code which tells how the indicator is computed from the c-variables. A nonzero value indicates that the unit belongs to the domain. Recall tha logical operations produce 1 for True and 0 for false. The code is parsed at this point, so syntax errors are detected at this point, but other errors (e.g. division by zero) are detected in `jlp()`.

Output	1	PROB
		the PROB object created
<code>print</code>	0 1	<code>REAL</code>
		If <code>print-></code> gives a value, then values >2 tell that the problem is printed (default)

Note 32.3.1. Examples are give in connection of `jlpz()` and `jlp()`.

Note 32.3.2. the cofficients in a PROB can be interpreted also using `jlpcoef()` function, which is used also by `jlp()` and `jlpz()` functions.

Note 32.3.3. Note Problems without `x`-variables can be solved also without `problem()` function by feeding in the necessary matrices.

32.4 **jlp()** for schedules DATA

jlp() solves linear programming problems. The function now assumes that there is schedules data. Without schedules **jlpz()** must be used.

Output	1	
		Output tells how objects created by jlp() are named. There is no JLP object type, but the output indicates that e.g. the following objects are created. Many other objects are created but they are currently used for debugging purposes and they will be described later. They can be used also to teach how the algorithm proceeds. beginitemize
		Output%weights The weights of the schedules, see teh example below.
		Output%objective= value of the objective function
		Output%rows= the vector the valuef of the constraint rows.
		Output%shprice = vector of shadow prices of the rows
		Output%xvars= LIST of xvariables in the schedules data Output%xvarsproblem= LIST of x -variables in the PROB
		Output%xsum= Vector of sums of variables in Output%xvarsproblem
		Output%xprice Shadow prices of the variables in Output%xvarsproblem
		Output%xsumint The sums of x -variables in the integer approximation, generated if integer-> is present
problem	1	PROB
		Problem object produced with problem()
data	1	DATA
		Unit data when schedules data is linked to it with linkdata() or schedules data when unit-> gives the unit variable which changes when unit changes.
z	-1 0	
		This option must be present when there are z -variables in the problem.
print	-1:1	REAL
		print-> set printing level to 2, print->value set the printling level to value, where zero indicates no printing. Default level is 1.
debug	-1 0 1	REAL

debug-> sets debugging on at start **debug->value** sets debugging on when pivot=value, After the debugging pivot, **Jlp22** generates **pause()** and during the pause the user can do any computations. Before the pause some additional matrices are generated in addition to matrices which are used the computations. default is **stop->(Change%.lt.0.01.and.Round.ge.30)**.

report -1|1 **CHAR**

the results are written to the file spesified.

echo|-1|0

When results are printed to a file, **echo->** implies that they are written also to the terminal.

refac -1|1| **REAL**

refac->value tells that the factors of the basis matrix are recomputed after value pivot operations. The default is **refac->1000**.

tolerance -1|1 **REAL**

tolerance->value tells that the default tolerances are multiplied with the value.

Note 32.4.1. In small problems dCPU, i.e. increase of used CPU time is not very accurate.

Example 32.1 (jlpx). **jlp()** solves linear programming problem

```
cdata=data(in->'cdat.txt',read-(cdata%nobs,site))
stat()
xdata=data(in->'xdat.txt',read-(npv#0,npv#5,income1...income5))
stat()
linkdata(data->cdata,subdata->xdata)

proba=problem();
** In this problem the 4% net present value at the beginning is maximized
** subject to the constraints telling that net incomes are nondecreasing
npv#0==max
;do(i,2,5)
income"i"-income"i-1"=0
;enddo
npv#5-npv#0>0
/
plist=;list(proba%?);
@plist;

jlp=jlp(problem->proba,data->cdata)
```

```

jlist=;list(jlpa%?);
@jlist;

    ** jlpa%weights gets the weights of schedules
    ** combain the weights with the data
xdataw=newdata(xdata,jlpa%weights,read->w)
stat(sum->)
    ** sum of weights is equal to the number of stands
w%sum;
    ** weighted statistics
    ** thesw agree with the jlp solution
stat(weight->w,sum->)
;do(i,1,len(xdataw%keep))
@xdataw%keep(i)%sum;
;enddo
***Problem with domains
prob=problem();
npv#0==max
**Domain definitions:
**there can be several domain definitions on a row
** one domain definition is:
** a logical statement in terms of stand variable
** a stand variable whose nonzero value implies that the domain applies
** All indicates all stands.
** before first domain definition row the default Domain is All
site.le.3:site.gt.3:
;do(i,2,5)
income"i"-income"i-1"=0
;enddo
npv#5-npv#0>0
/
plistb=;list(prob%?);
@plistb;
jlp=jlp(problem->prob,data->cdata)

```

32.5 **jlpz()** for an ordinary Lp-problem.

The problem defined in the **problem()** function can be given in **problem->** or by giving values for **max->** or **min->**, and **zmatrix->**, **rhs->** and **rhs2->** options.

Output 1

Theres is no jlpz -object, but the output is used to name several objects created with the function. The list of created objects can be seen with
outlist=;list(Output%?);
The objects can then be be seen with

@outlist;

The objects created can be used in debugging the algorithm and also in teaching how the alogrithm proceeds. This will demonstrated later.

problem	-1 1	PROB
		Problem defined in problem() . If problem-> is not present the following 3 options must be present and either min-> or max-> .
zmatrix	-1 1	MATRIX
		Constraint matrix.
rhs	-1 1	MATRIX
		Lower bounds as row or column vector having as many elements as there are rows in the matrix given in zmatrix-> .
rhs2	-1 1	MATRIX
		Upper bounds as row or column vector having as many elements as there are rows in the matrix given in zmatrix-> .
max	-1 1	MATRIX
		The objective vector for a maximization problem. It must have as many elements as the constraint matrix has columns.
min	-1 1	MATRIX
		The objective vector for a minimization problem.
dpivot	-1 1	REAL
		The objective function etc are printed after dpivot pivots.
debug	-1 0 1	REAL
		Gives the value of Pivot at which a pause is generated. During the pause all essential matrices can be studied. Pure debug-> is the same as debug->0 , which implies that pause is generated before pivoting. If variable Debug is given a new value, the the next pause is generated when Pivot.eq. Debug . The default is that the next pause is generated after the next pivot. The pause() function can now use also lis=;list(Output%?);

even if ;list is input programming function which are not otherwise allowed during `pause()`. !

Note 32.5.1. The ordinary Lp-algorithm can be taught using matrices generated in pause to show how the algorithm proceeds.

Example 32.2 (jlpzex). Problem with only `z`-variables.

```
probza=problem()
2*x1+x2+3*x3-2*x4+10*x5==min
x1+x3-x4+2*x5=5
x2+2*x3+2*x4+x5=9
x1<7
x2<10
x3<1
x4<5
x5<3
/
probzalist=;list(probza%?); !subobjects created
@probzalist; !printing the subobjects

jlpza=jlpz(problem->probza,dpivot->1)
jlpzalist=;list(jlpza%?);
@jlpzalist;
** The same problem is defined using different tools available.
!
probzb=problem()
2*x1+x2+x34c*x34+10*x5==min
x1+x3-x4+(2+0)*x5=5
x2+2*x3+2*x4+x5=9
x1<7
x2<i10
x3<'1+zero'
x4<5
x5<3
/
x34=list(x3,x4)
x34c=matrix(2,values->(3,-2))
i10=10
zero=0
jlpzb=jlpz(problem->probzb,dpivot->1)
**Now different problem is obtained
x34c=matrix(2,values->(3,-3))
zero=1
jlpzb=jlpz(problem->probzb,dpivot->1)
**
**The matrices needed to use jlpz without problem-> can be obtained from
a problem as follows
jlpcoefa=jlpcoef(probza)
jlpcoefalist=;list(jlpcoefa%?);
```

```
jlpza=jlpz(zmatrix->jlpcoefa%matrix, rhs->jlpcoefa%rhs, rhs2->jlpcoefa%rhs2,min
```

32.6 jlpcoef() PROB into numeric form

This function is used at the beginning of `jlp()` and `jlpz()`.

Note 32.6.1. see `jlpz()` for how `jlpcoef()` can be used to demonstate problem defintion using matrices only.

33 Plotting figures

The graphiscs of the current version of **Jlp22** is produced with Gnuplot, see <http://www.overleaf.com> **Jlp22** offers an alternative interface to Gnuplot, and it is quite easy to add more ploting routines later.

33.1 show(), show-> and continue->

By default, plotting functions plots (shows) FIGs immediately. When the final figure consists of several subfigures, it is convenient to prevent plotting using `show->0`. In developing scripts, it is convenient to switch with `show->`. This can be done by giving option in form `show->showfig`, then the ploting can be controlled with `REAL showfig`.

Withing `show()` it is possible to define or redefine `xlabel->`, `ylabel->`, `title->`, `xrange->` and `yrange->`

By default **Jlp22** generates `pause()` after showing a **FIG**. During `pause()`, the user can give any commands. If the user types 'e', then **Jlp22** generates a error condition causing return to to `sit>`.

It is possible to collect a **FIG** first (e.g. using loops), and show then the **FIG** using `show()` function. The argument of `show()` can be either a **FIG** or the name of the .jfig file withing apostrohes. Thus it is possible to edit the file using Gnuplot capabilities.

Example 33.1 (showex). Example of `show()`

```
fi=draw(func->sqrt2(x),x->x,xrange->(-50,50),continue->fcont)
show(fi,xrange->(-60,60),xlabel->'NEWX]Times Roman,16[ ',ylabel->'NEWY]Courier,
show(fi,axes->10,continue->fcont)
show(fi,axes->01,continue->fcont)
show(fi,axes->00,continue->fcont)
Window='400,800'
show(fi,continue->fcont)
Window='700,700'
fi=drawline(1,10,3,1,color->Red,continue->fcont)
```

```

show(fi,xrange->(1.1,11),continue->fcont) !the line is not visible
dat=data(read->(x,y),in->
1,4
2,6
3,2
5,1
/
stat()
fi=plotyx(y,x,continue->fcont) ! Gnuplot hides points at border
show(fi,xrange->(0,6),yrange->(0,7),continue->fcont)

```

33.2 Font in title->, xlabel->, ylabel->, label->

It is possible to change the font by appending the font definition between][] at the end of the label, e.g.,

`xlabel->'My-xlabel]Times-Roman,15['`

where 15 is the size of the font. Available fonts vary from system to system. Web provides further information, see e.g. https://gnuplot.sourceforge.net/docs_4.2/node356.html

According to this page, the following fonts may be available Helvetica Helvetica Bold Helvetica Oblique Helvetica Bold Oblique

Times Roman Times Bold Times Italic Times Bold Italic

Courier Courier Bold Courier Oblique Courier Bold Oblique

Symbol

Hershey/Cartographic_Roman Hershey/Cartographic_Greek Hershey/Simplex_Roman Hershey/Simplex_Greek Hershey/Simplex_Script

Hershey/Complex_Roman Hershey/Complex_Greek Hershey/Complex_Script Hershey/Complex_Italic

Hershey/Complex_Cyrillic Hershey/Duplex_Roman Hershey/Triplex_Roman Hershey/Triplex_Italic

Hershey/Gothic_German Hershey/Gothic_English Hershey/Gothic_Italian Hershey/Symbol_Set_1

Hershey/Symbol_Set_2 Hershey/Symbol_Math

ZapfDingbats. space within font name can be replaced with '-', e.g. Times-Roman.

33.3 color->Black, Red, Green, Blue, Cyan , Violet, Yellow, Orange

Gnuplot allows arbitrary color definitions. Currently the above colors can be used. General color definitions are implemented when requested.

33.4 Terminal

It is possible to change the terminal type used by Gnuplot by giving the name of the terminal to the predefined **CHAR** variable **Terminal**. The default is
Terminal='qt'.

33.5 Window size and shape

It is possible to change the window size and shape of Gnuplot by using the predefined **CHAR** variable **Window**. The default is
Window='700,700'

33.6 Legends

The default legends by Gnuplot do not look nice, and they are not implemented. The user can write own legends using **label->** option in **drawline()**.

33.7 **plotyx()** Scatterplot

plotyx() makes scatterplot.

Output 1 **FIGURE**

The FIGURE object created or updated.

Args 1 | 2 **REAL**

y and **x**-variable, if **func->** is not present. In case **y**-variable is given with **func->only**, **x**-variable is given as argument.

data N | 1 **DATA**

Data object used, default the last data object created or the data given with **data=list()**. @@figu

mark N | 1 **REAL | CHAR**

The mark used in the plot. Numeric values refer to mark types of Gnuplot. The mark can be given also as **CHAR** variable or constant.

func N | 1 **Code**

```
Example 33.2 (plotyxex). plotyx()
  xmat=matrix(do->(0,10,0.001))
  transa=transa()
  y=2+3*x+0.4*x*x+4*rann()
/
datyx=newdata(xmat,read->x,maketrans->transa,extra->(Regf,Resid))
fi=plotyx(y,x,continue->fcont)
fi=plotyx(x,func->transa(y),mark->3,color->Orange,continue->fcont)
reg=regr(y,x)
figyx=plotyx(y,x,show->0)
fi=plotyx(Regf,x,append->,continue->fcont)
fir=plotyx(Resid,x,continue->fcont)
```

Note 33.7.1. With data with integer values, the default ranges of Gnuplot may be hide point at borderlines.

Note 33.7.2. `fi=plotyx()` produces or updates file `fi.jfig` which contains Gnuplot commands and file `fi.jfi0` containing data.

33.8 `draw()` Draws a function

`draw()` draws a function.

Output 1 FIGURE

The FIGURE object created or updated.

func N | 1 Code

Code option telling how the `y`-variable is computed. @@draw

mark N | 1 REAL | CHAR

The mark used in the plot. Numeric values refer to mark types of Gnuplot. The mark can be given also as CHAR variable or constant.

width 0 | 1 REAL

the width of the line

Example 33.3 (drawex). Example of `draw()`

```
fi=draw(func->sin(x),x->x,xrange->(0,2*Pi),color->Blue,continue->fcont)
```

```

fi=draw(func->cos(x),x->x,xrange->(0,2*Pi),color->Red,append->,continue->fcont)
;if(type(figyx).ne.FIGURE)plotyxex
show(figyx,continue->fcont)
reg0=regr(y,x)
stat(data->datyx,min->,max->)
figyx=draw(func->reg0(),x->x,xrange->,color->Violet,append->,continue->fcont)
transa=trans()
x2=x*x
/
reg2=regr(y,x,x2,data->datyx,trans->transa)
transa=trans()
x2=x*x
fu=reg2()
/
Continue=1 !Error
figyx=draw(func->transa(fu),xrange->,color->Orange,append->,continue->fcont)
continue=0
figyx=draw(func->transa(fu),x-x,xrange->,color->Orange,append->,continue->fcont)
Continue=1 !Errors
fi=draw(func->sin(x),x->x)
fi=draw(xrange->(1,100),func->Sin(x),x->x)
Continue=0

```

Note 33.8.1. `fi=draw()` produces or updates file `fi.jfig`] which contains Gnuplot commands and file `fi.jfi0` containing data.

33.9 `drawclass()` Draws results of `classify()`

`drawclass()` can plot class means and/or lines connecting class means, with or without standard errors of class means, within class standard deviations, within class variances, frequency histograms, which can be scaled so that density functions can be drawn in the same figure.

Output 1 **FIGURE**

FIGURE object updated or generated.

Arg 1 **MATRIX**

A **MATRIX** generated with `classify()`.

se N | 0

Presence of option tells to include that error bars showing standard errors of class means computed as `sqrt(sample_within-class_variance)/number_of_obs`

sd N | 0

	Within-class standard deviations are drawn.
var	N 0
	Within-class sample variances are drawn.
histogram	N 0
	Within-class sample variances are drawn.
freq	N 0
	Absolute frequencies are drawn in histogram. Default percentage if area-> is not present
area	N 0
	the histogram is scaled so that it can be overlayed to density function
cumulative	N 0
	cumulative histogram is drawn. If freq-> is presented then absolute cumulative frequencies are drawn, otherwise cumulative percentages are drawn, except if also area-> is present then cumulative relative frequencies are drawn.

Example 33.4 (drawclassex). Examples of `drawclass()`

```
X=matrix(do->(1,100,0.1))
e=matrix(nrows(X))
e=rann()
X2=0.01*X*.X!elementwise product
Y=2*X+0.01*X2+(1+0.3*X) *.e !nonequal error variance,quadratic function
dat=newdata(X,Y,X2,read->(x,y,x2),extra->(Regf,Resid))
stat(min->,max->)
reg=regr(y,x)! Regf and resid are put into the data
fi=plotyx(y,x,continue->fcont)
fi=drawline(x%min,x%max,reg(x%min),reg(x%max),width->3,color->Cyan,append->,c
cl=classify(Resid,x->x,xrange->,classes->5)
fi=drawclass(cl,color->Blue,continue->fcont)
fi=drawclass(cl,se->,continue->fcont)
fi=drawclass(cl,sd->,continue->fcont)
fi=drawclass(cl,var->,continue->fcont)
** x-values were equally distributed due to data construction
fi=drawclass(cl,histogram->,area->,continue->fcont)
fi=draw(func->pdf(0,rmse(reg)),x->x,xrange->,append->,continue->fcont) !
xrange comes from stat()
```

Note 33.9.1. In previous versions of JIp22 if `se->` and `sd->` were both present, the error bars

were plotted. This possibility will be included later.

33.10 **drawline()** Draws a polygon through points.

Output 1 FIGURE

The FIGURE object created or updated.

Args 1- REAL | MATRIX

The points which are connected:

- **x1,...,xn,y1,...,yn** The **x**-coordinates and **y**-coordinates, \$n ≥ 1\$ If there is only one argument

- If there are two matrix (vector) arguments, then the first matrix gives the **x**-values and the second matrix gives the **y**-values. It does not matter if arguments are row or column vectors.

@@figure

label N | 1 CHAR

Label written to the end of line. If arguments define only one point, then with **label->** option one can write text to any point.

mark N | 1 REAL | CHAR

The mark used in the plot.

break N | 0

The line is broken when a **x**-value is smaller than the previous one.

set N|1 REAL<6

Set to which lines are put. If the option is not present, then a separate Gnuplot plot command with possible color and width information is generated for each **drawline()** and data points are stored in file **fi.jfi0**, i.e. the same file used by **plotyx()**. If set is given e.g as **set->3**, then it is possible to plot a large number of lines with the same width and color. The data points are stored into file **fi.jfi3**. This is useful e.g. when drawing figures showing transportation of timber to factories for huge number of sample plots. Numeric values refer to Gnuplot mar types. The mark can be given also as **CHAR** variable or constant.

width 0 | 1 **REAL**

the width of the line. Default: **width->1**

label N | 1 **CHAR**

Text plotted to the end of line.

Example 33.5 (drawlineex). Example of **drawline()**

```
;drawlineex:  
** Example of drawline() (line 13761 file c:/j3/j.f90)  
fi=draw(func->sin(x),x->x,xrange->(0,2*Pi),color->Blue,continue->fcont)  
fi=drawline(Pi,sin(Pi)+0.1,label->'sin()',append->,continue->fcont)  
xval=matrix(do->(1,10));  
mat=matrix(values->(xval,xval+1,xval,xval+2,xval,xval+3))  
fi=drawline(mat,color->Red,continue->fcont)  
fi=drawline(mat,color->Orange,break->,continue->fcont)  
xm=matrix(do->(0,100,1))  
e=matrix(101)  
e=rann(0,3)  
ym=2*x+0.3*xm*.xm+0.4+e  
dat=newdata(xm,ym,read->(x,y),extra->(Regf,Resid))  
reg=regr(y,x)  
figyx=plotyx(y,x,continue->fcont)  
figr=plotyx(Resid,x,continue->fcont)  
reg0=regr(y,x)  
stat(min->,max->)  
figyx=draw(func->reg0(),x->x,xrange->,color->Violet,append->,continue->fcont)  
  
transa=trans()  
x2=x*x  
if(type(reg2).eq.REGR)fu=reg2()  
/  
reg2=regr(y,x,x2,trans->transa)  
figyx=draw(func->transa(fu),x->x,xrange->,color->Orange,append->,continue->fcont)  
Continue=1 !Errors  
fi=draw(func->sin(x),x->x)  
fi=draw(xrange->(1,100),func->Sin(x),x->x)  
Continue=0  
;if(wait);pause  
;return
```

Note 33.10.1. if a line is not visible, this may be caused by the fact that the starting or ending point is outside the range specified by **xrange->** or **yrange->**.

33.11 `plot3d()` 3d-figure.

Plot 3d-figure with indicator contours with colours.

Output 1

`fi=plot3d()` generates Gnuplot file `fi.jfig`. No figure object is produced.

Args 1 **MATRIX**

The argument is a matrix having 3 columns for `x,y` and `z`.

sorted N | 1

`plot3d()` uses the Gnuplot function `splot`, which requires that the data is sorted with respect to the `x`-variable. `sorted->` indicates that the argument matrix is sorted either naturally or with `sort()` function. If `sort->` is not presented, `plot3d` sorts the data.

```
Example 33.6(plot3dex). plot3d() example see p. 328 in Mehtatalo Lappi 2020
mat=matrix(1000000,3)
mat2=matrix(1000000,3)
transa=trans() !second order response surface
x=0
x2=0
xy=0
irow=1
do(ix,1,1000)
y=0
y2=0
xy=0
do(iy,1,1000)
mat(irow,1)=x
mat(irow,2)=y
mat(irow,3)=12+8*x-7*x2+124*y+8*xy-13*y2
mat2(irow,1)=x
mat2(irow,2)=y
mat2(irow,3)=50+160*x-5*x2-40*y-20*xy+10*y2
irow=irow+1
y=y+0.01
y2=y*y
xy=x*y
enddo
x=x+0.01
x2=x*x
enddo
/
call(transa)
```

```
fi=plot3d(mat,sorted->,continue->fcont)
fi=plot3d(mat2,sorted->,continue->fcont)
```

34 Splines, stem splines, and volume functions

There are several spline functions.

34.1 **tautspline()** Creates a more regular TAUTSPLINE

tautspline(x1,...,xn,y1,...,yn[,par->][,sort->][,print->])// Output:// An interpolating cubic spline, which is more robust than an ordinary cubic spline. To prevent oscillation (which can happen with splines) the function adds automatically additional knots where needed.// Arguments:// **x1,...,xn** the **x** values// **d1,...,dn** the **y** values.// There must be at least 3 knot point, i.e. 6 arguments.// Options:// **par** Parameter determining the smoothness of the curve. The default is zero, which produces ordinary cubic spline. A typical value may 2.5. Larger values mean that the spline is more closely linear between knot points.// **sort->** option must be given// **print->** option is given, the knot points are printed (after possible sorting). The resulting spline can be utilized using **value()** function. The taut spline algorithm is published by de Boor (1978) on pages 310-314. The source code was loaded from Netlib.

34.2 **stemspline()** Creates STEMSPLINE

To be reported later.

34.3 **stempolar()** Puts a stem into polar coordinates

To be reported later

34.4 **laasvol()** Volume equations of Laasasenaho

To be reported later.

34.5 **laaspoly()** Polynomial stem curves of Laasasenaho

To be reported later.

34.6 **integrate()** Integrates volume from STEMSPLINE

To be reported later.

35 Bit functions

bit functions help to store large amount of binary variables in small space. These functions are used in domain calculations

35.1 Bitmatrix

A **BITMATRIX** is an object which can store in small memory space large matrices used to indicate logical values. A **BITMATRIX** object is produced by **bitmatrix()** function or by **closures()** function from an existing bitmatrix. Bitmatrix values can be read from the input stream or file or set by **setvalue()** function. The values of bitmatrix elements can be accessed with **value()** function.

Note 35.1.1. Also ordinary real variable can be used to store bits. See bit functions.

35.2 **setbits()** Sets bits

To be reported alter

35.3 **clearbits()** Clears bits

To be reported later

35.4 **getbit()** : Gets bit

To be reported later, see old manual

35.5 **bitmatrix()** Creates **BITMATRIX**

To be reported later, see old manual

35.6 **setvalue()** Set value for a **BITMATRIX**

To be reported later, see old manual

35.7 **closures()** Convex closure

To be described later, see old manual

36 Misc. functions

There are some functions which do not belong to previous classes.

36.1 **properties()** Properties of subjects

This function has been used to define properties of factories. It will be replaced with other means in later versions.

36.2 **cpu()** Cpu time

Example 36.1 (cpuex). Example of cpu-timing

```
cpu0=cpu()
a=matrix(100000)
a=ran() !uniform
mean(a),sd(a),min(a),max(a);
cpu1=cpu()
elapsed=cpu1-cpu0;
```

36.3 **secnds()** Clock time

Example 36.2 (secondsex). Example of elapsed time

```
cpu0=cpu()
sec0=secnds()
a=matrix(100000)
a=ran() !uniform
mean(a),sd(a),min(a),max(a);
cpu1=cpu()
sec1=secnds()
elapsed=cpu1-cpu0;
selapsed=sec1-sec0;
```

37 Error handling

There can happen basically three kinds of errors:

37.1 Error types

- The user makes an error and **Jlp22** detects the error, writes the proper error message and returns the control to the **sit>** prompt in the console, if variable **Continue** has value zero. If **Continue** has a nonzero value **Jlp22** continues one level above the console.

The user makes an error, but **Jlp22** does not recognize this. As **Jlp22** should recognize all errors the user can make, this case is thus also a programming deficiency. In this case **Jlp22** behaves similarly as in the following case.

- The error is a programming error in **Jlp22**. Then two cases can happen:
 - **Jlp22** does not recognize that something is in error, and the system crashes. The debug version writes then more information than the release version. It is important that **Jlp22** is used in the command prompt, so that it does not just disappear.
 - **Jlp22** recognizes in lower level subroutines that something is wrong, but the lower level subroutine does not know what is the reason. The **Jlp22** prints an error message starting with ***j***. Even if the user recognizes that she was guilty, these cases should be reported so that detection of user errors can be improved.

37.2 Handling of errors

There are two control layers, input programming and execution of one-line commands. Both can utilize the code obtained with parser, but input programming is utilizing the parser only a little. **Jlp22** function can use **TRANS** objects containing packed parsed code in many different ways. There can be nesting both in input programming and executing **TRANS** objects. The **;incl** files can be nested up to 5 levels. Functions can be recursive in many different ways. A function can call itself through many routes.

In case of error should be able to tell for all nested **;incl** files what line is processed, and errors within **TRANS** objects should be able to tell through the calling sequence which line is under execution. Let us test this in the following example.

```
Example 37.1 (errorex). rex
round=5
write('inca.txt', $, '**we are in inca.txt')
write('inca.txt', $, 'round; ')
write('inca.txt', $, '; incl(incb.txt)')
close('inca.txt')
print_f('inca.txt')
write('incb.txt', $, '**we are in incb.txt')
write('incb.txt', $, 'round; ')
write('incb.txt', $, 'round=round-1; ')
write('incb.txt', $, 'call(transa)')
write('incb.txt', $, '; incl(inca.txt)')
close('incb.txt')
```

```

print_f('incb.txt')
transa=trans()
c=4/round;
/
** let us see what happens
Continue=1
;incl(inca.txt)
** maximum ;incl nesting was obtained

    round=2
** what happens now?
;incl(inca.txt)
Continue=0
delete_f('inca.txt','incb.txt')

```

38 Co-operation between Jlp22 and R

Is is possible to run R script from **Jlp22** and **Jlp22** scripts from R.

38.1 **R()** Executes an R-script

An R script can be executed with **R(script)** where script is **CHAR** object defining the script text file. The function is calling // call execute_command_line('Rscript.lnk '//j_filename(1:le), wait=.false.)// Thus a shortcut for the Rscript program needs to be available.

Example 38.1(Rex). Example of Rscript

```

rscript=text()
#A simple R-script that generates a small data to file mydat.txt
wd<-"C:/jlp22/jmanual"
x<-runif(10,0,10)
y<-cbind(1,x)%*%c(1,2)+rnorm(10)
mydat<-data.frame(y,x)
write.table(mydat,file=paste(wd,"/mydat.txt",sep=""))
//
write('miniscript.r',rscript)
close('miniscript.r')
R('miniscript.r')
print('mydat.txt')
delete_f('mydat.txt','miniscript.r')

```

38.2 Calling Jlp22-scripts from R

File JR_0.0.tar.gz in the folder J_R contains R tarball for taking **Jlp22** subroutines into R. With R command JR("testr.inc") the example jp problem can be solved from R. Later lauri Mehtätalo will develop this co-operation further so that R can directly access also matrices in the **Jlp22** memory. For further information contact lauri.mehtatalo@luke.fi THIS DOES NOT WORK NOW We will reconsider it soon with Lauri

39 Future development

The previous version contained possibilities to include factories into the optimization. Factory optimization is not available in the current version, because I'm now building a completely new version. I have already cleaned the data structures of linear programming and put the algorithm into reasonable subroutines. This makes it possible to follow and optimized the the flow of control. This made it already possible to put ordinary linear programming into a separate **jlpz()** function.

I think that the current version of **Jlp22** provides many possibilities for future developments. For instance:

current version does not have any special functions for making simulators. The new **goto()** commands, possibility to work with submatrices, and the new **transdata()** function provide much more efficient ways to develop simulators. Examples will be provided shortly.Using the possibility to compute derivatives using the analytic derivates makes it quite straightforward to make it possible to have a nonlinear objective function and nonlinear constraints. These things are under design. It would be quite easy to include tools for piecewise linear constraints and objectives. It would be quite easy to develop **Jlp22** so that integer solution is produced with respect to the schedule weight. It would be interesting to see how **Jlp22** can put to work with Heureka. The possibility to run R scripts from **Jlp22** and **Jlp22** scripts from R provide new possibilities. **Jlp22** can now be used as an interface to Gnuplot. Google search show how many possibilities Gnuplot provides. It is quite straightforward to implement these graphs if it is not currently possible. The possibility to generate random numbers from any discrete or continuous distribution provide new possibilities to study the effects of random errors in the optimization. The new tools for analyzing grouped data are useful when studying the grouped data. it would be straightforward to implement mixed model methods based on expected means squares.

References

- [1] Dantzig, G.B. and VanSlyke, R.M. (1967) *Generalized upper bounding techniques* **J Compt Sys Sci** 1(10),213-226
- [2] Fletcher,R. 1996. Dense factors of Sparse matrices. Dundee Numerical Analysis Report NA/170.
- [3] Hoganson, H.M. and Rose, D.W. (1984), *A simulation approach for optimal timber management scheduling* Forest Science, 30:220-238
- [4] Hoganson, H.M. and Kapple, D.C. (1991), *DTRAN version 1.0. A multi-market timber supply model. Users' guide* Minneapolis: University of Minnesota Department of Forest Resources Staff Series Paper 82,
- [5] Hyvönen, Pekka, Lempinen, Reetta, Lappi, Juha, Laitila, Juha and Packalen, Tuula (2019) *Joining up optimisation of wood supply chains with forest*, Forestry an international journal of forestry, 93(1):163–177, DOI = <https://doi.org/10.1093/forestry/cpz058>
- [6] Lappi, Juha (1992) *JLP – a linear programming package for management planning* Finnish Forest Research Institute Research papers; 414, 134 p.
- [7] Lappi, Juha and Lempinen, Reetta (2014) *A linear programming algorithm and software for forest-level planning problems including factories* Scandinavian Journal of Forest Research,29 Supplement 178–184", DOI = <http://dx.doi.org/10.1080/02827581.2014.886714>
- [8] Thomas Williams, Thomas and Kelley, Colin (2022), *Gnuplot 5.5*, url = http://gnuplot.info/docs_5.5/