

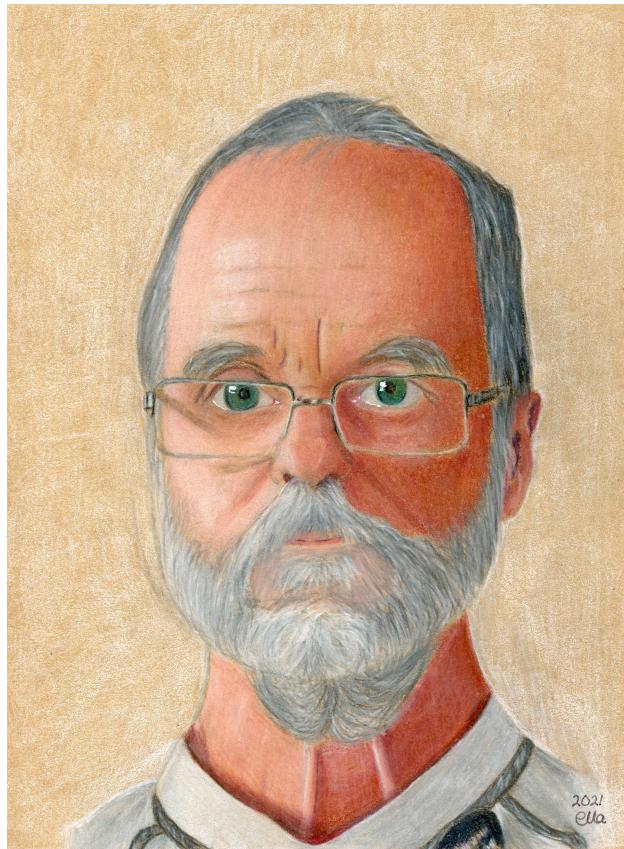
# **J** **Users' Guide**

Version 3.0    2022/07/29

**Juha Lappi**

[juha.lappi.sjk@gmail.com](mailto:juha.lappi.sjk@gmail.com)

**Reetta Lempinen**



# Contents

<b>Preface</b>	<b>8</b>
<b>1 Introduction</b>	<b>9</b>
1.1 Using J exe files . . . . .	9
1.2 Developing own J functions in Fortran . . . . .	9
<b>2 Installing J from Github</b>	<b>10</b>
2.1 Git package . . . . .	10
2.2 Loading the package . . . . .	12
<b>3 Starting to us J and Gnuplot</b>	<b>13</b>
3.1 Istalling Gnuplot and J . . . . .	13
3.2 Running examples . . . . .	13
3.3 J functions . . . . .	14
3.4 J objects . . . . .	17
3.5 System requirement . . . . .	18
3.6 Exiting J . . . . .	18
3.7 Typographical conventions . . . . .	18
3.8 Operation of J . . . . .	19
<b>4 Command input and output</b>	<b>20</b>
4.1 Input record and input line . . . . .	21
4.2 Input Paragraph . . . . .	22
4.3 Command shortcuts . . . . .	22
4.4 Input programming . . . . .	23
4.4.1 Labels in input programming . . . . .	23
4.4.2 Changing âiâ sequences . . . . .	23
4.4.3 ;incl() . . . . .	24
4.4.4 ;goto() . . . . .	25
4.4.5 ;return returns from include file . . . . .	26
4.4.6 ;do() . . . . .	26
4.4.7 ;sum() . . . . .	27
4.4.8 ;dif() . . . . .	28
4.4.9 ;pause . . . . .	28
4.4.10 ;return returns from include file . . . . .	28
4.5 Generating sequences with ... -construct . . . . .	29
<b>5 J functions: an overview</b>	<b>29</b>
<b>6 Special functions</b>	<b>37</b>

6.1	<code>setoption()</code> : set option on . . . . .	38
6.2	<code>getelem()</code> : extracting information from an object . . . . .	38
6.2.1	Get or set a matrix element or submatrix . . . . .	38
6.3	<code>setelem()</code> : Putting something into an object. . . . .	40
6.4	<code>list2()</code> . . . . .	40
6.5	<code>setcode()</code> : Initialization of a code option . . . . .	40
6.6	Own functions: <code>o1_o1_funcs()</code> , <code>o2_funcs()</code> and <code>o3_funcs()</code> . .	40
<b>7</b>	<b>Functions for handling objects</b>	<b>41</b>
7.1	Get type of an object: <code>type()</code> . . . . .	41
7.2	Deleting objects: <code>delete_o()</code> . . . . .	41
7.3	<code>_exist_o()</code> : <code>doesanobjectexist</code>	42
7.4	<code>name()</code> : writes the name of an object . . . . .	42
<b>8</b>	<b>Transformation objects</b>	<b>42</b>
8.1	Generating a transformation object <code>trans()</code> . . . . .	42
8.2	Excuting transformation object explicitly <code>call()</code> . . . . .	46
8.3	Pause: <code>pause()</code> . . . . .	46
8.4	Number of options in the current function: <code>noptions()</code> . . . . .	46
<b>9</b>	<b>Co-operation between J and R</b>	<b>47</b>
9.1	<code>R()</code> executes an R-script . . . . .	47
9.2	Calling J-scripts from R . . . . .	47
<b>10</b>	<b>Loops and control strucures</b>	<b>47</b>
10.1	<code>do()</code> loops . . . . .	47
10.2	<code>if()</code> . . . . .	48
10.3	assignment: <code>output=input</code> . . . . .	48
10.4	Selecting a value based on conditions. . . . .	49
10.5	<code>erexit()</code> . . . . .	49
10.6	<code>goto()</code> . . . . .	50
<b>11</b>	<b>Arithmetic and logical operations</b>	<b>50</b>
11.1	Minimum and maximum: <code>min()</code> and <code>max</code> . . . . .	51
<b>12</b>	<b>Statistical functions for matrices</b>	<b>51</b>
12.1	<code>mean()</code> : means or weighted means of matrix columns . . . . .	51
12.2	<code>sd()</code> : sd's or weighted sd's of matrix columns . . . . .	51
12.3	<code>var()</code> : Sample variances or weighted variances of matrix c . .	52
12.4	<code>sum()</code> : sums or weighted sums of matrix columns . . . . .	52
<b>13</b>	<b>Special arithmetic functions</b>	<b>52</b>

13.1	<code>der()</code> : derivatives . . . . .	52
13.2	<code>gamma</code> function: <code>gamma()</code> . . . . .	53
13.3	<code>logistic()</code> : value of the logistic function . . . . .	53
13.4	<code>npv()</code> : net present value . . . . .	54
<b>14</b>	<b>Functions for probability distributions</b>	<b>54</b>
14.1	Density for normal distribution: <code>pdf()</code> . . . . .	54
14.2	Cumulative distribution function for normal and chi2: <code>cdf</code> . .	54
14.3	<code>bin()</code> : binomial probability . . . . .	55
14.4	<code>negbin()</code> : negative binomial distribution . . . . .	55
14.5	<code>density()</code> define . . . . .	55
<b>15</b>	<b>Random number generators</b>	<b>56</b>
15.1	<code>ran()</code> : uniform random number . . . . .	57
15.2	<code>rann()</code> : normal random variate . . . . .	57
15.3	<code>ranpoi()</code> : random Poisson variables . . . . .	58
15.4	<code>ranbin()</code> : random binomial values . . . . .	58
15.5	<code>ranegbin()</code> : negative binomial variates . . . . .	59
15.6	<code>select()</code> : Random selection of elements . . . . .	59
15.7	<code>random()</code> : random variates from any distribution . . . . .	60
<b>16</b>	<b>Functions for interpolation</b>	<b>60</b>
16.1	<code>interpolate()</code> : linear interpolation . . . . .	60
16.2	<code>plane()</code> interpolation from a plane . . . . .	60
16.3	<code>bilin()</code> : bilinear interpolation . . . . .	60
<b>17</b>	<b>List functions</b>	<b>61</b>
17.1	Object lists . . . . .	61
17.2	<code>list()</code> generates a LIST object . . . . .	61
17.3	<code>merge()</code> . . . . .	62
17.4	Difference of LIST objects . . . . .	62
17.5	<code>index()</code> : index of a variable in a data object . . . . .	63
17.6	<code>index()</code> : index of a variable in a data object . . . . .	63
17.7	<code>len()</code> lengths of different lists or vectors . . . . .	63
17.8	<code>ilist()</code> : list of integers . . . . .	64
17.9	<code>putlist()</code> . . . . .	64
<b>18</b>	<b>Creating two types of text objects</b>	<b>64</b>
18.1	<code>text()</code> creates the old TEXT object . . . . .	65
18.2	<code>txt()</code> generates the new TXT object. . . . .	65
<b>19</b>	<b>File handling</b>	<b>65</b>

19.1	<code>oexist_o()</code>	:	<code>doesanobjectexist</code>	65
19.2	Deleting objects: <code>delete_o()</code>	.	.	65
19.3	<code>close()</code> closes a file	.	.	66
19.4	<code>showdir()</code> shows the current directory	.	.	66
19.5	<code>setdir()</code> sets the current directory	.	.	66
19.6	<code>thisfile()</code> returns the name of the current include file	.	.	66
19.7	<code>filestat()</code> gives information of a file	.	.	66
<b>20</b>	<b>Io-functions</b>			<b>66</b>
20.1	<code>read()</code> read from a file	.	.	67
20.2	<code>write()</code>	.	.	67
20.3	<code>print()</code> prints objects	.	.	68
20.4	<code>ask()</code> asks a value for REAL	.	.	69
20.5	<code>askc()</code> asks a value for a character variable	.	.	69
20.6	<code>printresult()</code> and <code>printresult2()</code> e	.	.	70
<b>21</b>	<b>Matrix functions</b>			<b>70</b>
21.1	Matrices and vectors	.	.	70
21.2	<code>matrix()</code> : create a matrix:	.	.	71
21.3	<code>nrows()</code> : number of rows in MATRIX, TEXT or BITMATRIX	.	.	72
21.4	<code>ncols()</code> : number of columns in MATRIX or BITMATRIX	.	.	72
21.5	<code>t()</code> gives transpose of a MATRIX or a LIST	.	.	73
21.6	<code>inverse()</code>	.	.	73
21.7	<code>solve()</code> solves a linear equation $A*x=b$	.	.	73
21.8	<code>qr()</code>	.	.	73
21.9	<code>eigen()</code>	.	.	74
21.10	<code>sort()</code> sorts a matrix	.	.	74
21.11	<code>envelope()</code> computes the convex hull of point	.	.	74
21.12	<code>find()</code>	.	.	75
21.13	<code>mean()</code> : means or weighted means of matrix columns	.	.	76
21.14	<code>sum()</code> : sums or weighted sums of matrix columns	.	.	76
21.15	<code>var()</code> : Sample variances or weighted variances of matrix c	.	.	76
21.16	<code>sd()</code> : sd's or weighted sd's of matrix columns	.	.	76
21.17	<code>minloc()</code> : locations of the minimum values in columns	.	.	76
21.18	<code>maxloc()</code> : locations of the maximum values in columns	.	.	77
21.19	<code>cumsum()</code> : cumulative sums of matrix columns	.	.	77
<b>22</b>	<b>Working with DATA objects</b>			<b>77</b>
22.1	<code>data()</code>	.	.	78
22.2	<code>newdata()</code>	.	.	84
22.3	<code>datacase()</code> : Creates a data object where each observation has name	.	.	85
22.4	<code>exceldata()</code>	.	.	85

22.5	<code>linkdata()</code> links hierarchical data sets . . . . .	86
22.6	<code>getobs()</code> loads an obsevarion from DATA . . . . .	87
22.7	<code>nobs()</code> : number of observations in DATA or REGR . . . . .	87
22.8	<code>classvector()</code> . . . . .	88
22.9	<code>values()</code> extracts values of class variables . . . . .	90
22.10	<code>transdata()</code> own transformations for data . . . . .	90
<b>23</b>	<b>Statistical functions</b>	<b>91</b>
23.1	<code>stat()</code> . . . . .	91
23.2	<code>cov()</code> : covariance matrix . . . . .	93
23.3	<code>corr()</code> computes a correlation matrix. . . . .	94
23.4	<code>regr()</code> : linear regression. . . . .	94
23.5	<code>nonlin()</code> :: nonlinear regression . . . . .	95
23.6	<code>varcomp()</code> : variance and covariance components . . . . .	95
23.7	<code>classify()</code> . . . . .	95
23.8	<code>class()</code> . . . . .	97
<b>24</b>	<b>Linear programming functions</b>	<b>98</b>
24.1	Problem definition object . . . . .	98
24.2	<code>problem()</code> defines a Lp-problem . . . . .	98
24.3	Solving large problems without schedule data. . . . .	101
24.4	<code>weights()</code> weights of schdules . . . . .	105
24.5	<code>partweight()</code> weights of split schedules . . . . .	105
<b>25</b>	<b>Plotting figures</b>	<b>105</b>
25.1	Figures . . . . .	106
25.1.1	Figure object . . . . .	106
25.2	Scatterplot: <code>plotyx()</code> . . . . .	106
25.3	Draw a function: <code>draw()</code> . . . . .	107
25.4	Draw values in a matrix generated with <code>classify()</code> : . . . . .	108
25.5	Draw a polygon through points: <code>drawline()</code> . . . . .	110
25.6	Show figure: <code>show()</code> . . . . .	112
25.7	Plot 3d-figure: <code>plot3d()</code> . . . . .	113
<b>26</b>	<b>Splines, stem splines, and volume functions</b>	<b>114</b>
26.1	<code>tautspline()</code> . . . . .	114
26.2	<code>stemspline()</code> : splines for stems . . . . .	114
26.3	<code>stempolar()</code> : polar coordinates . . . . .	114
26.4	<code>laasvol()</code> : svolume eqaitions of Laasasenaho . . . . .	115
26.5	<code>laaspoly()</code> : polynomila stem curves of Laasasenaho . . . . .	115
26.6	<code>integrate()</code> : integrate . . . . .	115

<b>27 Bit functions</b>	<b>115</b>
27.1 Bitmatrix . . . . .	115
27.2 <code>setbits()</code> : setting bits on . . . . .	115
27.3 <code>clearbits()</code> : clearing bits . . . . .	115
27.4 <code>getbit()</code> : get bit value . . . . .	115
27.5 <code>getbitch()</code> : get bit value . . . . .	116
27.6 <code>bitmatrix()</code> : define a matrix for bits . . . . .	116
27.7 <code>setvalue()</code> : set value for a bitmatrix . . . . .	116
27.8 <code>closures()</code> :convex closures . . . . .	116
<b>28 Misc. functions</b>	<b>116</b>
28.1 <code>properties()</code> : defining properties of some subjects. . . . .	116
28.2 <code>cpu()</code> gives the elapsed cpu time . . . . .	116
28.3 <code>seconds()</code> gives the elapsed clock time . . . . .	116
28.4 Object names . . . . .	117
28.5 Copying object: <code>a=b</code> . . . . .	117
28.6 Deleting objects: <code>delete_o()</code> . . . . .	117
28.7 Object types . . . . .	118
28.7.1 Real variables and constants . . . . .	118
28.7.2 Character constants and variables . . . . .	119
28.7.3 Logical values . . . . .	119
28.8 Predefined objects . . . . .	119
28.8.1 Transformation object . . . . .	121
28.9 Code options . . . . .	121
28.10 <b>J</b> transformations . . . . .	122
28.11 Generating a transformation object <code>trans()</code> . . . . .	122
28.12 Using a transformation object as a function . . . . .	126
28.13 Transformation control structures . . . . .	126
28.13.1 <code>if()</code> . . . . .	126
28.13.2 <code>if() elseif() else endif</code> . . . . .	127
28.14 Loops and control strucures . . . . .	127
28.15 <code>return</code> . . . . .	127
28.16 <code>erexit()</code> . . . . .	127
28.17 <code>goto()</code> . . . . .	128
28.18 Numeric operations . . . . .	128
28.19 Logical and relational expressions . . . . .	129
28.20 Arithmetic functions . . . . .	130
28.20.1Text objects . . . . .	131
28.21 The main components of <b>J</b> program . . . . .	131
<b>29 Future development</b>	<b>132</b>

<b>30 J story</b>	<b>133</b>
30.1 JLP and first version of <b>J</b> . . . . .	133
30.2 <b>J</b> with factories: J2.0 . . . . .	135
30.3 Battle over open-source J3.0 starts in Luke . . . . .	135
30.4 Retired, frozen conflict . . . . .	138
30.5 Operation Charles XII . . . . .	139
30.6 Last battle, victory and peace in Olavinlinna . . . . .	141
30.7 Total balance with Luke . . . . .	142
30.8 Freedom . . . . .	143

## Preface

The **J** software is the successor of the JLP software which has been used as the optimizer in the Mela software and in the Norwegian GAYA planning software which was then called GAYA-JLP. JLP was published 1992 and Finnish Forest Research Institute (Metla) started to distribute it version 0.9.3 was published in August 2004. The GAYA group was involved in the development and started to use **J** immediately 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**. Simsol started to use **J** as an optimizer from the beginning. **J** version 2.0. published in 2013 made it possible optimize simultaneously forestry and transportsations to factories and factory production.

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. The leaders of Luke told that this a good idea, 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 1.10. 2021 when I got the permission to publish the software and manuals as I like. The development of JLP and **J** is described in some detail in section 'J story'.

When Luke did not prevent the development of **J** any more, I have rewritten all central parts of **J**. **J** is now a 64-bit application. And **J** is now finally published as an open source software at [github.com/juhalappi/J](https://github.com/juhalappi/J). New versions are published there all the time (**J** contains still many bugs).

**J** is utilizing linear programming subroutines of Roger Fletcher. Even Bergseng from NMBU helped in the first version of **J**. The role of Reetta Lempinen was essential when factories were included. She advised how to use Github for the distribution. She has also helped to test the new version, and she participated in the writing of the manual before I developed new tools for the making of manuals. Victor Strimbu advised how to change **J** into 64-bit and we are developing together solutions for using **J** with the new simulator of GAYA. Lauri Mehtätalo helped to convince the leaders of Luke that Luke's interests do not require that they continue preventing the publication and development of **J**. With Lauri, we have developed a solution for using the optimizer of **J** from R. More advanced solutions will come later. I thank my grand daughter Ella for the permission to use the portrait she drew for my 70 yr birthday.

The web - launch of J3.0 was 22.4. 2022. The J-story was then part

of the preface. Following the advice of Heikki Smolander, I separated this preface and the J-story at 25.5. 2022.

Juha Lappi

## 1 Introduction

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

### 1.1 Using J exe files

**J** is a general program for many different tasks. In one end, **J** 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 **J** functions and **J** trasformations can be combined in many ways.

There are several alternatives for doing general mathematical and statistical computations available in **J**, most prominent being R. For users of R, the most interesting functions in **J** are evidently the linear programming functions which utilize the the structure of typical forest managment planning problems. The forest management planning can now combined with factories. R users can do general data management in R and use **J** only for linear programming. But after learning basics of **J**, it may be more straightforward to do also data management in **J**.

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

### 1.2 Developing own J functions in Fortran

The user's of **J** can utilize the open source of **J** in principally two different ways. Either the user can develop new versions of existing **J** 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 **J** functions. When modifying an existing **J** 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 **J**. It is very easy to add new functions in **J** and even more easy to add new options.

When developing a new method in **J**, it is possible to first use the **J** 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 **J**.

## 2        **Installing J from Github**

The Github distribution was made under the guidance of Reetta Lempinen. This section describes the folders of the Github distribution and also how to install **J** and Gnuplot.

### 2.1        **Git package**

The **J** package can be loaded by pressing load zip button under the green code button in the right side of the page [github.com/juhalappi/j](https://github.com/juhalappi/j). The package contains the following components

**J Data:**        folder for data files

**J test.cda**        example unit data file for small **jlp()** example

**J test.xda**        example schedule file for small **jlp()** example

**J test.inc**        include file for the **jlp()** test

**J J\_R:**        using **J** from R, courtesy of Lauri Mehtätalo.

**J j.par**        default include file for starting **J**

**J JR\_0.0.tar.gz**        File needed to use Fortran subroutines in R

**J testr.cda**

**J testr.xda**

**J testr.inc**        include file for an **jlp**-example

**J testr.j**

- J Jbin:** binary .exe files and dll files
  - J j3d.exe** Debug version of J, release version is provided after some testing period
  - J jmanual.exe** makes the latex code file jmanual.tex
  - J jpre.exe** the precompiler which generates the code for accessing variables in module
  - J 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
  
- J Jdoc\_demo** documents and include file for running examples from User's guide
  - J hyvonenetal2019.pdf** A paper utilizing the factory optimization.
  - J J3.0\_userguide\_2021.pdf** old version of the manual, explains better some functions than j3.pdf
  - J J3.pdf** Users guide made with Latex
  - J jexamples.inc** include file which can be used to run all examples in the manual and which is generated with jmanual.exe
  - J jlp92.pdf** Manual of old JLP which explains the theory behind the jlp algorithm
  - J lappilempinen.pdf** Paper explaining the theory behind factory optimization.
  
- J Jmanual:** Source files for making Latex code for the manual and the include file for running examples
  - J jmanual.f90** source for making the Latex code and jexamples.inc
  - J jmanual.tex** Latex code generated with jmanual.exe
  - J jsections.txt** describes such manual sections not in source files
  - J 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
  - J main.tex** Preamble code containing Latex definitions
  - J Makefile\_debug** Makefile for making jmanual.exe

**J** Source : source code before precompilation

- J** fletcherd.for Fletchers subroutines turned into double precision
- J** j.f90 code for **J** functions
- J** jlps.f90 code for linear programming
- J** j.main main prorgam for calling **J** when used as is, if **J** is used as a subroutine then this must be made a subroutine
- J** jmodules.f90 data structure definitions
- J** jutilities.f90 subroutines for handling objects etc.
- J** jsysdep\_gfortran.f90 system dependent routines
- J** matsub.f subroutines obtaininde from other sources, e.g. from Netlib
- J** other subroutines for setting up users own function

**J** Source2 : source code files after precompilation in addition to files in Source (such files which are not precompiled are put in both folders)

- J** makefile\_debug makefile for making debug- version
- J** makefile\_release makefile for making release- version

**J** LICENSE:the license file

**J** README.m :readme file

## 2.2 Loading the package

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

The load zip button loads file J-master.zip. Copy this file into a proper folder. Let it be Jgit. Clicking the J-master.zip icon shows folder J-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 J-master is copied directly in folder Jgit.

The j3d.exe is the debug version of J3. The debug version should be used as long as the most memory acces probems are solved. Let us assume that the working folder is jtest.

## **3 Starting to us J and Gnuplot**

This section tells how to install **J** so that the user can start running the example

### **3.1 Iinstalling Gnuplot and J**

Let us then install Gnuplot. Go to page 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:files. Open then command prompt. Give command gnuplot. If the compuler says that it is not operable command, this means that gnuplot is not properly on the PATH of the system. I had some problems to get the PATH to work properly. When I edited the Environmental variable for system and added new item by adding C:fileshaving space between 'program' and 'files', I did get gnuplot to the PATH, and PATH command showed that it was actually two times, but anyhow it worked.

Also folder Jgit/Jbin should be put on the PATH. This happens by adding item C:to the environmental system variable PATH. Restart then the computer.

If you have problems with the environmental variable PATH **J** and Gnuplot can be put into path by defining file jpath.bat in the working directory containing the lines:

```
PATH =%PATH%;C:files
```

```
PATH =%PATH%;C:
```

When starting to work in the working directory, launch Command prompt, got ot the working directory using cd commands, and when in the working directory write jpath which the puts both j3d and Gnuplot temporarlily into the path.

### **3.2 Running examples**

Copy then jexamples.inc and j3.pdf from jdoc\_demo folder into the Jtest folder. It is not wise to start working in the Jdoc\_demo folder, because if you load a new version of **J** in a similar way into Jgit folder and allow the computer replace existing folders with the same name, you would loose the work done in Jgit folder.

Open the command prompt and move to the directory 'jtest' by 'cd' commands. It is possible to use **J** also directly, but its necessary to use **J** through the command prompt at this testing phase, bacause then, if **J**

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 j3d in this folder, **J** 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 fisrts line of j.par

```
*3000
```

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

Then start j by giving command j3d 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 **J** by **J3d jexamples.inc**

**J** 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, **J** 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 giving at **sit>** promt 'fcont=1' before giving ALL. 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.

### 3.3 J functions

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

```
data1=data(read->(x1...x3),maketrans->mt,in->)
```

Here **data1** is the output. **read->** is an option which tells what are the variable names in the data. Options can transmit object names or numeric values, here **read->** transmits object names. **maketrans->mt** tells that for each observation the trasformations defined in the trasformation object **mt** are first computed and the output variables are included in the data object.

Option `in->` tells that the data are read from the following input paragraph.

Let us then look at a function with arguments and codeoptions. Function  
`stat(x1,x3,min->,max->,filter->(x2.gt.3))`

Now the arguments `x1` and `x2` tell that stasistics are computed for variables `x1` and `x2`. The options `min->` and `max->` tell that the minimum of `x1` is stored in variable `x1%min` and maximum in variable `x1%max`.

Option `filter->` is a code option is trasmits a piece of code. `filter->(x2.gt.3)` tells that only such observations are accepted for which `x` is greater than 3. All operations which look like logical operations are actually numeric operations which produce value 1 for TRUE and value 0 for FALSE. Other options are interpreted only once when entering the function, but the code within a code option is here computed repeatedly for all observations. If the code needed in a code option is long or must be computed using several lines, the code can be put into a transformation object, and e.g. `filter->(tr(a).gt.3)` is done so that transformation `tr` is first computed and `tr(a)` trasmits the value of variable `a` after the transforamtion is computed.

`stat()` function does not produce an output object. For such function which produce output but the name of the output is not given, the name of the output is `Result`. Try e.g. '`1+1;`' If an output is produced, the it is printed if the code line ends with ';' or ';;'. See section 3.8 how the printing is controlled with the variable `Printoutput`.

For an option which basically transmits on/off information, it may be necesssary to control wheter the option is on by a control variable. For instance, in plotting figures option `continue->` indicates that the execution continues without `pause()` when the figure is plotted. The option `continue->fcont` that the option is on when variable `fcont` has non-zero value.

The value of an option needs to be put into parenthesis when it is not a single constant, object name or simple function call as in  
`fi=draw(func->sin(x),x->x,xrange->(0,10))`. Here there arguments can be computed using computations. For istansce  
`fi=draw(func->sin(x),x->x,xrange->(0,max(10*ran(),3)))`  
would compute a random upper range for the x-axes. Note here `x->x` means that the name of the x-axes variable is `x`, which used as the argument in `sin([x])`

### In a function all the arguments must be before all options.

The computations are done going through the parse tree form right to left. This should be taken into account when getting the values of option arguments using transformations, for instance if `a` and `b` are computed in transformation `tr` then `filter->(tr(a).gt.b)` does not work in the intended way but `filter->(a.gt.tr(b))` does. The reason for this nonstandard direction for going through the parse tree is that the options mus be computed before

entering the function, and it had made the processing of the parse tree more complicated.

Some of the errors made by the user are noted at the time the function is interpreted, some errors are noted after entering the function. Some errors are not recognized and unintended results are obtained. In some cases the system will crash.

The general (non arithmetic) **J** functions are used either in statements  
func(arg1, $\dots$ ,argn,opt1->value1, $\dots$ ,optm->valuem)

or

output=func(arg1, $\dots$ ,argn,opt1->value1, $\dots$ ,optm->valuem)

If there is no output for a function in a statement, then there can be three different cases: i) The function does not produce any output (if an output would be given, then **J** would just ignore it)

ii) The function is producing output, and a default name is used for the output (e.g. Result for arithmetic and matrix operations, Figure in graphic functions).

iii) The function is a sub expression within a transformation consisting of several parts including other function or arithmetic operations. Then the output is put into a temporary unnamed object which is used by upper level functions as an argument (e.g. `a=inverse(b)*t(c)`) If the value of an option is not a single object or numeric constant, then it must be enclosed in parenthesis.

It is useful to think that options define additional argument sets for a function. Actually an alternative for options would be to have long argument lists where the position of an argument determines its interpretation. Hereafter generic term 'argument' may refer also to the value of an option.

When **J** is interpreting a function, it is checking that the option names and the syntax are valid, but it is not checking if an option is used by the function. Also when executing the function, the function is reacting to all options it recognizes but it does not notice if there are extra options, and these are thus just ignored.

An argument for a **J** function can be either functional statements producing a **J** object as its value, or a name of **J** object. Some options can be without any argument (indicating that the option is on).

An essential feature in **J** functions is that the driver subroutine which is computing the functions is recursive. This recursion is used when code options SEE? are used to compute the the output of an code option or when transformation objects are explicitly called within an transformation object or a function dealing with data is computing `trans->` transforamtion for each observation.

`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,â!valn, and objects by obj1,â!objn, or the names of real variables are

indicated by var1,â!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.

`stat(D,H,filter->(sin(D).gt.cos(H+1)) )` !

only those observations are accepted which pass the filter

`draw(func->(sin($x)+1),x->$x,xrange->(0,10,1))` !the func-> option transmits the function to be drawn not a single value.

## 3.4 J objects

J objects have a simple yet efficient structure. Each object is associate with a double precision variable, 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 con-

ventions. All objects are global, i.e. also users can acces all objects even if some predefined objects are locked so that users cannot change them.

### **3.5 System requirement**

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

See J3.0 Development Guide to start develop the software or to add own functions. The development package contains, in addition to source code for the standard **J** software, program Jmanual which can be used to generate Latex code for the manual and a precompiler Jpre which writes necessary Fortran statements to access all global **J** data structures and it makes indentations, writes comments to endif and enddo telling how the ifthen or do was started. The procompiler also gives better description what is wrong if ifthens and do's are mixed up.

Figures are made with Gnuplot. Gnuplot is freely available at  
<https://sourceforge.net/projects/gnuplot/files/gnuplot/5.4.2/>

Download download gp542-win64-mingw.exe. This will install gnuplot on your windows system under C:Files. J will strat Gnuplot automatically when plotting figures if Gnuplot is on the PATH (see section Installing Gnuplot and J).

### **3.6 Exiting J**

To exit **J** program and close console window, just give end command:  
**sit>end**

### **3.7 Typographical conventions**

In this manual function names are written in red, option names in blue, object types in capital letters, object names within the text are written in this color: Object. Names like ob1 are used as generic names for object and names like var1 are generic names for REAL variables. If there is no output

for an operation command line, the object `Result` is used as the default output. if the line ends with a single semicolon ';' or double semicolon ';;', then the output may be printed depending on the context. In many cases there is no output object, and a possible output given is ignored. If an explicit output is necessary, then '=' is put in front of the function name. Notation `â[=]â` means that the output can be given but it is not necessary. In most cases the default output `Result` is then used: In some cases no output is then generated (this will be indicated). For functions that return real values or matrices which can be used directly in arithmetic or matrix operations, the existence of output is not indicated.

Subroutines obtained from other sources  
The following subroutines are obtained from other sources.

- J 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: <http://pages.cs.wisc.edu/~deboor/pgs/tautsp.f>
- J real function `ppvalu` used in J function `value` from Carl de Boor (1978)  
A practical guide to splines. Springer, New York, p.310-314 No licence restrictions known distribution: <http://pages.cs.wisc.edu/~deboor/pgs/tautsp.f>
- J subroutine `interv`, used in function `ppvalue` from Carl de Boor (1978)  
A practical guide to splines. Springer, New York, p.310-314 No licence restrictions known obtained from: <http://pages.cs.wisc.edu/~deboor/pgs/tautsp.f>  
Lapack matrix routines
- J Several subroutines from [www.netlib.org/lapack](http://www.netlib.org/lapack) licence : <http://www.netlib.org/lapack/L>

### 3.8 Operation of J

In this section the main tools in code development in a project are presented. 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. !The script files should start with shortcuts for each section. If it is 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 developed in place the problems started.

If a **J** code line, either in the input paragraph defining a transformation object or outside it, ends with ';' or ';;', the 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 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 the code line is computed.

If a code line within a tranformation 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 transforasmton definition paragraph is '**;pause**', then a similar pause is generated except also input programming commands can be give.

If the variable **Debugtrans** has value 1, them a **pause()** is generated before each line within a tranformation object is executed. If variable **Debugconsole** has value 1, a '**;pause**' is generated before the line is excuted. In bot 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 8teh default case), the control comes into **sit>** prompt when an real error occurs or if an atrficial error condition is generated with **erexit()**. If **Continue** has value 1 then the computation continues in the same script file where the error occred. This property is used in file jexamples.inc to demonstrate possible error conditions so that the computation continues as if no error had occred.

[operexr]Exapmple of operation of J.

## 4 Command input and output

**J** has two programming levels. First level, called input programming, generates text lines which are then transmitted to the interpreter which gener-

ates code which is then put into transformations sets or executed 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.

## 4.1 Input record and input line

**J** reads input records from the current input channel which may be terminal, file or a text object. When **J** 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 ',', '+', '\*Â', '-', '(', '=' 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 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). The continuation line cannot start with '\*' or '[' because these are reserved to indicate comments. Note: '/' (division)cannot be used as last character indicating the continuation of the line because it can be legal last character indicating the end of an input paragraph.

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 **J** 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 **J** 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.

## 4.2 Input Paragraph

Many **J** functions interpreted and executed 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 ends 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. An input paragraph can contain input programming commands; the resulting text lines are transmitted to the **J** function which interprets the input paragraph [inpuparag]Example of inputparagraph

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

## 4.3 Command 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, **J** executes the command. The command can be either input programming command or ??? command. The file jexamples.inc shows an useful way to organize shortcuts and include files. [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>
;return
//
write('shortex.txt',$te)
;incl(shortex.txt)
ju1
ju2
delete_f('shorttext.txt')
te=0 !delete also text object te

```

## 4.4 Input programming

The purpose of the input programming is to read or generate **J** commands or input lines needed by **J** 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 **J** functions, but the input programming functions cannot have an output. There are also controls structures in the input programming. An input paragraph can contain input programming structures.

### 4.4.1 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 cannot be other text but not commands on the label line.

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

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 addresses and code labels. It is up to input programming what code alabels become part of the transformation object.

### 4.4.2 Changing âiâ 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\' name='area1' extension='svs'` then `in->"directory""name"."extension"` is equivalent to `in->'D:\j\area1.svs'` If the "-expression is not a character variable then J 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 `ââ` 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->ây=[f5.2]coef(reg,x1)â*x1+â[f5.2]coef(reg,1)ââ)` See file `jex.txt` and Chapter 8 for an ex

#### 4.4.3 ;incl()

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 <code>;incl().he</code>	

---

<code>from</code>	N 1	Ch
-------------------	-----	----

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

---

<b>wait</b>	N 0
	<b>J</b> waits until the include file can be opened. Useful in client server applications. See chapter <b>J as a server</b> .

Include files can be nested up to 4 levels. See Chapter Defining a text object with text function and using it in ;incl how to include commands from a text object. When editing the include file with Notepad ++, it is reasonable to set the language as Fortran (free form). [inpuincl]Example of ;incl()

```
file=text()
i=1;
goto(ad1)
i=2;
ad1:i=66;
goto(ad2,ad3,2) !select label from a label list
ad2:
i=3;
ad3:i=4;
goto(5) !select label from the list of all labels
ad4:i=5;
ad5:i=6;
//
write('file.txt',file)
close('file.txt')
;incl(file.txt)
;incl(file.txt,from->ad2) The adress line can contain comment starting with '!'.

```

#### 4.4.4      ;goto()

Go to different adress in ;incl() file.

---

Args	1	CHAR
		The label from which the reading continues. With ;goto('adr1') the adress line starts ;adr1:

[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')

```

#### 4.4.5 ;return returns from include file

**;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:

- J The control came to the starting address 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.
- J The control came to the starting label from within the same include file using either an explicit **;incl** or **;goto** command or generating these commands commands with command shortcut.

#### 4.4.6 ;do()

Generates new input records and replaces text with other text using " " to generate numbers, @list to generate lists of object names and @list(elem) to pick the names of the elements of a list, or **;sum()** to generate sums and **;dif()** to generate differences.

---

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.

---

```
[inpudoex]Examples of ;do()
;do(i,1,2)
x"i"="i"*10
print('Greetings from iteration "i")
;enddo
print(x1,x2)
```

```
!After dropping out extra text about the processing we get:
<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
```

#### 4.4.7 ;sum()

J can generate text of form part1+part2+...partn into input line using input programming function ;isum(). 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 noninteger values, the integer part is used) or REAL variables. Thus the value cannot be obtained from arithmetic operations. Sum is useful at least in problem() function. [inpusumex]Example of ;sum()

```
su=';sum(i,1,5)(a"i"*x")'
```

```
print(su)
```

```
<print(su)
'a1*x1+a2*x2+a3*x3+a4*x4'
```

```
prob=problem()
```

```
;sum(i,1,5)(a"i"*x"i")==max
```

```
<prob=problem()
```

```
prob< a1*x1+a2*x2+a3*x3+a4*x4+a5*x5==max
```

;dif()() works similarly for minus

#### **4.4.8 ;dif()**

J 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 noninteger values, the integer part is used) or REAL variables. Thus the value cannot be obtained from arithmetic operations. ;dif() is useful at least in problem() function.

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

#### **4.4.9 ;pause**

Including input from an include file can be interrupted using an input programming command ;pause prompt or the J function pause('<prompt>'). In both cases the user can give J 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 J 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> J 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 J proceeds similarly as if an error had occurred, i.e. print error messages and returns control to sit>-prompt.

#### **4.4.10 ;return returns from include file**

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

- J The control came to the starting address 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.
- J The control came to the starting label from within the same include file using either an explicit ;incl or ;goto command or generating these commands with command shortcut.

## 4.5 Generating sequences with ... -construct

It is often natural to index object names, and often we need to refer object names having consecutive index numbers or index letters. In J 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 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. [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
```

## 5 J functions: an overview

J functions are organized into 21 groups. Some of the functions are such that the interpreter converts the code given by the user into new function names. For instance the code `1+2` is first changed into `PLUS(1,2)`, and code `a(3)` is changed into form `getelem(a,3)`. The following list contains also such implicit function names to support also those users who are interested to start looking at the open source code. The ordering of functions in this manual is the same as in the file `jmodules.f90` in order to make it easier to start looking the source code, even if the order is not the most logical from the application point of view. When adding new functions into any group is easy when the new function is put to the end of group so new functions are not inserted in the middle of group even if it would more logical. !

- Special functions
  - setoption
  - getelem
  - setelem
  - list2
  - o1\_funcs
  - o2\_funcs
  - o3\_funcs
  - setcodeopt
- Objects
  - type
  - delete\_o
  - exist\_o
  - name
- Transformations
  - trans
  - call
  - pause
  - noptions
  - R
- Loops and controls structures
  - do
  - if
  - ASSIGN
  - sit
  - which
  - erexit
  - goto
  - itrace

- trace
- tracenow
- itraceoff
- traceoff
- tracetest
- assone
- enddo
- assmany
- goto2
- goto3
- Arithmetic and logical operations after converting to the polish notation
  - HMULT
  - HDIV
  - IPOWER
  - MULT
  - DIV
  - PLUS
  - MINUS
  - EQ
  - NE
  - LE
  - LT
  - GE
  - GT
  - NOT
  - AND
  - OR
  - EQV
  - NEQV
  - POWER

- Arithmetic functions which can operate on scalars or on matrices
  - max
  - sign
  - mod
  - nint
  - int
  - ceiling
  - floor
  - sqrt
  - sqrt2
  - log10
  - exp
  - sin
  - sind argument is in degrees, also in the following
  - cos
  - cosd
  - tan
  - tand
  - cotan
  - cotand
  - asin
  - asind
  - acos
  - acosd
  - atan
  - atand
  - acotan
  - acotand
  - sinh
  - cosh
  - tanh

- fraction
- abs
- Special arithmetic functions
  - der
  - gamma
  - loggamma
  - logistic
  - npv
- Probability distributions
  - pdf
  - cdf
  - bin
  - negbin
  - density
- Random numbers
  - ran
  - rann
  - ranpoi
  - ranbin
  - rannegbin
  - select
  - random
- Interpolation
  - interpolate
  - plane
  - bilin
- List functions
  - list
  - merge

- difference
- index
- index\_v
- len
- ilist
- putlist
- Creating a text object
  - text
  - txt
- File handling
  - exist\_f
  - delete\_f
  - close
  - showdir
  - setdir
  - thisfile
  - filestat
  - read
  - write
  - print
  - ask
  - askc
  - printresult
  - printresult2
- Matrices
  - matrix
  - nrows
  - ncols
  - t
  - inverse

- solve
- qr
- eigen
- sort
- envelope
- ind
- mean
- sum
- var
- sd
- minloc
- maxloc
- cumsum
- corrmatrix
- Data functions
  - data
  - newdata
  - exceldata
  - linkdata
  - getobs
  - nobs
  - classvector
  - values
  - transdata
- Statistical functions
  - stat
  - cov
  - corr
  - regr
  - mse

- rmse
- coef
- r2
- se
- nonlin
- varcomp
- classify
- class
- Linear programming
  - problem
  - jlp
  - weights
  - unit
  - schedcum
  - schedw
  - weight
  - partweights
  - partunit
  - partschedcum
  - partschedw
  - partweight
  - priceunit
  - weightschedcum
  - priceschedcum
  - priceschedw
  - weightschedw
  - integerschedw
  - xkf
- Plotting figures
  - plotyx

- draw
- drawclass
- drawline
- show
- plot3d
- Splines, stem splines, and volume functions
  - tautspline
  - stemspline
  - stempolar
  - laasvol
  - laaspoly
  - integrate
- Bit functions
  - setbits
  - clearbits
  - getbit
  - getbitch
  - bitmatrix
  - setvalue
  - closures
- Misc. utility functions
  - value
  - properties
  - cpu
  - seconds

## 6 Special functions

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

## 6.1 setoption(): set option on

When a function has an option then the interpreter generates first code `setoption(...)` where the arguments of the option are interpreted in the similar way as arguments of all functions. Then the interpreter generates the code for `setoption()` function in a special way.

## 6.2 getelem(): extracting information from an object

The origin of this function is the function which was used in previous versions to take a 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`. 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.

### 6.2.1 Get or set a matrix element or submatrix

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

One can get or set matrix elements and submatrices as follows. If the expression is on the right side of '=' then J gets a REAL value or submatrix, if the expression is on the left side of '=', the J 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 x 1 MATRIX. This can be useful when working with matrices whose dimensions can vary starting from 1 x 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 il1 and il2 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	REAL   ILIST
------	-----	--------------

row and column range as explained below.

---

<b>diag</b>	N  Get or set diagonal elements
<b>sum</b>	N 0 1 When setting elements, the right side is added to the current elements. If the <b>sum-&gt;</b> 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.

<b>J M(r,c)</b>	Get or set single element.
<b>J C(r)</b>	Get or set single element in column vector.
<b>J R(c)</b>	Get or set single element in column vector.
<b>J M(RANGES)</b>	Get or set a submatrix, where RANGES can be. For a column vector, the column range need not to specified.

<b>J r1,-r2,c1,-c2</b>	
<b>J r,c1,-c2</b>	part of row r
<b>J r1,-r2,c</b>	part of column c
<b>J r1,-r2,All</b>	All columns of the row range
<b>J All,c1,-c2</b>	All rows of the column range
<b>J r1,...,rm,c1,...,cn</b>	Given rows and columns
<b>J r1,...,rm</b>	Given rows for column vector
<b>J il1,il2</b>	for matrix with several columns
<b>J il1</b>	for column vector

**J** When  $r_2 = m$ , then  $-r_2$  can be replaced with **Tolast**.

**J** When  $c_2 = n$ , then  $-c_2$  can be replaced with **Tolast**.

If option **diag->** is present then

**J M(diag->)** Get or set the diagonal. If **M** is not square matrix, and error occurs.

**J M(r1,-r2,diag->)** (Again  $-r_2$  can be **Tolast**.

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. [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,sum->2);  
C=A(1,3,4...2);  
H=matrix(4,4,diag->,do->3);  
H(3,-4,diag->)=matrix(2,values->(4,7)); When giving range, the lower and  
upper limit can be equal.qual
```

### 6.3 **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)=..). If someone starts to use the own function property of the open source J, she/he probably would like to get the possiblity to put information into from her/his object types also. To implement this property requires some co-operation from my side. In effect the **getelem()** and **setelem()** functions are excuted in the same **getelem()** subroutine, because bot functions can utilize the same code.

### 6.4 **list2()**

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

### 6.5 **setcode()**: Initialization of a code option

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

### 6.6 **Own functions: o1\_o1\_funcs(), o2\_funcs() and o3\_funcs()**

The users of open J can define their own functions using three available own-function sets. In addition to own functions open J is ready to recog-

nize also own object types and options which are defined in the source files controlled by the users. The main **J** does not know what to do with these own object types and options, they are just transmitted to the own functions. In the main **J** the control is transmitted to the own functions using **J** functions o1\_o1\_funcs(), o2\_funcs() and o3\_funcs().

## 7 Functions for handling objects

The following functions can handle objects.

### 7.1 Get type of an object: **type()**

The index of any object can be accessed by **type(object)**. If the argument is a character variable or 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. [typeex]Example of type

ttt=8; !REAL

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

### 7.2 Deleting objects: **delete\_o()**

When an object with a given name is created, the name cannot be removed. With **delete\_o()** function one can free all memory allocated for data structures needed by general objects: **delete\_o(obj1,â&gt;,objn)** After deleting an object, the name refers to a real variable (which is initialized by the **delete\_o()** function into zero). Other objects except matrices can equivalently be deleted by giving command **obj1,â&gt;,objn = 0** This is because the output objects of any functions are first deleted before defining them anew. Usually an object is automatically deleted if the object name is used as an output object for other functions. One can see how much memory each object is using **print(Names).mes** Deleting a compound object deletes also such subobjects which have no meaning when the main object is deleted. But e.g. if a data object is deleted then the associated transformation object is not deleted as the transformation can be used independently. Files can be

deleted with `delete_f(file)`. See IO-functions for details. If the user has defined own new compound objects in the open source **J** software she/he needs to define the associated delete function.

### 7.3        `oexist_o()` : does an object exist

looks whether an object with the name given in the character constant argument exists. In the previous versions of **J** same function was used for files and objects.

### 7.4        `name()`: writes the name of an object

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

## 8        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 executed 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.

### 8.1        Generating a transformation object `trans()`

`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. **J** 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\[` yielding `]tr\ob[`. 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.

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.	

---

Options input->, local->, matrix->, arg->, result->, source-> of previous versions are obsolete. 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.`. The value of Printresult can be changed in other parts of the transformation, or in other transformations called or during execution of `pause()`.

Output variables in `maketrans->` transformations whose name start with \$ are not put into the new data object. [transex]Demonstrates also error handling

```

tr=trans()
$x3=x1+3
x2=2/$x3;
/
tr%input,tr%output,tr%source;
x1=8
call(tr)
tr2=trans(x1,x2)
$x3=x1+3
x2=2/$x3;
x3=x1+x2+$x3;
/
tr2%input,tr2%output,tr2%source;
call(tr2)

```

```

tr23; !x3 is now local
tr3=trans()
x1=-3
call(tr) !this is causing division by zero
/
Continue=1 !continue after error
call(tr3)

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

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

<x1=8

<call(tr)
x2=0.18181818

<tr2=trans(x1,x2)
<$x3=x1+3
<x2=2/$x3;
<x3=x1+x2+$x3;
</
<tr2%input,tr2%output,tr2%source;
tr2%input is list with           1 elements:
x1
tr2%output is list with         1 elements:

```

```

x2
tr2%source is text object:
1 $x3=x1+3
2 x2=2/$x3;
3 x3=x1+x2+$x3;
4 /
///end of text object

<call(tr2)
x2=0.18181818

tr2\x3=19.1818181

<tr2\x3;
tr2\x3=19.1818181

<tr3=trans()
<x1=-3
<call(tr)
</
<Continue=1
<call(tr3)
*division by zero
*****error on row           2  in tr%source
x2=2/$x3;
recursion level set to     3.0000000000000000

*****error on row           2  in tr3%source
call(tr)
recursion level set to     2.0000000000000000

*err* transformation set=$Cursor$
recursion level set to     1.0000000000000000
****cleaned input
call(tr3)
*Continue even if error has occurred
<;return

```

## 8.2 Executing transformation object explicitly `call()`

Interpreted transformations in a transformation object can be automatically executed by other **J** functions or they can be executed explicitly using `call()` function.

---

Arg	1	TRANS
		The transformation object executed.

---

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. [recursion]Recursion produces system crash.

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

## 8.3 Pause: `pause()`

Function `pause()` stops the execution of **J** 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 **J** 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. 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.

## 8.4 Number of options in the current function: `noptions()`

`noptions()` returns as a REAL value the number of options currently active. This may be used for testing purposes. When **J** processes options in different funtions, it varies at which point options are cleared and number of options decreases

## 9 Co-operation between J and R

Is is possible to run R script from J and J scripts from R.

### 9.1 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. [Rex]Example of Rscript

```
rscript=text()  
# A simple R-script that generates a small data to file mydat.txt  
wd<-"C:/j3/"  
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')
```

### 9.2 Calling J-scripts from R

File JR\_0.0.tar.gz in the folder J\_R contains R tarball for taking J subroutines into R. With R command `JR(âtestr.incâ)` 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 J memory. For further information contact lauri.mehtatalo@luke.fi

## 10 Loops and control structures

This section describes nonstandard functions.

### 10.1 do() loops

The loop construction in J looks as follows:  
`do(i,start,end[,step])`

```

enddo
cycle and exit are implemented in the current J version with goto() Within
a doâloop there can be cycleand exitdostatements There can be 8 nested
loops. do-loop is not allowed at command level.evel [doex]do-loop
'begin';
tr=trans()
do(i,1,5)
i;
ad1: if(i.eq.3)goto(cycle)
i;
if(i.eq.4)goto(jump)
cycle:enddo
jump:i;
!goto(ad1) !it is not allowed to jump into a loop
/
call(tr)

```

## 10.2      **if()**

**if()**j\_statementâ|  
The one line if-statement.

## 10.3      assignment: **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

- J **output** is MATRIX and **input** is scalar, then each element of MATRIX is replaced with the **input** in **assone()** function.
- J **output** is submatrix expression, then the elements of the submatrix are assigned in **setelem()** funtion whether **input** is MATRIX or submatrix expression, scalar or LIST.
- J **output** is MATRIX and on input side is a random number generation function, the random numbers are put to all elements of the matrix.
- J If on output side are many object names, and input side is one REAL value, this is put to all variables.

- J 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.

[assignex]Examples of assignments

```
a=matrix(2,3);
a=4;
a=rann();
v1...5=2...6;
v1...5=77;
Continue=1 !ERROR
v1..3=1,5;
Continue=0
```

## 10.4 Selecting a value based on conditions.

Usage://

output=which(condition1,value1,...,conditionn,value<sub>n</sub>) // or// output=which(condition1,value<sub>1</sub>,value<sub>2</sub>,...,value<sub>n</sub>)  
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. [whichex]Example of which()

```
c=9
which(a,eg.3.or.c.gt.8,5,a.eq.7,55);
a=7
which(a,eg.3.or.c.gt.8,5,a.eq.7,55);
a=5
which(a,eg.3.or.c.gt.8,5,a.eq.7,55);
which(a,eg.3.or.c.gt.8,5,a.eq.7,55,108);
```

## 10.5 erexit()

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

```
[erexitex]itex
tr=trans()
if(a.eq.0)erexit('illegal value ',a)
s=3/a; !division with zero is teste automatically
/
a=3.7
```

```

call(tr)
tr(s); !tr can also be used as a function
a=0
Continue=1 !Do not stop in this selfmade error
call(tr)
Continue=0

```

## 10.6      **goto()**

Control can be transferred to a line in a transformation set with **goto()**. [go-toex]

```

tr=trans()
i=0
if(i.eq.0)goto(koe)
'here';
koe:ch='here2';
/
call(tr)
ch;

```

It is not allowed to jump in to a loop or into if -then structure. This is checked already in in the interpreter. It is not yet possible to continue within an include file using Continue=1. It is not recommended to use **goto()** according to modern computation practices. However, it was easier to implement cycle and exitdo with **goto()**, especially if cycle or exitdo does not apply the innermost do-loop.

## 11      Arithmetic and logical operations

**!The arithmetic and logical operations are first converted into the polish notation.**

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,

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

**J** 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 +.

## 11.1 Minimum and maximum: **min()** and **max**

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

**J** **min**(x1,x2):: minimum of two REAL

**J** **min**(MATRIX,REAL):: each element is **min**(elem,REAL)

**J** **min**(MATRIX):: row vector having minimums of all columns

**J** **min**(MATRIX,**any->**):: minimum over the whole matrix

# 12 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:

[J] **mean**(VECTOR) computes the mean of the vector, output is REAL

[J] **mean**(MATRIX) computes the mean of each column. Result is

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

## 12.1 **mean()**: means or weighted means of matrix columns

See section matrixstat for details

## 12.2 **sd()**: sd's or weighted sd's of matrix columns

See section matrixstat for details

## 12.3 **var(): Sample variances or weighted variances of matrix c**

See section matrixstat for details

## 12.4 **sum(): sums or weighted sums of matrix columns**

See section matrixstat for details

# 13 Special arithmetic functions

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

## 13.1 **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 ] <b>d[[Argi]</b> variable will get the value of the derivative with respect to the argument <b>Argi</b> .
------	---

---

```
[derex]Derivatives with der()
tr=trans()
der(x)
f=(1+x)*cos(x)
/
fi=draw(func->tr(d[x]),x->x,xrange-(0,10),color->Blue,continue->)
fi=draw(func->tr(f),x->x,xrange-(0,10),color->Cyan,append->,continue->fcont)
[derex2]2
```

```

X=matrix(do->(0,1000,10))
e=matrix(nrows(X))
e=rann(0,2);
A,Pmax,R=0.1,20,2
A*Pmax*1000/(A*1000+Pmax);
Y=A*Pmax*X/.(A*X+Pmax)-R+ e !rectangular hyperbola used often for photosynthesis
rect=trans()
der(A,Pmax,R)
f=A*Pmax*I/(A*I+Pmax)-R
/
fi=draw(func->(rect(f)),x->I,xrange->(0,1000),color->Orange,width->2,continue-
>,show->0)
da=newdata(X,Y,e,extra->(Regf,Resid),read->(I,Per))
stat()
fi=plotyx(PI,append->,show->0,continue->fcont)
A,Pmax,R=0.07,17,3 !initial values
fi=draw(func->(rect(f)),x->I,xrange->(0,1000),color->Green,width->2,append-
>,show->0,continue->)
reg=nonlin(Pf,par->(A,Pmax,R),var->,corr->,data->da,trans->rect)
reg%var;
reg%corr;
corrmatrix(reg%var);
fi=draw(func->(rect(f)),x->I,xrange->(0,1000),color->Violet,append->,continue-
>fcont)

```

## 13.2 gamma function: **gamma()**

Function **gamma()** produces the value of gamma function for a positive argument. The function utilises gamma subroutine from library dcdflib in Netlib.

## 13.3 **logistic()**: value of the 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 non-linear 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 [logisticex]Example of logistic function

```
tr=trans()
der(a,x0)
f=logistic(a*(x-x0));
/
x,x0,a=10,5,0.1
d[a],d[x],tr(d[x0]);
```

In the previous example `tr(d[x0])` has the effect that TRANS 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.

## 13.4 `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`.

# 14 Functions for probability distributions

There are currently the following functions relate to probability distributions. 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.

## 14.1 Density for normal distribution: `pdf()`

---

Output	1	REAL the value of the density.
Args	0-2	REAL <code>Arg1</code> is the mean (default 0), <code>Arg2</code> is the standard deviation (default 1). If <code>sd</code> is given, the mean must be given explicitly as the first argument.

---

See example `drawclassex` for an utilization of `pdf()`

## 14.2 Cumulative distribution function for normal and chi2: `cdf`

---

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

### 14.3      **bin()**: binomial probability

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

### 14.4      **negbin()**:: negative binomila distribution

**negbin(k,myy,theta)**// Gives the probability that a negative binomial random variable has value **k** when the variable has mean **myy** and variance **myy+theta[\*]myy[\*\*2]**. **negbin(k,n\*p,0)= bin(k,n\*p)**. Sorry for the parameter inconsistency with **rannegbin()**.

### 14.5      **density()** define

any discrete or continues distribution for random numbers either with a function or histogram generated with **classify()**

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

---

Actually the function generates a matrix having two rows which has values for the cumulative distribution function. When defining the density function, the user need not care about the scaling constant which makes the integral to integrate up to 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)  
fi=drawclass(cl,area->)  
fi=draw(func->pdf(x),x->x,xrange->,append->)  
f=matrix(1000)  
f=rann()  
da=newdata(f,read->x)  
stat(min->,max->)  
cl=classify(x->x,xrange->)  
fi=drawclass(cl,histogram->,classes->20)  
den=density(cl);  
fi=drawline(den)
```

## 15 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.

## 15.1 ran(): uniform random number

Uniform random numbers between 0 and 1 are generating usig Netlib function ranf.

---

Output 1 REAL|MATRIX

The generated REAL value or MATRIX. Random matrix cab generated by defining first the matrix with `matrix()`.

---

```
[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;
```

## 15.2 rann(): normal random variate

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

---

Output 1 REAL|MATRIX

The matrix to be generated bus be defined earlier with `matrix()`.cm er

---

Args 0-2 num

`rannn()` produces  $N(0,1)$  variables, `rann(mean)` will produce  $N(\text{mean},1)$  variables and `rann(mean,sd)` procuses  $N(\text{mean},\text{sd})$  variables.

---

[rannex]Random normal variates, illustrating also find  
`rx=rann()` !Output is REAL

```

rm=matrix(100)
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->)
print(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(rm,filter->($.ge.14),any->)
print(100*nrows(large)/nrows(rm))
! 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.

```

### 15.3 ranpoi(): random Poisson variables

`ranpoi(myy)` returns a random Poisson variable with expected value and variance `myy`

### 15.4 ranbin(): random binomial values

Binomial random numbers between 0 and n are generated using Netlib `ign-bin(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. (J 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. !

[ranbinex]x

`ranbin(10,0.1);`

```

ranbin(10,0.1);
!
A=matrix(1000,2)
A(All,1)=ranbin(20,0.2)
A(All,2)=ranbin(20,0.2)
da=newdata(A,read->(s1,s2))
stat()
cl=classify(1,x->s1)
fi=drawclass(cl,histogram->,color->Blue,continue->fcont)
cl=classify(1,x->s2)
fi=drawclass(cl,histogram->,color->Red,append->,continue->fcont)

```

## 15.5 **rannegbin()**: negative binomial variates

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 râth failure when p is the probability of success. **ranbin**(r,1)returns 1.7e37 and **ranbin**(r,0)returns 0.

---

!Args	REAL	
	<b>r=Arg1</b> and <b>p=Arg1</b>	

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) inconsistency of parameters with function **negbin()**. **rannegbin()** 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.

## 15.6 **select()**: Random selection of elements

---

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

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

---

Args            2            REAL  
k=[Arg1](#) and n=[Arg2](#).

---

[selectex]Random selection  
S=[select](#)(500,10000)  
[mean](#)(S),[sum](#)(S),500/10000;

## 15.7      **random()**: random variates from any distribution

usage [random](#)([dist](#)) where [dist](#) is the density defined in [density\(\)](#). See [density\(\)](#) for examples.

# 16        Functions for interpolation

The following functions can be used for interpolation

## 16.1        **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. The argument x need not be within the interval of given x values (thus the function also extrapolates).

## 16.2        **plane()** interpolation from 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.

## 16.3        **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

## 17 List functions

The following list functions are available

### 17.1 Object lists

An object list is a list of named J 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.

### 17.2 `list()` generates a LIST object

---

Output	1	LIST
		The generated LIST object.
Args	0-	
		named objects. If an argument is LIST it is ex+panded
<code>mask</code>	N 1-	REAL
		Which object are picked from the list of arguments. value 0 indicates that he 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.

---

The same object may appear several times in the list. (see `merge()`)ge There may be zero arguments, which result in an empty list which can be updated later. The index of object in a LIST can be obtained using `index().ex`

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

```

[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

```

### 17.3 merge()

`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.

---

```

[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

```

### 17.4 Difference of LIST objects

`difference()` removes elements from a LIST

---

Output	1	LIST
		the generated LIST.

---

---

Args	2	LIST OBJ
		The first argument gives 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 remode from the lisrt.

---

```
[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
```

## 17.5 **index(): index of a variable in a data object**

To be documented later

## 17.6 **index(): index of a variable in a data object**

To be documented later

## 17.7 **len() lengths of different lists or vectors**

**len(arg)** gives the following lenghts for different argument types

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

J **arg** is TEXT => len=the number of chracter in TEXT object

J **arg** is LIST => len=the number of elements in LIST

J **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.

## 17.8 **ilist()**: list of integers

Generates a list of integers which can be used as indexes. This function is used implicitly with .

Output	1	I LIST
		The generated I LIST.
Args	0-	REAL
		Values to be put into I LIST, or the dimesion of the I LIST when values are given in <b>values-&gt;</b> , or variables whose indeces in in the data are put into the I LIST.
<b>data</b>	N 1	DATA
		The DATA object from whose variable indeces are obtained.
<b>extra</b>	1	REAL
		Extra space reserved for later updates of the I LIST.
<b>values</b>	N 1-	REAL
		Values to be put into I LIST when dimesnion is determined as the only argument

I LIST is a new object whose all utilization possiblities are not yet explored. It will be used e.g. when developing factory optimization. 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 I LIST object is the same as LIST object which can be used in matrix computations. [ilistex]I LIST examples

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

## 17.9 **putlist()**

Usage:// **putlist**(LIST,OBJ)// put OBJ into LIST

# 18 Creating two types of text objects

There are now two object types for text.

## **18.1      `text()` creates the old TEXT object**

Text objects are created as a side product by many J functions. Text objects can be created directly by the `text()` function which works in a non-standard way. The syntax is: `output=text()// â| //`

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)

## **18.2      `txt()` generates the new TXT object.**

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

# **19        File handling**

The following function can handle files.

## **19.1      `_exist_o()` : does an object exist**

looks whether an object with the name given in the character constant argument exists. In the previous versions of J same function was used for files and objects.

## **19.2      Deleting objects: `delete_o()`**

When an object with a given name is created, the name cannot be removed. With `delete_o()` function one can free all memory allocated for data structures needed by general objects: `delete_o(obj1,â|,objn)` After deleting an object, the name refers to a real variable (which is initialized by the `delete_o()` function into zero). Other objects except matrices can equivalently be deleted by giving command `obj1,â|,objn = 0` This is because the output objects of any functions are first deleted before defining them anew. Usually an object is automatically deleted if the object name is as an output object for other functions. One can see how much memory each object is using `print(Names).mes` Deleting a compound object deletes also such subobjects which have no meaning when the main object is deleted. But e.g. if a data object is deleted then the associated transformation object is not deleted as the transformation can be used independently. Files can be

deleted with `delete_f(file)`. See IO-functions for details. If the user has defined own new compound objects in the open source J software she/he needs to define the associated delete function.

### 19.3 `close()` closes a file

`close(file)` closes an open file where file is either a character constant or character variable associated with a file. No `open(9)` function is needed. An file is opened when it is first time in `write()`.te if the file exists, it is asked whether the old file is dleted.

### 19.4 `showdir()` shows the current directory

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

### 19.5 `setdir()` sets the current directory

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

### 19.6 `thisfile()` returns the name of the current include 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. Using this function the shortcuts work even if the name of the include file is changed. See file `jexamples.inc` for an application

### 19.7 `filestat()` gives 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

## 20 io-functions

Theree are following io functions

## 20.1 **read()** read from a file

**read(file,format[,obj1,â],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.// '(â.)' a Fortran format. Does not work when reading matrices. \$ the \* format of Fortran// obj1,â,objn **J** 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 **J** is waiting until the file can be opened. Useful in client-server applications. See chapter **J** as a server. Use **ask()** or **askc()** to read values from the terminal when reading lines from an include file. When reading matrices, their shapes need to be defined earlier with **matrix()** hfunction.

## 20.2 **write()**

**write(file,format,val1,â, 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 **J** object is printed (usually it will be zero). If the val1 argument is a matrix, then all values are printed. val1,â, 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,â[,tn,valu[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,â[,tn,valu] 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.

## 20.3 `print()` prints objects

`print(arg1,â[,argn[,maxlines->][,[data->][,[row->][,[file->][,[func->][,[debug->]]]]])`// Print values of variables or information about objects.// Arguments: arg1,â[,argn] arguments can be any J objects or values of arithmetic or logical expressions or the only argument can be name of a text file. 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(âfileâ)`) 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 â(15f6.2)â` 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 For simple objects, all the object content is printed, for compli-

cates objects only summary information is printed. `print`(Names) will list the names, types and sizes of all named **J** objects. The printing format is dependent on the object type. `print()` function can be executed for the output of a **J** command 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, both ';' and ';;' outputs are printed.

## 20.4 `ask()` asks a value for 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. 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)

```
[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>')
```

## 20.5 `askc()` asks a value for a character variable

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)

<b>default</b>	0 1	CHAR default character strings
<b>q</b>	0 1	CHAR text used in asking
<b>exit</b>	-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 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). If there are no arguments, then the value is asked for the output variable, otherwise for the arguments.

## 20.6 printresult() and printresult2() e

The **J** 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, the bot ';' and ';;' outputs are printed. **printresult()** and **printresult2()** are simple functions which just test the value of **Printoutput** and then call the printing subroutine, if needed.

# 21 Matrix functions

**J** contains now the following matrix functions.

## 21.1 Matrices and vectors

Matrices and vectors are generated with the **matrix()** function or they are produced by matrix operations, matrix functions or by other **J** 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.

## 21.2 matrix(): create a 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 <code>matrix()</code> is an argument of an arithmetic function or matrix function. If no element values are given in <code>values-&gt;</code> or obtained from <code>in-&gt;</code> input, all elemets get value zero.
Args	0-2	REAL The dimension of the matrix. The first argument gives the number of rows, the second argument, if present, the number of columns. If the matrix is generated from submatrices given in <code>values-&gt;</code> , 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 <code>values-&gt;</code> option. If the first argument is <code>Inf</code> , the the number of rows is determined by the number number of lines in source determined by <code>in-&gt;</code> .
in	N 0 1	CHAR The input for values. <code>in-&gt;</code> means that values are read in from the following input paragrapgs, <code>in-&gt;file</code> 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, <code>J</code> gives possibility to continue with better luck, otherwise an error occurs.
values	N 1-	REAL values or MATRIX objects put to the matrix. The argumenst of <code>values-&gt;</code> 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 sub-matrices 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->**

---

[matrixex]Example of generating matrices

A=**matrix**(3,

### 21.3        **nrows()**: number of rows in MATRIX, TEXT or BIT-MATRIX

can be used as:

**J nrows(MATRIX)**  
**J nrows(TEXT)**  
**J nrows(BITMATRIX)**

If the argument has another object type, and error occurs

### 21.4        **ncols()**: number of columns in MATRIX or BITMATRIX

can be used as:

**J nrows(MATRIX)**  
**J nrows(BITMATRIX)**

If the argument has another object type, and error occurs

## 21.5 `t()` gives 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. Multiplying a matrix by the transpose of a matrix can be made by making new operation `*`. The argument matrix can also be a submatrix expression.

## 21.6 `inverse()`

`inverse(A)` computes the inverse of a square MATRIX A. The function utilized dgesv funtion 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 A is not a square matrix or REAL, or A is singular according to dgesv. instead of writing `c=inverse(a)*b`, it is faster and more accurate to write `c=solve(a,b)`

## 21.7 `solve()` solves a linear equation $A*x=b$

A linear matrix eqaution  $A*x=b$  can be solved for x with code// `x=solve(A,b)` `x=solve(A,b)` is faster and more accurate than `x=inverse(A)*b` solve works also if A and b are scalars. This is useful when working with linear systems which start to grow from scalars.

## 21.8 `qr()`

Makes QR decomposition of a MATRIX This can be used to study if columns of a are linearly dependent. `J` 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<sup>th</sup> 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 `J` has not properly interpreted which diagonal elements are zero. In `J 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.

---

## 21.9 **eigen()**

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 largest eigenvalue. Netlib subroutines DLASCL, DORGTR, DSCAL, DSTEQR, DSTERF, DSYTRD, XERBLA, DLANSY and DLASCL are used.

---

Args	1	MAT
		A square MATRIX.

---

## 21.10 **sort() sorts a 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. It is currently assumed that if there are two keys then the values in first key column have integer values. If key2 is not given and key1 is positive, then the syntax is: `sort(a,key->key1)`. If there is no output, then the argument matrix is sorted in place.lace The argument can be the data matrix of a data object. The data object will remain a valid data object.

## 21.11 **envelope() computes the 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
------	------	------

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

---

The transpose of the output can be directly used in frawline() function to draw the envelope. The function is using a subroutine made by Alan Miller and found in Netlib

## 21.12 **find()**

Function **find()** can be used to find the first matrix element satisfying a given condition, or all matrix elements satisfying the condition, and in that case the found elements can be put to a vector containing element numbers or to a vector which has equal size as the input matrix and where 1 indicates that the element satisfies the condition.. Remember that matrices are stored in row order. If a given column or row should be searched, use submatrix() 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 condition. 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  
Gives 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 to the output matrix

---

[findex] Example of find, illustrating also **rann()**

**!Repeating the example, different results will be obtained**

**rm=matrix(100)**

```

m,s=2,3
rm=rann(m,s)
print(mean(rm),sd(rm),min(rm),max(rm))

= 2.4564691829681395
= 3.2549002852383477
= -5.6481685638427734
= 10.714715003967285

first=find(rm,filter->($.ge.m+1.96*s))
large=find(rm,filter->($.ge.m+1.96*s),any->)
large2=find(rm,filter->($.ge.m+1.96*s),expand->)
print(first,100*nrows(large)/nrows(rm),100*sum(large2)/nrows(rm))

first= 12.000000000000000
= 4.000000000000000
= 4.000000000000000

```

## **21.13 mean(): means or weighted means of matrix columns**

See section matrixstat for details

## **21.14 sum(): sums or weighted sums of matrix columns**

See section matrixstat for details

## **21.15 var(): Sample variances or weighted variances of matrix c**

See section matrixstat for details

## **21.16 sd(): sd's or weighted sd's of matrix columns**

See section matrixstat for details

## **21.17 minloc() : locations of the minimum values in columns**

**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.

## 21.18 **maxloc()** : locations of the minimum values in columns

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

## 21.19 **cumsum()**: cumulative sums of matrix columns

**cumsum**(MATRIX) generates a MATRIX with the same dimesnions as the argument, and puts the cumulative sums of the columsn into the output matrix. If the argument is vector, the cumsum makes a vector having the same form as the argument.

## 21.20 Making correaltion matrix from variance-covariance amtrix:

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

Output	1	MATRIX matrix having nondiagonal values $\text{Out}(i,j)=\text{arg}(i,j)= \text{arg}(i,j)/\sqrt{\text{arg}(i,i)*\text{arg}(j,j)}$ .
Args	1	MATRIX symmetric matrix
sd	N 0	If $\text{sd} >$ is given, then diagonal elements will be equal to $\sqrt{\text{arg}(i,i)}$

## 22 Working with DATA objects

Data can be analyzed and processed either using matrix computations or using DATA objects. A DATA object is compound object linked to a data MATRIX and LIST object containing variable (column) names, some other information. When data ere used via DATA object in statistical or linear programming functions, the data are processed obsevarion by observation. It is possible to work using DATA object or using directly the data

matrix, wherever 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 **J** functions which create DATA objects from files, `data()` and `exceldta()`. `data()` can create hierarchical data objects. Function `newdata()` creates DATA object from matrices, which themselves can be picked from data objects. Function `linkdata()` can link two data sets to make a hierarchical data. If a data file contains columns which are referred with variable names and some vectors, it is practical to read data first into a matrix using `matrix()` function and then use matrix operations and `newdata()` to make DATA object with variable names and matrices. See Simulator section for an example. `transdata()` function goes through DATA object 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. 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.

## 22.1 `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	0 1	Data	
	Output	0 1	Data object to be created. If there is no output then the default is \$Data\$. It is recommended that this default is used only when only one data object is used in the analysis. !

---

<b>read</b>	0 1           REAL List
	Variables read from the input files or the name of the list containing all variables to be read in. If no arguments are given and there is no <b>readfirst-&gt;</b> option then the variables to read in are stored in the first line of the data file separated with commas.?? Also the $\wedge$ -shortcut can be used to define the variable list. If no arguments are given and there is <b>readfirst-&gt;</b> option then the variable names are read from the second line.
<b>in</b>	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 <b>read-&gt;</b> or <b>in-&gt;</b> option is given, then both options must be present.
<b>form</b>	-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 access for Intel Fortran files.
<b>maketrans</b>	-1 1           TRANS
	Transformations computed for each observation when reading the data
<b>keep</b>	-1 1-           REAL
	variables kept in the data object, default: all <b>read-&gt;</b> variables plus the output variables of <b>maketrans-&gt;</b> transformations.
<b>obs</b>	-1 1           REAL
	Variable which gets automatically the observation number when working with the data, variable is not stored in the data matrix, default: Obs. When working with hierarchical data it is reasonable to give obs variable for each data ob-

---

ject.

---

<b>filter</b>	-1 1      Code logical or arithmetic statement (nonzero value indicating True) describing which observations will be accepted to the data object. <a href="#">maketrans-&gt;</a> -transformations are computed before using filter. Option <a href="#">filter-&gt;</a> 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.
<b>reject</b>	-1 1      Code Logical or arithmetic statement (nonzero value indicating True) describing which observations will be rejected from the data object. If <a href="#">filter-&gt;</a> option is given then reject statement is checked for observations which have passed the filter. Option <a href="#">reject-&gt;</a> 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 <a href="#">in-&gt;</a> . subread,â subobs sub data options similar as <a href="#">read-&gt;</a> â obs-> for the upper level data. ( <a href="#">subform-&gt;</a> 'bgaya' is the format for the Gaya system). The following options can be used only if <a href="#">subdata-&gt;</a> is present
<b>nobsw</b>	-1 1      REAL A variable in the upper data telling how many subdata observations there is under each upper level observation, necessary if <a href="#">subdata-&gt;</a> option is present.
<b>nobswcum</b>	-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,â nobswcum+nobsw

---

<b>obsw</b>	-1 1        REAL	A variable in the subdata which automatically will get the number of observation within the current upper level observation, i.e. obsw variable gets values from 1 to the value of nobsw-variable, default is 'obs_variable%obsw'.
<b>duplicate</b>	-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 <a href="#">duplicate-&gt;</a> option, then all transformations for the subdata can be defined in the duplicate transformation object, and <a href="#">submaketrans-&gt;</a> is not necessary.
<b>oldsubobs</b>	-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 <a href="#">subkeep-&gt;</a> list, or, if <a href="#">subkeep-&gt;</a> option is not given then this variable is automatically put into the <a href="#">keep-&gt;</a> list of the subdata.
<b>oldobsw</b>	-1 1        REAL	This works similarly with respect to the initial obsw variable as <a href="#">oldsubobs-&gt;</a> works for initial obs variable.
<b>nobs</b>	-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 <a href="#">nobs-&gt;</a> option and <a href="#">maketrans-&gt;</a> transformation, which can use Obs variable as argument. Creation of data object this way is indicated by the presence of <a href="#">nobs-&gt;</a> option and absence of <a href="#">in-&gt;</a> and <a href="#">read-&gt;</a> options. Second, if <a href="#">read-&gt;</a> option is present <a href="#">nobs-&gt;</a> 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.

---

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

---

data

If there are both rfhead-> and rfcode-> then rfhead-> is excuted 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
------	---

**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 containg the data as a single precision matrix. The number of observations can be obtained by nobs(Data) or by nrows(Data%matrix). See common options section for how data objects used in other J functions will be defined. 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. When reading the data the **obs->**variable (default Obs) can be used in maketrans-> transformation and in **reject->** option and **filter->** option, and the variable 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. 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. If no observations are rejected, obs variable and Record variable get the same values. If virtual memory overflow occurs, see **nobs->** optio. This should not happen easily with the currrent 64-bit application. 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->**. [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
/
```

## 22.2 newdata()

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.
<b>read</b>	N 1-	REAL Variable names for columns of matrices in the order of matrices.
<b>maketrans</b>	N 1	TRANS A predefined transformation object computed for each observation.
time	-1 0	If time-> is present, the cpu-time and total time in function are printed

It is not yet possible to drop variables. An error occurs if the same variable is several times in the variable list obtained by combining variables in data sets and **read->** variables. An error occurs if the numbers of rows of matrices and observations in data sets are not compatible. Output variables in **maketrans->** transformations whose name start with \$ are not put into the new data object. [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
/
newtr=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->newtr)
print(new)

```

## 22.3      **datawcase()**: Creates a data object where each observation has name

This function will replace or be alternative for properties function. This function, to be reported later, will be used in factory optimization.

## 22.4      **exceldata()**

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 J 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;species0
```

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.

## 22.5 linkdata() links hierarchical data sets

linkdata(data->,subdata->,nobs->[,obsw->])// links hierarchical data sets.

data	1	DATA the upper level data set object
subdata	1	DATA the lower data set object
nobs	1	REAL the name of variable telling the number of lower level observations for each
obsw	0 1	REALV

variable which will automatically get the number of lower level observation within each upper level observation. If not given, then this variable will be the Obs-variable of the upper level data.

---

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. When using linked data in other functions, the values of the upper level variables are automatically obtained when accessing lower level observations. Which is the observational unit in each function is determined which data set is given in `data->` option or defined using Data list. In the current version of J it is no more necessary to use linked data sets in `jlp()` function, as the treatment unit index in data containing both stand and schdedule data can be given in `unit->` option

## 22.6 `getobs()` loads an 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 object

---

`obs` 1 REAL  
row number in the data matrix of the dataset

---

`trans` -1|1 TRANS  
these transformations are also executed.

---

## 22.7 `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()`.

## 22.8 **classvector()**

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 <b>first-&gt;</b> and/or <b>last-&gt;</b> are present. Let $\$Arg$ be the generic name for arguments.	
<b>class</b>	1	REAL	
	.oindent class	1	REAL
<b>class</b>	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 <b>trans-&gt;</b> transformations. When the <b>class-&gt;</b> variable, denoted as $\$Class$ changes, the class changes.	
<b>data</b>	0 1	Data	
		Data object used. Only one data object used; extra <b>data-&gt;</b> objects just ignored. The default is the last data object generated.	
<b>expand</b>	-1 0		
		If <b>expand-&gt;</b> 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 <b>expand-&gt;</b> is not present, the lengths of the output vectors are. equal to the number of classes.	
<b>first</b>	0		
		The the number of first observation in class is stored in vector $\$Class\%first$ if <b>expand-&gt;</b> is present and $\$Class\%first$ if <b>expand-&gt;</b> is not present.	

---

<b>last</b>	0	The the number of lastt observation in class is stored in vector <code>Class%&gt;%last</code> if <code>expand-&gt;</code> is present and <code>Class%&gt;%last</code> if <code>expand-&gt;</code> is not present.
<b>obsw</b>	0	If there axpnad-> option then vector <code>Class%&gt;%obsw</code>
<b>ext</b>	-1 1	Char The extension to the names of vectors generated for arguments. Let Ext be denote the extension.
<b>mean</b>	-1 0	The class means are stored in the vectors <code>Â\$Arg#Class%&gt;%mean</code> with <code>expand-&gt;</code> and without <code>ext-&gt;</code> <code>Â\$Arg#Class%&gt;%meanExt</code> with <code>expand-&gt;</code> and with <code>ext-&gt;</code> are <code>Â\$Arg#Class%&gt;%mean</code> without <code>expand-&gt;</code> and without <code>ext-&gt;</code> <code>Â\$Arg#Class%&gt;%meanExt</code> without <code>expand-&gt;</code> and with <code>ext-&gt;</code>
<b>sd</b>	-1 0	Class standard deviations are computed to sd vectors
<b>var</b>	-1 0	Class variances are computed to var vectors
<b>min</b>	-1 0	Class minimums are computed to min vectors
<b>max</b>	-1 0	Class maximums are computed to max vectors.

---

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` [newclassdata]Making class level  
 data object

```

classvector(x1,x2,class->stand,data->trededata,mean->,min->)
standdata=newdata(x1#stand%mean,x2#stand%mean,x1#stand%min,x2#stand%min,
read->(x1,x2,x1min,x2min)) [addingclass]Adding class means and devia-
tions from class means
classvector(x1,x2,class->stand,data->trededata,mean->,expand->)
tr=trans()
relx1=x1-x1mean

```

```

relx2=x2-x2mean
/
treedata=newdata(treedata,x1#stand%mean,x2#stand%mean,read->(x1mean,x2mean),
maketrans->tr)

```

## 22.9        **values()** extracts values of class variables

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

---

Output	1	VECTOR the vector getting differen values
<b>arg</b>	1	REALV variables whose values obtained
<b>data</b>	1	DATA The data set.

---

The values found will be sorted in an increasing order. After getting the values into a vector, the number of different values can be obtained using **nrows()** function.

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

## 22.10        **transdata()** own transformations for data

**transdata()** is useful when all necassy computations are put into a TRANS object, and a DATA object is gone throug obsevation by observation. This is useful e.g. when simulating harvesting schdules using a simulator which is defined as an ordinary TRANS object. 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

```

## 23 Statistical functions

There are several statistical functions which can be used to compute basic statistics linear and 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 21.2

### 23.1 stat()

Computes and prints basic statistics from data objects.

---

Output	0-1 kokopo	REAL
Args	0-99 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	REAL
data	-1,99 data objects , see section Common options for default!	Data weight gives the weight of each observations if weighted means and variances are transformation or it can be a variable in the data object @@seecom
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. stat(x1,x2,min-> "%pien") stores minimums into variables x1%pien and x2%pien. The

---

default value for min is '%min'. If the values of the [min->](#) option are variables, then the minima are stored into these variables.

---

<a href="#">max</a>	-1,99	REAL	
			maxima are stored, works as <a href="#">min-&gt;</a>
<a href="#">mean</a>	-1,99	REAL	
			means are stored
<a href="#">var</a>	-1,99	REAL	
			variances are stored
<a href="#">sd</a>	-1,99	REAL	
			standard deviations are stored
<a href="#">sum</a>	-1,99	REAL	
			sums are stored, (note that sums are not printed automatically)
<a href="#">nobs</a>	-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
<a href="#">trans</a>	-1   1	TRANS	
			transformation object which is executed for each observation. If there is a transformation object associated with the data object, those
<a href="#">filter</a>	-1   1	Code	
			logical or arithmetic statement (nonzero value indicating True) describing which observations will be accepted. <a href="#">trans-&gt;</a> transformations
<a href="#">reject</a>	-1   1	Code	
	reject	-1   1	Code
<a href="#">transafter</a>	-1   1	TRANS	
			transformation object which is executed for each observation which has passed the filter and is not rejected by the <a href="#">reject-&gt;</a> -option

---

1: `stat()` function prints min, max, means, sd and sd of the mean computed as sd/sqrt(number of observations) 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. [statex]`stat()` computes minimums, maximums, means and std devaitons

```
;if(type(data1).ne.DATA)dataex
stat()
stat(area,data->cd,sum->bon20,filter->(site.ge.18.5))
stat(ba,data->cd,weight->area)
stat(vol,weight->(1/dbh***2))
```

## 23.2 `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.

the output is not automaticall printed, but it can be printed using ';' at the end of line. The covariance matrix can changed into correaltion matrix with `corrmatrix()` function. If variable `w` in the data is used as the weigth, this can be expressed as `weight->w` [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
dat=newdata(X1...X6,read->(x1...x5))
co=cov(x1...x5);
co=cov(dat%keep);
```

### 23.3 **corr()** computes a correlation matrix.

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

### 23.4 **regr()**: linear regression.

Ordinary or stepwise linear regression 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	<b>noint-&gt;</b> implies that the model does not include intercept
step	-1 1	REAL t-value limit for stepwise regression. Regression variables are dropped 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 <b>var-&gt;</b> is present <b>regr()</b> generated matrix <b>]output%var[</b> for the variance-covariance matrix of the coefficient estimates.
corr	-1 0	if <b>vcorr-&gt;</b> is present <b>regr()</b> generated matrix <b>]output%corr[</b> 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.

If the DATA object contains variables **Regr** and **Resid**, then the values of the regression function and residuals are put into these columns. Space for these columns can be reserved with **extra->** option in **data()** or in **newdata()**. 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 teh function is called. Information from the REGR object can be obtained with the following functions. let `re` be the name of the REGR object.

- J `coef(re,xvar)` = coefficient of variable xvar
- J `coef(re,xvar,any)` = returns zero if the variable is dropped from the equation in the setwise procedure of due to linear dependencies.
- J `coef(re,1)` or `coef(Jre,$1)` returns the intercept
- J `se(re,xvar)` standard error of a coeffcient
- J `mse(re)` MSE of the regression
- J `rmse(re)` RMSE of the regression
- J `r2(re)` adjusted R2. If the intercept is not present this can be negative.
- J `nobs(re)` number of observations used
- J `len(re)` number of independent variables (including intercept) used

## 23.5        **nonlin()**:: nonlinear regression

To be reported later, see old manual

## 23.6        **varcomp()**: variance and covariance components

TO BE RAPORTED LATER, see old manual

## 23.7        **classify()**

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      A matrix containing class information (details given below)
Args	1-	REAL	

---

	Args	1-	REAL	Variables for which class means are computed.
			@@data	
<b>x</b>	1	REAL		The first variable defining classes.
<b>minobs</b>	-1 1	REAL		minimum number of observation in a class, obtained by merging classes. Does not work if <b>z-&gt;</b> is given
<b>xrange</b>	-1 0 2	Real		Defines the range of x variable. If <b>xrange-&gt;</b> is given without arguments and <b>J</b> variables x%min and x%max exist, they are used, and if they do not exist an error occurs. Note that these variables can be generate with <b>stat(min-&gt;,max-&gt;)</b> . Either <b>xrange-&gt;</b> or <b>any-&gt;</b> must be present.
<b>any</b>	-1 0			Indicates that each value of the x-variables foms a separate class. either <b>xrange-&gt;</b> or <b>nay-&gt;</b> must be present.
<b>tailtofirst</b>	-1 0			If the x-variable is less than the lower xrange, the observation is put to the first class
<b>tailtolast</b>	-1 0			If the x-variable is greater than the upper xrange, the observation is put to the first class
<b>classes</b>	-1 1	Real		Number of classes, If <b>dx-&gt;</b> is not given, the default is that range is divided into 7 classes. <b>minobs-&gt;</b> minimum number of observations in one class. Classes are merged so that this can be obtained. Does not work if <b>z-&gt;</b> is present. !
<b>z</b>	-1 1	REAL		The second variable (z variable) defining classes in two dimensional classification.
<b>zrange</b>	-1 0 2	Real		

Defines the range and class width for a continuous z variable. If **J** variables x%min and x%max exist, provided by **stat(min->,max->)**, they are used.

---

<b>dz</b>	-1 1	Real
		Defines the class width for a continuous z variable. mean if z variable is given, class means are stored in a matrix given in the <b>mean-&gt;</b> option classes number of classes, has effect if dx is not defined in <b>xrangedx-&gt;</b> . The default is <b>classes-&gt;7</b> . If z is given then, there can be a second argument, which gives the number of classes for z, the default being 7. @@trans @@filter @@reject
<b>print</b>	-1 1	Real

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

---

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 Variable Accepted gives the number of accepted obsevations.

## 23.8 **class()**

Function **class()** computes the 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.
<b>xrange</b>	2	Real
		The range of values.
<b>dx</b>	N 1	Real
		The class width.

---

<b>classes</b>	N 1	Real
The number of classes.		

---

Either `dx->` or `classes->` must be given. If both are given, `dx->` dominates. If `stat()` is used earlier for variables including `Var1` and options `min->` and `max->` are present, then `xrange->(Var1%min,Var1%max)` is assumed.

## 24 Linear programming functions

The linear programming (LP) functions are called jlp-functions. The jlp-functions can be used to define linear programming problems, solve them and access the results. The jlp-problems are defined using `problem()` function, and the problems can be solved using `jlp()` function. There are several ways to access the results. The main interest in jlp-functions may be in the forest planning problems, where a simulator has generate treatment schedules. There are four different applications of `jlp()` function.

- J Small ordinary LP problems with text input.
- J Large ordinary LP problems with MATRIX input.
- J Forest planning problems without factories.
- J Forest palnning problems with factories.

The problem definition for each case is generated with `problem()` function. These applications are presented in different subsections

### 24.1 Problem definition object

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

### 24.2 `problem()` defines a Lp-problem

An LP-problem is defined in similar way as a TEXT object// `problem([repeatdomains->])// /`

```
Define a lp problem for jlp() function.
Output:
a problem definition object
```

**0Option:**  
**repeatdomains**  
if this option is given then the same domain definition can be in several places in the problem definition, otherwise having the same domain in different places causes an error (as this is usually not what was intended). If the same domain definition is in several places is slightly inefficient in computations, e.g. a function computes and prints the values of x-variables for each domain definition even if the same values have been computed and printed for earlier occurrences of the domain definition.

The problem definition paragraph can have two types of lines: problem rows and examples of problem definitions showing the syntax.

```
pr=problem() !ordinary lp-problem
```

$$7*z2+6*z3-z4==min$$

$2*z1+6.1*z2 > 2 < 8+$  !both lower and upper bound is possible

$$(a+\log(b)) \cdot z_5 - z_8 = 0$$

$$-z_7 + z_1 > 8$$

1

```
prx=problem() ! timber management planning problem
```

All:

npv, θ==max

sitetype.eq.2; domain7;

income 2-income 1>0

1

In the above example domain7 is a data variable. Unit belongs to domain if the variable domain7 is anything else than zero.

The objective row must be the first row. The objective must always be present is to just get a feasible solution without objective, this can be obtained by function

In problems having large number of variables in a row it is possible to give a vector and variables as a list e.g.

ESTMERKKI

In problems with x-variables it is possible to maximize or minimize the objective function. In factory problems this would also be quite straightforward to do. In problems with x-variables it is possible to maximize or minimize the objective function. In factory problems this would also be quite straightforward to do. This does not come as a side effect of computations as in the case of maximization and thus it has not been implemented. The maximization of a factory objective function constraints can be obtained by adding to the problem constraints which require amounts of transported timber assortments to different factories are greater than zero.

`Function problem()` interprets the problem paragraph, and extracts the coeff

variables in the object row and in constraint rows. The coefficients can be defined by arithmetic statements utilizing the input programming "-sequence or enclosed in parenthesis. The right hand side can utilize arithmetic computations with variables. The values are computed immediately. So if the variables used in coefficient definitions have not yet been defined, the problem() function must be computed again in order to get the correct values later, the problem() function must be computed again in order to get the correct values. Note that a problem definition does not yet define a JLP task. This is only possible when the problem definition and simulated data are linked in the problem definition stage. At the problem definition stage it is not yet known which variables are x-variables and which are factory variables (see Lappi 1992).

NNote that < means less or equal, and > means greater or equal. The equality : part of linear programming constraints.

The logic of jlp() function is the same as in the old JLP software. There is one difference: domain definitions are now included in the problem definition which makes the life a little easier with J. In J the problem definition can include domain definitions which are used similarly as if they would become part of linear programming constraints.

vol#1-vol#0>0

where vol#0 is the initial volume, i.e. a c-variable, and vol#1 is the volume after one period. In old JLP these initial values had to be put into the x-data.

NNote also that problem definition rows are not in one-to-one relation to the domains in the final lp problem. A problem definition row may belong to several domains. This is called explicit domain definition. Domain definitions describe logical or arithmetic statements indicating for which units the following rows apply. Problem will generate problem definition objects described below.

Starting from J3.0 it is also possible to specify the period of the row for each variable:

#2# income.2-income.1 >0

If the row contains x variables from several periods, the period of the row is given for all x variables. If the period is given for some rows containing x variables, the period is given for all x variables. All except for the objective row. The period of the objective is assumed to be 1. Having any other period for the objective would not make any sense. If wrong period is given for a row, J computes the correct solution but not as efficiently as with correct period. If periods are given for rows, J is utilizing the tree structure of schedules. This leads to smaller amount of additions and multiplications as the computation of a branch of the tree can for each node utilize the value of branch before the node. Unfortunately this was not more efficient e.g. in test problems with five periods. NNote 1: Only maximization is allowed in problems including factories. To change a minimization problem to a maximization problem, multiply the objective function by -1. \*\*\* We may later add the possibility to define also minimization problems. NNote 2: If optimization problem includes factories (see chapter 11.2 Optimization including factories), there have to be variables in the objective function or in the constraint row. Example of problem definition including factories can be found in the next section.

JLP Examples.

NNote 3: An ordinary linear programming problem contains only z-variables.

NNote 4: It is not necessary to define `problem()` function if the problem incl

For more information see chapter 11.8 Solving a large problem with z-variabl

NNote 5: If the problem contains harvest/area constraints for several domain

if the constraints are written in form

harvest < area\_of\_domain\*constant

instead of

(1/area\_of\_domain)\*harvest < constant.

The latter formulation takes the number of domains times more memory than the formulation.

## 24.3 Solving large problems without schedule data.

When solving problems including only a large number of z-variables, it is possible to feed the coefficients as a matrix with `zmatrix->` option. Unit and schedule data (c- and x-variables) are not allowed when `zmatrix->` is used.

=jlp(`zmatrix->`,`max->|min->[`,`rhs->][`,`rhs2->][`,`tole->][`,`print->][`,`maxiter->][`,`test->][`,`debug->]`

) Output: Function `jlp()` generates output row vectors `output%zvalues`, `output%redcost` and output column vectors `output%rows`, `output%shprice` `output` is the name of the output. Options: `zmatrix` Matrix containing coefficients of z-variables for each constraint row. `max` Vector containing coefficients of z-variables for the objective row of a maximization problem. Either `max->` or `min->` option has to be defined but not both. `min` Vector containing coefficients of z-variables for the objective row of a minimization problem. Either `max->` or `min->` option has to be defined but not both. `rhs` Vector containing lower bound for each constraint row. Value `j_inf` is used to indicate the absence of the lower bound in a row. Either or both of the bound options (`rhs->`, `rhs2->`) has to be defined. `rhs2` Vector containing upper bound for each constraint row. Value `j_inf` is used to indicate the absence of the upper bound in a row. Either or both of the bound options (`rhs->`, `rhs2->`) has to be defined. Other options described above in chapter Solving a problem: `jlp( )`. NNNote. When `zmatrix->` option is used, the solution is not automatically printed. Use `jlp` solution objects to access solution. For more information see chapter 11.10 Objects for the JL enEdnote

There are two versions of `jlp()` function call: one with `problems->` option for problems defined by `problem()` function and the other with `zmatrix->` option for large ordinary linear programming problems with z-variable coefficients defined by matrix. A lp problem defined by `problem()` function can be solved using `jlp()` function: [=]jlp(`problem->[`,`data->][`,`z->][`,`trans->][`,`subtrans->][`,`tole->][`,`subfilter->][`,`subreject->][`,`class->][`,`area->][`,`notareavars-`

`>][,print->][,report->][,maxiter->][,refac->][,slow->][,warm->][,finterval->][,fastrounds->][,fastpercent->][,swap->][,test->][,debug->][,memory->])` Output: Necessary for factory problems, otherwise optional. If output is given then function generates several matrices and lists associated with the solution (e.g. the values of the constraint rows, the shadow prices of the rows, the values of the z-variables, the reduced costs of z-variables, the sums of all x-variables of the data in all domains and their shadow prices, lists telling how problem variables are interpreted. See Objects for the JLP solution for more detailed description. Options: problem problem definition generated by `problem()` function data data set describing the stand (management unit) data or the schedules data. The unit data set must be linked to schedule data either using sub-options in the `data()` function or using `linkdata()` function. Following the JLP terminology, the unit data is called cdata, and the schedule data is called xdata. The `jlp()` function tries if it can find a subdata for the data set given. If it finds, it will assume that the data set is the unitdata. If subdata is not found, it tries to find the upper level data. If it finds it, then it assumes that the data set given is the schedules data. If `data->` is not given, then the problem describes an ordinary lp-problem, and all variables are z-variables. If `data->` option is given but no variable found in problem is in the schedules data set, then an error occurs. z If the `data->` option is given then the default is that there are no z-variables in the problem. The existence of z-variables must be indicated with `z->` option (later the user can specify exactly what are the z variables, but now it is not possible). The reason for having this option is that the most jlp-problems do not have z variables, and variables which J interprets as z-variables are just accidentally missing from the data sets. trans transformation set which is executed for each unit. subtrans transformation set which is executed for each schedule. NNote: the subtrans transformations can utilize the variables in the unit data and the output variables of `trans->` transformations. NNote: transformations already associated with cdata and xdata are taken automatically into account and they are executed before transformations defined in `trans->` or `subtrans->` options. \*\*\* Later we may add the possibility to have several data sets (note that several files can be read into one data object in the `data()`function) tole the default tolerances are multiplied with the value of the `tole->` option (default is thus one). Smaller tolerances mean that smaller numerical differences are interpreted as significant. If it is suspected that `jlp()` has not found the optimum, use e.g. `tole->0.1,tole->0.01` or `tole->10.` subfilter logical or arithmetic statement (nonzero value indicating True) describing which schedules will be included in the optimization. If all schedules are rejected, an error occurs. Examples: `filter->(.not.clearcut)`, `filter->(ncuts.ge.5)`, `filter->harvest` (which is equivalent to: `filter->(har-`

vest.ne.0)). If the subfilter statement cannot be defined nicely using one statement, the procedure can be put into a transformation set which can be then executed using value() function. subreject logical or arithmetic statement (nonzero value indicating True) describing which schedules will not be included in the optimization. If **subfilter->** is given then test applied only for such schedules which pass the subfilter test. If the subreject statement cannot be defined nicely using one statement, the procedure can be put into a transformation set which can be then executed using value() function. Kommentoinut [LR(46]: Repon puolelle Kommentoinut [LR(47]: Repon puolelle[Natural resources and bioeconomy studies XX/20XX] 95 class **class->**(cvar, cval) Only those treatment units where the variable cvar gets value cval are accepted into the optimization. The units within the same class must be consecutive. area gives the variable in cdata which tells for each stand the area of the stand. It is then assumed that all variables of cdata or xdata used in the problem rows are expressed as per are values. In optimization the proper values of variables are obtained by multiplying area and per area values. Variables of cdata used in domain definitions are used as they are, i.e. without multiplying with area. Variables which are not treated as per area values are given with the **notareavars->** option. notareavars If **area->** option is given then this option gives variables which will not be multiplied with area. print of output printed, 1 => summary of optimization steps, 2=> also the problem rows are printed, 3=> also the values of x-variables are printed, 9= the pivot steps and the point of code where pivoting is done and the value of objective function are written to fort.16 file (or similar file depending on the operating system). The value 9 can be used in the case where jlp seems to be stuck. From fort.16 file one can then infer at what point debugging should be put on. Some cycling situations are now detected, so it should be rather unlikely that jlp is stuck. report the standard written output is written into the file given in **report->** option (.e.g. **report->**'result.txt'). The file remain open and can be written by several jlp-functions or by additional **write()** functions. Use **close()** function to close it explicitly if you want to open it with other program. maxiter maximum number of rounds through all units (default 10000). refac after refac pivot steps the basis matrix is refactorized. The default value is 1000. New option since J3.0. Actually refactorization was present in the first version of J but it had to be dropped because the refactorization corrupted some times the factors of the basis matrix. The reason was found and corrected for J3.0. The reason for misbehavior of the refactorization algorithm of Fletcher was such that it never caused problems in ordinary linear programming problems for which Fletcher designed his algorithms. slow if improvement of the solution in one round through all units is smaller than

value given in **slow->** option, then **J** terminates under condition slow improvement. New option since J3.0. Earlier slow improvement is computed from the tolerances of the problem, and if the **slow->** option is not present these tolerances are still used. If **slow->** option gives negative value, then the absolute value of the option indicates per cent change. Note that in large problems the solution is often very long time quite close the actual optimum, and hence the optimization time can be decreased with rather low loss in accuracy using the **slow->** option. If **slow->** option is give value zero it is equivalent to omitting the option and hence the slow improvement is determined from the tolerances. **warm** If option is present in ordinary problems with x-variables then the key schedules of previous solution are used as the starting values of the key schedules. In factory[Natural resources and bioeconomy studies XX/20XX] 96 problems also the previous key factories are used as starting values. If there is no previous solution available or the dimension of the key schedules vector (number of treatment units) or the dimensions of the key factories matrix (number of treatment units and number of factories) do not agree with the current problem, **warm** option is ignored. Thus it is usually safe to use the option always, the only exception is that the factories and number of units do agree with the previous problem even if factories or schedule data are changes. The warm start may reduce solution time perhaps 40-80%. **finterval** In factory problems the transportsations to new factories are checked if the round number is divisible with **finterval**. The default value is 3. When there have not been improvements during the last round, the value is changed into 1. **fastrounds** The shadow prices are used to select an active set of schedules which are considered as entering schedules. **fastrounds** gives the number of rounds using the same active set. The default is 10. When there have not been improvements during the last round, all schedules are used as the active set. **fastpercent** A schedule belongs to the active set if its shadow price is at least **fastpercent** % of the shadow price of the best schedule. The default is 90. **swap** If option is present, the schedules data matrix is written to a direct access binary file. This option may help if virtual memory overflow occurs. The data needs to be used from the file until all inquiry function calls are computed. Thereafter the data can be loaded again into memory using function **unswap()**. If this does not happen ordinary functions using this data object work a little slower. If a new problem is solved with the **swap->** option, there is no need to **unswap()** before that. In an Intel Fortran application the **swap->** option is given without arguments. In a Gfortran application the option must be given in form **swap->4**. If there is shortage of virtual memory, read note 5 for **problem()** function before starting to use **swap->**. **test** If option is present then **jlp()** is checking the

consistency of the intermediate results after each pivot step of the algorithm. Takes time but helps in debugging. debug determines after which pivot steps `jlp()` starts and stops to print debugging information to `fort.16` file. If no value given, the debugging starts immediately (produces much output, so it may be good to use step number which is close to the step where problems started (print variable `Pivots` at the error return). `debug->(ip1,ip2,ip3)` indicates that debugging is put on at pivot step `ip1`, off at pivot `ip2` and the again on at pivot `ip3`. `memory` gives the amount of memory in millions of real numbers that can be used to store data needed in solving the problem. In factory problems also the `xdata` stored in a direct access file are loaded into memory as much as possible. It is not possible to figure out how large number memory option can give, so it must be determined with experimentation. Using `disk->` option in `data()` function and `memory->` option in `jlp()` function makes it in principle possible to solve arbitrary large problems. In practise the ability of double precision numbers cannot store accurately the needed quantities in very huge problems. Kommentoinut [LR(48): Vain gfortran käänös? Kommentoinut [LR(49): Lisätty. Oliko tämä mukana julkaistavassa versiossa? [Natural resources and bioeconomy studies XX/20XX] 97 Function `jlp()` is generating output (amount is dependent on the `print->` option) plus a JLP-solution stored in special data structures which can be accessed with special `J` functions described below and if output is given then several output objects are created (see Objects for the JLP solution). NNote 1: a feasible solution (without an objective) can be found by minimizing a `z`-variable (remember `z->` option), or by maximizing a unit variable (which is constant for all schedules in a unit). NNote 2: If virtual memory overflow occurs, see first Note 5 for `problem()` function and then

## 24.4 weights() weights of schedules

TO BE RAPORTED LATER

## 24.5 partweight() weights of split schedules

TO BE RAPORTED LATER

# 25 Plotting figures

The graphiscs of the current version of `J` is produced Gnuplot. `J` offers nowan alternative interface to Gnuplot, and it is quite easy to add more

plotting routines later.

## 25.1 Figures

Figures are made using Gnuplot. **J** transmits information into Gnuplot using text files. **J** generates the files using .jfig extension. Necessary files are generated by deleting old files without asking permission. If **fig** is the output of a figure function, then **J** creates always, except in 3D, file with name **fig.jfig** and possibly other files with .jfi0, jfi1 etc extensions. All figure functions use the following options.

---

Output      1      FIGURE  
The FIGURE object created or updated @@figure

---

is possible to show a figure using **show()** function. It can have either the **fig** object as the argument or the file name of **fig.jfig** -file. Thus it is possible to edit the file using Gnuplot capabilities. It is possible to change the terminal type used by Gnuplot by giving the name of the terminal to the predefine CHAR variable **Terminal**. The default is **Terminal='qt'**. The default written by Gnuplot does not look nice and is not implemented. The user can write own legends using **label->** option in **draw-line()**. Easiest way to delete an nonmatrix object **fi** is **fi=0**, which makes it possible to use **append->** also for an **fi** without the need to construct if then- structures.

### 25.1.1 Figure object

Graphic functions produce FIGURE objects. Each FIGURE object can consist of several subfigures. Each FIGURE object stores information of x- and y axes, the range of all x- and y-values, and for each sub-figure information of the ranges of x and y in the subfigure plus the subfigure type and the needed data values. Currently, when Gnuplot is used for graphics, most data values are stored in text files which Gnuplot reads. Function **plot3d()** is plotting 3-d figures without making a FIGURE object. See Plotting figures for more information.

## 25.2 Scatterplot: **plotyx()**

**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 dta 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  
Code option telling how the y-variable is computed.

---

```
[plotyxex]plotyx()  
xmat=matrix(do->(0,10,0.001))  
tr=trans()  
y=2+3*x+0.4*x*x+4*rann()  
/  
da=newdata(xmat,read->x,maketrans->tr,extra->(Regf,Resid))  
fi=plotyx(y,x,continue->fcont)  
fi=plotyx(x,func->tr(y),mark->3,color->Orange,continue->fcont)  
reg=regr(y,x)  
fi=plotyx(y,x,show->0)  
fi=plotyx(Regf,x,append->,continue->fcont)  
fir=plotyx(Resid,x,continue->fcont) With data with integer values, the de-  
fault ranges of Gnuplot may be hide point at borderlines. fi=plotyx() pro-  
duces or updates file fi.jfig] which contains Gnuplot commands and file  
fi.jfi0 containg data.
```

## 25.3      Draw a function: **draw()**

**draw()** draws a function.

---

Output          1        FIGURE  
The FIGURE object created or updated.

---

<b>func</b>	N   1	Code Code option telling how the y-variable is computed. @@draw
-------------	-------	--

---

<b>mark</b>	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.

<b>width</b>	0   1	REAL the width of the line
--------------	-------	-------------------------------

---

[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,cont->fcont)
reg0=regr(y,x)
stat(data->datyx,min->,max->)
figyx=draw(func->reg0(),x->x,xrange->,color->Violet,append->,continue->fcont)
tr=trans()
x2=x*x
fu=reg2()
/
reg2=regr(y,x,x2,data->datyx,trans->tr)
figyx=draw(func->tr(fu),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 fi=draw() produces or updates file fi.jfig] which contains Gnu-plot commands and file fi.jfi0 containg data.

```

## 25.4 Draw values in a matrix generated with **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 funtions can be drawn in the same figure.

<b>Output</b>	1	FIGURE FIGURE object updated or generated.
---------------	---	---

---

Arg	1	MATRIX
		A MATRIX generated with <code>classify()</code> .
se	N   0	Presence of option tells to include that error bars showing standard errors of class means computed as <code>sqrt(sample_within-class_variance)/number_of_obs</code> )
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 <code>area-&gt;</code> 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 <code>freq-&gt;</code> is presented then absolute cumulative frequencies are drawn, otherwise cumulative percentages are drawn, except if also <code>area-&gt;</code> is present then cumulative realtive freaquencies are drawn.

[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->,continue->fcont)
```

```

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)
fi=drawclass(cl,histo->,area->,continue->fcont)
fi=draw(func->pdf(0,rmse(reg)),x->x,xrange->,append->,continue->fcont) !xrange comes from s
In previous versions of J if se-> and sd-> were both present, the error bot
bars were plotted. This possibility will be included later.

```

## 25.5 Draw a polygon through points: `drawline()`

`drawline()` draws a function through points.

---

Output	1	FIGURE
		The FIGURE object created or updated.

---

Args	1-	REAL   MATRIX
------	----	---------------

The points which are connected:

J x1,...,xn,y1,...,yn The x-coordinates and y-coordinates,  
 $\$n \geq 1$  If there is only one argument which is a matrix object having two rows, the

J 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 <code>label-&gt;</code> 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.

---

<code>set</code>	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 <code>drawline()</code> and data points are stored in file <code>fi.jfi0</code> , i.e. the same file used by <code>plotyx()</code> . If set is given e.g as <code>set-&gt;3</code> , then it is possible to plot a large number of lines with the same width and color. The data points are stored into file <code>fi.jfi3</code> . 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.
<code>width</code>	0   1      REAL the width of the line. Default: <code>width-&gt;1</code>
<code>label</code>	N  1      CHAR Text plotted to the end of line.

---

[drawlineex]Example of `drawline()`

```

fi=draw(func->sin(x),xrange->(0,2*Pi),color->Blue,continue->fcont)
fi=drawline(Pi,sin(Pi)+0.1,label->'sin()',append->,continue->fcont)
xval=matrix(do->(1,100))
mat=matrix(values->(xval,xval+1,xval,xval+2,xval,xval+3))
fi=drawline(mat,color->Red)
fi=drawline(mat,break,color->Orange,break->,continue->fcont)
x=matrix(do->(0,100,1))
e=matrix(101)
e=rann()
y=2*x+0.4+e
da=newdata(x,y,read->(x,y))
reg=regr(y,x)
if(type(figyx).ne.FIGURE)plotyxex
show(figyx)
reg0=regr(y,x)
stat(data->datyx,min->,max->)
figyx=draw(func->reg0(),x->x,xrange->,color->Violet,append->,continue->fcont)
tr=trans()
x2=x*x
fu=reg2()
/

```

```

reg2=regr(y,x,x2,data->datyx,trans->tr)
figyx=draw(func->tr(fu),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 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->.

```

## 25.6 Show figure: `show()`

An figure stored in a figure object or in Gnuplot file can be plotted. If the argument is FIGURE, the parameters of the figure can be changed. If the argument is the name of Gnuplot file, the file must be edited.

---

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

The figure object or the name of the file containg Gnuplot commans, @@figure
---

---

If the argument is the file name with .jfig extension, and you edit the file, its is safe to change the name, becase if an figure with teh same name is generated, the edited fike is autimatically deleted. If the file refers other files, it is wise to rename also these files and change the names in the beginning of the .jfig file. You may wish to use show also if you cnange the window size

[showex]Example of `show()`

```

fi=draw(func->sqrt2(x),x->x,xrange->(-50,50),continue->fcont)
show(fi,xrange->(-60,60), xlabel->'NEWX', ylabel->'NEWY')
show(fi,axes->10)
show(fi,axes->01)
show(fi(axes->00))
Window='400,800'
show(fi)
Window='700,700'
fi=drawline(1,10,3,1,color->Red,continue->fcont)
show(fi,xrange->(1.1,11)) !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))

```

## 25.7 Plot 3d-figure: `plot3d()`

Plot 3d-figure with indicator contours with colours.

---

Output	1 <code>fi=plot3d()</code> generates Gnuplot file <code>fi.jfig</code> . No figure object is produced.
Args	1 MATRIX The argument is a matrix having 3 columns for x,y and z.
<code>sorted</code>	N   1 <code>plot3d()</code> uses the Gnuplot function splot, which requires that the data is sorted with respect to the x-variable. <code>sorted-&gt;</code> indicates that the argument matrix is sorted either naturally or with <code>sort()</code> function. If <code>sort-&gt;</code> is not presented, plot3 sorts the data.

---

[plot3dex]plot3d() example see p. 328 in Mehtatalo Lappi 2020

```

mat=matrix(1000000,3)
mat2=matrix(1000000,3)
tr=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(tr)
fi=plot3d(mat,sorted->)
fi=plot3d(mat2,sorted->)

```

## 26 Splines, stem splines, and volume functions

There are several spline functions.

### 26.1 tautspline()

**tautspline**( $x_1, \dots, x_n, y_1, \dots, y_n$ [,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://  $x_1, \dots, x_n$  the x values//  $y_1, \dots, y_n$  the y values.// There must be at least 3 knot point, i.e. 6 arguments.// Options:// par gives the 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 the default is that the  $x_i$ s are increasing, if not then sort-> option must be given// print if 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.

### 26.2 stemspline(): splines for stems

TO bE REPORTED LATER, see old manual

### 26.3 stempolar(): polar coordinates

TO bE REPORTED LATER, see old manual

## **26.4      *laasvol()*: svolume eqaitions of Laasasenaho**

TO bE REPORTED LATER, see old manual

## **26.5      *laaspoly()*: polynomila stem curves of Laasase-naho**

TO bE REPORTED LATER, see old manual

## **26.6      *integrate()*: integrate**

TO bE REPORTED LATER, see old manual

# **27      Bit functions**

bit functions help to store large amount of binary variables in small space. These functions are used in domain calcualtions

## **27.1      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 *set-value()* function. The values of bitmatrix elements can be accessed with *value()* function. Also ordinary real variable can be used to store bits. See bit functions.

## **27.2      *setbits()*: setting bits on**

To be reported alter

## **27.3      *clearbits()*: clearing bits**

To be reported alter

## **27.4      *getbit()* : get bit value**

To be reported later, see old manual

## **27.5        `getbitch()` : get bit value**

To be reported later, see old manual

## **27.6        `bitmatrix()` : define a matrix for bits**

To be reported later, see old manual

## **27.7        `setvalue()` : set value for a bitmatrix**

To be reported later, see old manual

## **27.8        `closures()` :convex closures**

To be described later, see old manual

# **28        Misc. functions**

There are some functions which do not belong to previous classes.

## **28.1        `properties()`: defining properties of some subjects.**

This function has been used to define properties of factories. It will be replaced with other means in later versions.

## **28.2        `cpu()` gives the elapsed cpu time**

```
[cpue]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;
```

## **28.3        `seconds()` gives the elapsed clock time**

```
[secondsex]Example of elapsed time  
cpu0=cpu()
```

```

sec0=seconds()
a=matrix(100000)
a=ran() !uniform
mean(a),sd(a),min(a),max(a);
cpu1=cpu()
sec1=seconds()
elapsed=cpu1-cpu0;
selapsed=sec1-sec0;

```

## 28.4 Object names

Object names start with letter or with '\$'. Object names can contain any of symbols '#.%\$\\\_'. J 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 [ ] 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 ob 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 objec. There are many objects intitilized automatically. Some of these are locked so that the users cannot change them. Names of objects having a predefined interpretation start with capital letter. The user can freely use lower or upper case letters. J is case sensitive. All objects known at a given point of a J session can be listed by command: `print(Names)`

## 28.5 Copying object: a=b

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

## 28.6 Deleting objects: `delete_o()`

When an object with a given name is created, the name cannot be removed. With `delete_O()` function one can free all memory allocated for data struc-

tures needed by general objects: `delete_o(obj1,â|,objn)` After deleting an object, the name refers to a real variable (which is initialized by the `delete_o()` function into zero). Other objects except matrices can equivalently be deleted by giving command `obj1,â|,objn = 0` This is because the output objects of any functions are first deleted before defining them anew. Usually an object is automatically deleted if the object name is as an output object for other functions. One can see how much memory each object is using `print(Names).mes` Deleting a compound object deletes also such subobjects which have no meaning when the main object is deleted. But e.g. if a data object is deleted then the associated transformation object is not deleted as the transformation can be used independently. Files can be deleted with `delete_f(file)`. See IO-functions for details. If the user has defined own new compound objects in the open source **J** software she/he needs to define the associated delete function.

## 28.7 Object types

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

### 28.7.1 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->(x1â|x4))` ! `x1, x2, x3, x4` are variables in the data set, and get their values when doing operations for the data.

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.

In this manual 'variable' refers to a **J** object whose type is REAL.

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

## 28.7.3 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
```

## 28.8 Predefined objects

The following objects are generated during the initialization.

<b>Names</b>	Text	Text object containing the names of named objects
<b>Pi</b>	REAL	The value of Pi (=3.1415926535897931)
<b>\$Cursor\$</b>	TRANS	The transformation object used to run <code>sit&gt;</code> prompt
<b>\$Cursor2\$</b>	TRANS	Another transformation object used to run <code>sit&gt;</code> prompt
<b>Val</b>	TRANS	Transformation object used to extract values of mathematical statements, used,

<b>Round</b>	REAL	<b>jlp()</b> : The current round through treatment units in <b>jlp()</b> function.
<b>Change</b>	REAL	<b>jlp()</b> : The change of objective in <b>jlp()</b> in one round before finding feasible and thereafter
<b>Imp</b>	REAL	<b>jlp()</b> : The number of improvements obtained from schedules outside the current active
<b>\$Data\$</b>	List	Default data set name for a new data set created by <b>data()</b> -function.
<b>Obs</b>	REAL	The default name of variable obtaining the the number of
<b>Maxnamed</b>	REAL	The maximum number of named objects. Determined via j.par in
<b>Record</b>	REAL	The name of variable obtaining the the number of
<b>Subcord</b>	REAL	The name of variable obtaining the the number of
<b>Duplicate</b>	REAL	A special variable used in <b>data()</b> function when duplicating observations
<b>LastaData</b>	List	A list object referring to the last data set made, used as default data set.
<b>\$Buffer</b>	Char	A special character object used by the <b>write()</b> function.
<b>\$Input\$</b>	Text	Text object used for original input line.
<b>1\$Input1\$</b>	Text	Text object for input line after removing blanks and comments.
<b>Data</b>	List	List object used to indicate current data sets
<b>\$textcolor{teal}{tabto}25mm</b>	REAL	
		Object name used to indicate console and '*' format in reading and writing
<b>x#</b>	REAL	Variable used when drawing functions.
<b>Selected</b>	REAL	Variable used to indicate the simulator selected in simulations
<b>Printinput</b>	REAL	Variable used to specify how input lines are printed. Not properly used.
<b>Prinoutpu</b>	REAL	Variable used to indicate how much output is printed. Not properly used.
<b>\$Debug</b>	REAL	Variable used to put debugging mode on.
<b>Accepted</b>	REAL	The number of accepted observations in functions using data sets.
<b>Arg</b>	REAL	The default argument name when using transformation object as a function.

<b>Continue</b>	REAL	If Continue has nonzero value then the control does not return to the <b>sit&gt;</b> prompt
<b>Err</b>	REAL	If Continue prevents the control from returning to <b>sit&gt;</b> prompt
<b>Result</b>	?	The default name of output object.

### 28.8.1 Transformation object

A transformation object groups several operation commands together so that they can be used for different purposes by **J** functions and **J** objects. A transformation object contains the interpreted transformations. For more details see **J** 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 **J** functions use also implicitly transformations object **\$Cursor2\$**.

## 28.9 Code options

There are some special options which do not refer to object names or values. Some options define a small one-statement transformations 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. [codeoptex]Codeoptions

```
dat=data(read->(D,H),in->)
```

```
3,2
```

```
2,4
```

```
4,1
```

```
/
```

```
stat(D,H,filter->(H.gt.D)) ! only those observations are accepted which pass the filter
fi=draw(func->(sin($x)+1),x->$x,xrange->(0,10),color->Red,ylabel->'sin(x)+1', xlabel->'x',width->2)
```

Interpreted transformations in a transformation object can be automatically executed by other **J** functions or they can be executed explicitly using **call()** function.

---

Arg	1	TRANS
		The transformation object executed.

---

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. [recursion]Recursion produces system crash.

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

## 28.10 J transformations

Most operation commands affecting **J** 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 **J** objects. General **J** 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 **J** 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 **J** 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.

## 28.11 Generating a transformation object **trans()**

**trans()** function interprets lines from input paragraph following the **trans()** command and puts the interpreted code into an integer vector, which can be excuted in several places. If there are no arguments in the function, the all objected used within the transforamations are global. This may cause conflicts if there are several recursive functions operating at the same time

with same objects. **J** 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\[** yielding **]tr\ob[**. 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 objec.

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 semicolns.

!

---

Output	1	Data The TRANS object generated.
Args	N 1-	Global objects.

---

Options **input->**, **local->**, **matrix->**, **arg->**, **result->**, **source->** of previous versions are obsolete. 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**. The value of **Printresult** can be changed in other parts of the transformation, or in other transforamations called or during execution of **pause()**.

Output variables in **maketrans->** transformations whose name start with \$ are not put into the new data object. [transex]Demonstrates also error handling

```
tr=trans()
$x3=x1+3
x2=2/$x3;
/
tr%input,tr%output,tr%source;
x1=8
call(tr)
tr2=trans(x1,x2)
```

```

$x3=x1+3
x2=2/$x3;
x3=x1+x2+$x3;
/
tr2%input,tr2%output,tr2%source;
call(tr2)
tr23; !x3 is now local
tr3=trans()
x1=-3
call(tr) !this is causing division by zero
/
Continue=1 !continue after error
call(tr3)

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

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

<x1=8

<call(tr)
x2=0.18181818

<tr2=trans(x1,x2)
<$x3=x1+3
<x2=2/$x3;

```

```

<x3=x1+x2+$x3;
</
<tr2%input,tr2%output,tr2%source;
tr2%input is list with           1 elements:
x1
tr2%output is list with         1 elements:
x2
tr2%source is text object:
1 $x3=x1+3
2 x2=2/$x3;
3 x3=x1+x2+$x3;
4 /
///end of text object

<call(tr2)
x2=0.18181818

tr2\x3=19.1818181

<tr2\x3;
tr2\x3=19.1818181

<tr3=trans()
<x1=-3
<call(tr)
</
<Continue=1
<call(tr3)
*division by zero
*****error on row           2 in tr%source
x2=2/$x3;
recursion level set to     3.000000000000000

*****error on row           2 in tr3%source
call(tr)
recursion level set to     2.000000000000000

*err* transformation set=$Cursor$
recursion level set to     1.000000000000000
***cleaned input
call(tr3)

```

```
*Continue even if error has occurred  
<;return
```

## 28.12 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.

[transfunc] Transformation as a function

```
delete_o(a,c)  
tra=trans()  
a=8;  
c=2;  
/  
trb=trans()  
a=5;  
c=1;  
/  
c=2  
a=c+trb(a)+c+tra(a);
```

## 28.13 Transformation control structures

Within **J** transformations, there can be similar controls structures as in the input programming. The difference is that these will remain as part of the transformation set. Only the 'if()output=' structure is allowed at the command level, other are possible only within a transformations set.

### 28.13.1 if()

```
if()j_statementâ!  
The one line if-statement.
```

### **28.13.2      if() elseif() else endif**

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

```
if()then  
â!.  
elseif()then  
â!  
else  
â!.  
endif
```

## **28.14      Loops and control strucures**

This section describes nonstandard functions.

### **28.15      return**

Return from a transformation set to the transformation object where **call()** function was, or to the include file with **call()**, or to the **sit>** prompt, if **call()** was at **sit>**. [retex]example of return and goto ()

```
tr=trans()  
ad1:r=ran();  
if(r.lt.0.2)return  
goto(ad1)  
/
```

**call(tr)** return is automatically put to the end of transformation object. Labels in a transformation object are without ';' as the addresses in an include file start with ';

### **28.16      erexit()**

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

```
[erexitex]itex  
tr=trans()  
if(a.eq.0)erexit('illegal value ',a)  
s=3/a; !division with zero is teste automatically  
/  
a=3.7
```

```

call(tr)
tr(s); !tr can also be used as a function
a=0
Continue=1 !Do not stop in thsi seflmade error
call(tr)
Continue=0

```

## 28.17        **goto()**

Control can be transferred to a line in a transformation set with **goto()**. [go-toex]

```

tr=trans()
i=0
if(i.eq.0)goto(koe)
'here';
koe:ch='here2';
/
call(tr)
ch;

```

It is not allowed to jump in to a loop or into if -then structure. This is checked already in in the interpreter. It is not yet possible to continue within an include file using Continue=1. It is not recommended to use **goto()** according to modern computation practices. However, it was easier to implement cycle and exitdo with **goto()**, especially if cycle or exitdo does not apply hte innermost do-loop.

## 28.18        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.

**J** - unary minus

**J** \*\*\* integer power

**J** \*\* or ^real power

**J** \* multiplication

**J** / division

**J** + addition

## **J** - 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.

**J** \*. elementwise product (Hadamard product)

**J** /. elementwise division

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

## **28.19 Logical and relational expressions**

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

**J** .eq. == equal to

**J** .ne. <> not equal

**J** .gt. > greater than

**J** .ge. >= greater or equal

**J** .lt. < less than

**J** .le. <= less or equal

**J** .not. ~ negation

**J** .and. conjunction

**J** .or. disjunction

**J** .eqv. equivalent.

**J** .neqv. not equivalent

The relational and logical expressions produce value 1 for True and value 0 for False. Note: Testing equivalence can be done also using 'equal to' and 'not equal', as the same truth value is expressed with the same numeric value. when the truth value of an expression is tested with **if()**, then all nonzero real values means that the expression is true.

## 28.20 Arithmetic functions

The arithmetic functions return single REAL value or a MATRIX. `sqrt()`, `sqrt2()`, `exp()`, `log()`, `log10()`, `abs()`

J `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.

J `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.

J `exp(x)` \$e\$ to power `x`. If `x>88`, then J produces error in order to avoid system crash.

J `log(x)` natural logarithm

J `log10(x)` base 10 logarithm

J `abs(x)` absolute value

Real to integer conversion

J `nint(x)` nearest integer value

J `nint(x,modulo)` returns `modulo*nint(x/modulo)`, e.g. `nint(48,5)=50`; `nint(47,5)=45`;

J `int(x)` integer value obtained by truncation

J `int(x,modulo)` returns `modulo*int(x/modulo)`, e.g. `int(48,5)=45`

J `ceiling(x)` smallest integer greater than or equal to `x`.

J `ceiling(x,modulo)` returns `modulo*ceiling(x/modulo)`, e.g. `ceiling(47,5)=50`.

J `floor(x)` greatest integer smaller than or equal to `x`.

J `floor(x,modulo)` returns `modulo*floor(x/modulo)`, e.g. `floor(47,5)=45`.

The following rules apply both for `min()` and `max()`. The rules are presented here only for `min()`.

J `min(x1,...,xn): $n>1$` and all arguments are REAL, `Result` is REAL.

J `min(A):` If `A` is matrix then the result result is row vector containg minimum of each column. If `A` is a column vector, `Result` is REAL.

J `min(A,any->)` If `A` is matrix, then `Result` minimum over all elements.

- J **min**(x,A) If **x** is REAL and **A** is matrix, then **Result** is matrix with the same dimensions as **A** and **Result**(i,j)=**max**(**x**,**A**(i,j)). The order of arguments does not matter.
- J **min**(A,B), **A** and **B** compatible matrices. **Result** is a matrix with the same dimensions containing elementwise minimums.

### 28.20.1 Text objects

Currently there are two text object types, the old text object TEXT and the new TXT. The TEXT object stores text in a long vector of single characters. The TXT object stores text in lines of 132 characters. The TEXT objects save memory but are not so easy to modify and use. Several J functions create associated text objects. J functions **text()** and **txt()** can be used to create text objects directly. All the names of J objects are also stored in a TEXT object called Names. The number of lines in a text objects can be obtained with **nrows()** function and the total number of characters can be obtained with **len()** function.

## 28.21 The main components of J program

The structure of J program

- J Input programming which generates text input for the interpreter (subroutine **j\_getinput**). J commands are obtained:
  - J from **sit>** prompt
  - J from possibly nested include files
- J Interpreter which generates from text lines integer vectors containing function indices, option indices and object indices (subroutine **j\_interpret**).
- J Function driver which executes the code in the interpreted integer vector (subroutine **dotrans**). The function driver is using:
  - J J functions which operate on arguments which are determined either as formal arguments or via options.
  - J J objects
  - J Global variables and matrices
  - J Utility subroutines

A user of **J** needs only input programming and **J** functions, but understanding of the other properties may help to understand what is going on in a **J** session.

## 29 Future development

I think that the current version of **J** provides many possibilities for future developments. For instance:

- - **J** The 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.
  - **J** Using the possibility to compute derivatives using the analytic derivatives makes it quite straightforward to make it possible to have a nonlinear objective function
  - **J** It would be quite easy to develop **J** so that integer solution is produced with respect to the schedule weight.
  - **J** It would be interesting to see how **J** can put to work with Heureka.
  - **J** The possibility to run R scripts from **J** and **J** scripts from R provide new possibilities.
  - **J** **J** 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.
  - **J** 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.
  - **J** 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.

## 30 J story

! J software version 3.0 is now published as a open source software. The preparation of the new version was very complicated and frustrating process. I got 7.10.2021 in a co-operation agreement with Luke I will here describe the history of J here in unusual length and detail. Readers interested only in the use of the current software can perhaps look briefly the subsection Freedom. The reason why I'm going through in detail the difficulties with Luke is that I think that the policy insisted by the leaders of Luke that the researchers of Luke do not have any moral or legal right to publish the results of their research should be discussed. I think also that the leaders of Luke were willing to waste large amount of taxpayers' money when they prevented the development and timely publication of J software. I hope that this part of the preface gets some attention also outside the potential users of the software e.g. in the ministry.

### 30.1 JLP and first version of J

I started to develop J software as a successor of the linear programming software JLP [JLP] around 2004. I had also done several programs for statistical computing (AKTA and Jakta) since late seventies when there was not easy to use software even for ordinary linear regression. Later I had to write own software for mixed linear models when doing my doctoral thesis. AKTA, Jakta, and JLP contained means to use script files and make new variables described in arithmetic expressions. The starting idea in J was to put all my previous software developments into one program. Version 0.9.3 of J was published in August 2004.

In JLP the crucial property was the utilization of the generalized upper bound (GUB) technique which I invented and, which I could later find also in the literature ([dant]), as I expected. GUB is just the right technique which is needed in forest management planning. JLP made it possible to solve significantly larger LP problems significantly faster than using standard commercial LP software. In JLP I programmed all the necessary matrix operations needed to change columns of the basis matrix in the revised simplex method. I updated the inverse of the basis matrix explicitly, instead of using factorization procedures as is the standard way in LP. I treated nonbinding constraints in a nonstandard way by reducing the dimension of the basis matrix instead of using residual basic variables, as is normally done.

When I started to develop J, I thought that it might be good idea to use matrix routines based on factorizations and developed by a professional in this field. I found the LP software bqbd by Fletcher based on [flet]. The

bqbd software was meant to use 'as is' software for linear and quadratic programming. When I told Fletcher that I plan to separate the matrix routines needed in the GUB algorithm, he told he is certain that I will not succeed, as his Fortran code did not have any comments. He wrote that he will not have any time to help me. However, it was not that difficult because his code was divided to proper subroutines. His code did computations in single precision, and it was necessary to change computations into double precision. Because I do not have a proper training in the rounding error business, I had hoped his advice in changing the several tolerance parameters to correspond double precision computations. In the development of the original JLP algorithm, I spent two-three times more time to fight rounding errors than to get the code mathematically correct. Now I understood the rounding errors better, but anyhow they are the permanent nuisance. The fundamental question with respect to rounding errors is: is a small-looking number zero or non-zero.

When I later told Fletcher how large problems and how fast my algorithm could solve, his attitude towards my efforts clearly changed.

Even Bergseng from NMBU started to use **J** in forest management problems in a quite premature stage, and we had quite tough time to keep his project in time. It took some time to clear a bug in Fletcher code which every now and then took the optimization into a wrong path. I had a quite slow computer, and the data transfer between Norway and Finland was slow. The bug was such that it had never caused problems in standard applications of bqbd software. In forest planning problems it can happen that after many pivot operations only residual variables corresponding non-binding constraints are in the basis. And when **J** refactorized of the basis after fixed number of pivot operations, as is the common procedure, the basis became slightly corrupted. In such a case, the refactoring is not needed. NMBU started to use **J** together with their GAYA simulator, and called the whole system GAYA-J, as the previous system was called GAYA-JLP. I appreciate that they have acknowledged our co-operation this way. **J** version 0.9.3 was published in August 2004.

**J** contained also a simulator language by which one describes a simulator which can be used to generate treatment schedules which are later optimized with the LP functions of **J**. When Simosol started to develop software which would compete with the Mela, which had had a monopoly status in planning software in Finland, and had all the problems which are inevitable in all monopoly projects. Simosol made first simulator developments using **J**, but moved to other solutions before first published version of Simo software. Simosol however used the linear programming routines of **J**. They are still using **J** when being part of Afry.

## **30.2 J with factories: J2.0**

For me the most disturbing feature of **J** and **JLP** was that they were not able to treat factories. I thought that the clever heuristic DTRAN algorithm of Howard Hoganson ([dtran] and [howard] showed that it should be possible to extend basic ideas of the **JLP** algorithm to treat with factory problems. I was able to derive the needed equations (see [lappilem]). Reetta Lempinen started to work with me to implement the formulas. Reetta has professional training in programming, while I'm a self-learning amateur. The necessary data structures were quite complicated. I had made some wrong initial decisions which made the data structures even more complicated than was necessary. Reetta had a clear head to keep data structures in order. It was a nice new experience to work together through video connection on the code which both could see simultaneously. I just gave commands, but it was not necessary to give detailed instructions because Reetta understood from a half word what to do. An important contribution of her was that when there were several dead ends, and I started to doubt whether we can really do what we were aiming at, she told, 'listen Juuso, we can solve this problem as we have solved all previous problems'. Interestingly, the problems were usually not in any programming errors, but the path could be found by raising to a little upper level and going to the main ideas. Reetta's role was essential in the factory optimization. Also later she has been helpful in minor technical matters, in writing the manual, testing the new developments etc. Recently she advised me how to use Git and Github. Reetta has also been solidary during the painful Luke years, when she was not allowed to work with **J** as she had liked to do. I appreciate her contribution very much. She is the second author of this manual and the paper [lappilem] for good reasons. However, I use word 'I' for such situations where Reetta has not been involved in the decisions how to proceed. The factory optimization was implemented in **J** version 2.0. published in 2013.

## **30.3 Battle over open-source J3.0 starts in Luke**

Initially I made the software so that only I could understand the structure and the code. When Reetta started to work with me in factory problems, I learned what are the weakest points in the software if it should be maintained by a group of people. But as I was always able to tell Reetta how the software worked, only very slight improvements in the documentation and comments of the code etc. were made. When I realized that my retirement age is approaching, I started to worry how the software could be maintained and developed after my retirement.

I had worked for Finnish Forest Research Institute (Metla) with small Academy and University of Joensuu brakes since 1978. In 2015 Metla and two other institutes were merged into Institute of Natural Resources Finland (Luke). Based on my long service in a government organization, I expected that the new organization would mean new leaders, new lawyers, new bureaucrats, and much more bureaucracy, and less time for researchers to do research, as always happens when government organizations simplify their administration and make it more efficient. My expectations were in the right direction, the reality was worse than I had expected.

Lauri Mehtätalo and I had agreed with an international publisher to make a book about forest biometry. In Metla this kind of agreement had been considered as a merit to Metla. But Luke forbad me to put any working time to this book project. After retirement I was free to prepare this book with Lauri. !

I started to clean and reorganize the **J** code so that it would be easier to maintain it. My superior Olli Salminen forbad me to continue that effort because he was certain that I would never get that work ready. I didn't obey, of course not. The eternity of this first cleaning round lasted two and half weeks. Reorganization of files took 2-3 days, but programming of a pre-compiler took two weeks. In JLP I already had learned that a precompiler could help to manage data areas of JLP. In J, the precompiler has greatly helped to manage global variables. The precompiler allows the users access global module variables without knowing where they are. To separate the global variables from local variables, the global variables have j\_ or jlp\_ prefix. By changing the data structures, **J** also became significantly faster (main reason was that allocatable pointers were changed into allocatable arrays).

In 2014 when we were looking at how **J** could be utilized in Mela software, I encountered old JLP concept âown functionâ, which was the method for allowing users of JLP to add own (arithmetic) functions if they had access to the source code. I thought that this idea would be useful also with respect to J. So, I organized **J** so that different users could add their own **J** functions, object types and options.

I was then convinced that the best way to utilize these improvements would be to make the soft-ware open source. This would also allow me to continue my work freely with **J** after my retirement.

The leaders of Luke agreed with me that the open-source **J** is a good idea. Unfortunately they also thought that open **J** is so important for Luke that the leaders could not allow me to take care of the publication and prepare and present the necessary decisions for their approval, or even participate as member in the group which started to hustle with the publication.

The leaders wanted themselves take care of the publication. Unfortunately, none of the leaders involved considered that the publication of J would be even so important that he/she had taken care that J would be eventually published. This absurd deadlock lasted almost seven years.

The previous version utilized some subroutines of IMSL package and from the âNumerical Recipes in Fortranâ book. I replaced these subroutines mainly by open access routines from Lapack and Ranlib packages from the Netlib library. Roger Fletcher allowed to distribute his linear programming sub-routines in the open J package. Fletcher gave a very liberal permission to use his subroutines in open source distribution (the price of his bqbd software was perhaps 100-200 Euros). But the lawyers of Luke studied his permission so long before they realized that it did not have correct words that Fletcher died before giving permission with better formulation. A permission with better formulations was obtained from his department in Dundee University. But the leading lawyer of Luke, Emilia Katajajuuri was not satisfied, she wanted make sure that the legal position of the person who gave the new permission was such that he could give the permission.

The following persons were involved in process: P/"aivi Eskelinen, Olli Salminen, Kari T. Korhonen, Kimmo Kukkavuori, Tuula Packalen, Sirpa Thessler, Sari Forsman-Hugg, Emilia Katajajuuri and Johanna Buchert. Iikka Sainio was an outside legal consult.

The leading lawyer of Emilia Katajajuuri made my position clear in a video meeting to which I also was accidentally invited to listen their new instructions. When I accidentally said 'could we decide that..', she interrupted me and said: 'Listen Juha, you do not decide anything in this matter'. Their message was that I have done my part.

When it was evident that the leaders of Luke wanted to get rid of me, I threatened that I will not retire before the opening decision is done. Sari Forsman-Hugg told she will make the decision. But as my threat seemed to make no influence, I retried at the beginning of 2017. When I despite of all the humiliation still hoped that some kind a co-operation with Luke would be possible, I applied the position outside researcher, which had provided me access to Luke's e-mail and library services. Sari Forsman-Hugg was not able to make a decision also with respect to my application. I did withdraw my application when my e-mail connections were interrupted two times.

Later I heard from Reetta that Luke had made the opening decision but she did not know what kind decision and I was not informed of the decision either, in disagreement with the distribution list of the decision, as I noticed in when I finally could see the decision after three years.

## 30.4 Retired, frozen conflict

After my retirement I was still hoping that some kind of co-operation without outside researcher status with Luke would be possible, and I participated in the application of factory optimization which was published in ???. Prof. Packalen told late 2017 that the publication of **J** is approaching. When I asked about the opening decision, she 'did not remember' what it contained but promised to check it out, which she did forget to do or at least forget to tell me what the decision contained. Prof. Packalen was planning a very high level launch of **J** with prominent international guests. I wrote that such seminar would not probably be worth of for trans-Atlantic flights. I was so stupid that I believed her promise that the publication of **J** was approaching and I submitted a correction to a bug which produced some amount of negative timber quantities.

During 2018-2021 I made some small parameter adjustments for Simosol and Norway and made some additions for my own research. Prof. Packalen had lost all interest in the publication, and she did not allow Reetta to develop the publication documents. When I heard 2020 that prof Packalen had left Luke and could not prevent publication any more, I asked Reetta to ask her superiors whether she could continue the preparation of manuals. She got the permission to use some time for that. This work with all style details was not very nice for her as she had already done big part of the work for the previous format of Lukes's report series. The report series had changed the formats, and Reetta had to do such tedious work she already had done once before. Reetta's superiors did never discuss with me anything related to the manuals or to the code. This way they had been free to pretend that I have not contributed to the work if **J** had been some time published.

In spring 2021 Hannu Salminen from Luke contacted me. He had memory problems with a very large data set. I made a rapid fix for his acute problem and did develop more permanent solutions for large data sets using direct access files. Actually that work was unnecessary as Viktor Strimbu from NMBU advised me later how to make **J** a 64-bit application using MSYS2 environment. The Gfortran environment I had used before did not support 64-bit applications. The 64-bit program allows to put the whole country into one run also in factory optimization. Hannu organized a video meeting where we discussed the development and utilization of the **J** software. He was the first person in Lukes six years history who was willing to discuss with me such things.

I started to work with **J** again. Reetta had told that **J** had could collapse after some hours of computations in large data sets in factory optimization. I asked Luke to get the problematic data sets so that I could try to fix

the problem. I got the answer that Luke is not allowed to send the data sets, and the answer did not indicate that Luke would do anything to get such permission. I was quite upset from such answer, and I started to think how to open the deadlock situation. Later I got the data, and I was able to fix the problem, which was not exactly a clear bug but rather a thin-ice place in the algorithm so that **J** did drop through the ice when going over the place repeatedly.

### 30.5 Operation Charles XII

When I started to think how I could find a way out from the deadlock, I remembered Charles XII, the king of Sweden (which included also Finland). He was in war with Denmark and he decided to fight Denmark by attacking Norway, which belonged to Denmark. He failed as almost his soldiers died in snowstorms in Northern Norway and he was shot by his own soldier. I was in conflict with Luke, even if Luke did acknowledge that such conflict existed because Luke insisted that in a legal sense, I did not even exist in this **J** affair. I thought to conquer Norway with nice **J** codes. Renovation of my co-operation with GAYA group suited their plans as they were rebuilding their simulator.

I wrote to Johanna Buchert, director general of Luke (who was already in the group of Luke leaders hustling in the publication of **J** when I was in Luke) Antti Asikainen, research director of Luke, and Kari T. Korhonen, who has been involved in this **J** affair and was the superior of Reetta, and told that I will not send to Luke new **J** codes including working factory optimization codes without a written co-operation agreement. I wrote also to registry-office and asked for the opening decision, and to a lawyer of Luke and asked what kind of legal actions Luke will take against me if I started to publish factory optimization things with GAYA group using codes which I would not give to Luke. The leaders did not comment in any way my co-operation proposal. The research director just wrote that all codes done in METLA are property of Luke. Buchert did not respond, but the Senior Vice President Ilkka P. Laurila answered that Luke regrets for the delays in the publication of **J** caused by personnel changes (a funny expression for the fact that the publication process could just start in 2020 when prof Packalen left Luke) and that Luke has started to prepare the publication and will publish the **J** on its web pages. Kari T Korhonen did not respond.

Thus the leaders of Luke insisted that Luke will publish tens of thousands code and manual lines I had written, and insisted that it has no reason or obligation to discuss with me what and in what form it will publish these lines. It is evident that Luke had not been able to publish **J** in my

life time (I'm over 70 yrs and I have a heart disease). But if I had been alive when Luke had published **J** under my name, I had made a lawsuit against Luke for shaming my researcher honor by publishing something I had not accepted for publication. Or perhaps Luke had followed the previous custom of Romania where all chemistry research was published under the name of Elena CeauÈescu, and had published the software and manuals under the name of some equivalent to Elena. When the director general of Luke, the research director of Luke, the Senior Vice President of Luke and the lawyers of Luke decided that Luke has absolutely no interest in working factory optimization **J** codes or other up to date **J** codes, did they discuss with any researchers?

After getting such a response to my co-operation suggestion, it was evident that I would not give Luke any new codes, and would require Luke to remove all codes I had submitted after my retirement as Luke would not acknowledge that it had got any codes from me after my retirement, and it would publish my codes as if they were developed in Luke. So I would continue my Charles XII operation. Unfortunately NMBU did not have factory and transportation cost data ready. In Norway the transportation costs can not be estimated as easily from coordinates as in Finland.

Laurila did send the decision to publish **J** as a open source software after the lawyers of Luke had considered two weeks whether Luke should do that. The decision was signed by the research director Johanna Buchert 30.8. 2017. The process of trying to get permission to use Fletchers codes after his death was not described properly. It was written that after Fletchers death the university of Dundee did not respond to queries of Luke. As described above, the things did not go that way. When Luke was not satisfied with the corrected permission sent by the university, the university had probably decided that it is vain to continue correspondence with Luke. However, the university wanted to communicate with me, when they asked my statement about the importance of Fletchers code in planning of natural resources. The government wanted to figure out whether the university is doing something useful. I think that my statement was more valuable for the university than the euros the university would lose when not getting payments for the bqbd code.

The decision told that **J** is published under licence AGPLv3. The licence is specially planned for programs which provide computing services through the net. Luke has not done anything to develop such net work services, as it has not developed **J** in any way after my retirement in 2017. The leaders of Luke did not discuss with me the license matters, of course not.

The decision nominated prof Packalen to take care of the launch of the software. Unfortunately she could not organize the launch, as **J** was not

ready to publication because prof Packalen did not allow Reetta to do the necessary preparations with respect to the code and manuals.

Lauri Mehtätalo became Professor in Mathematical Modeling for Forest Planning in Luke in Mai 2021. Coming from an university environment, he is interested in the development of science and research. He wanted to get **J** finally published after 6 year deadlock. Lauri did have anything against that I would take care of the publication. Lauri even thought that it would be good for science and research that I would work without payment. It was a refreshing new attitude in Luke to put science into priority. Lauri told that he would try to convince the leaders of Luke that it would not harm Luke's interests that I would take care of the publication of the software I had made (for most part). Lauri told initially that he wants to persuade me to give all new codes to Luke. When I protested his choice of words, he apologized, and used thereafter the word 'negotiate'. When Lauri started to 'negotiate' with me, I consider that Luke first time in its history acknowledged that I do exist as an legal entity is this **J** affair.

Lauri was able to rotate the head of the research director 180 degrees. The research director even told that he would be interested to become a coauthor in the publication dealing the factory optimization. It was, however, not mentally feasible for me, as he did not even answer my previous co-operation suggestion, but just told that Luke has everything it needs. Being a researcher, Lauri understood what were my aims and was able to get approval of the research director. So it seemed that the agreement was about ready. But then the agreement was stuck on the table of the research director.

## **30.6        Last battle, victory and peace in Olavinlinna**

I was invited to the 100 year anniversary celebration of the Finnish National Forest Inventory as I had worked also in the NFI group. I was interested to see my former colleagues, but it started to disturb me that I would not know whether I would be a guest of my enemy or my co-operations partner. I had a very exciting video meeting with the GAYA people. They promised me access to the Norwegian supercomputers needed in large factory optimizations, funding for traveling and for any consulting work. I started to think that have been stupid when I spent years of my short residual life waiting for such co-operation with Luke. As Lauri had tried to establish such co-operation between me and Luke, I decided to give Luke a last chance. I made an ultimatum that if we do not get a agreement with Luke within a week, I would break all negotiations with Luke and would continue only with Norwegian people, even if Luke might try to make a lawsuit against

me. Twenty-four hours before the time limit Lauri called that Luke is willing to make treaty with me. The lawyers of Luke did finalize the treaty two hours before the NFI celebration.

Antti Asikainen, the research director of Luke and I signed the co-operation treaty in the king's hall in Olavinlinna (St. Olaf's Castle) in Savonlinna 7.10. 2021. In the treaty I got almost everything I had fought for: The **J** software will be published, and I have full responsibility of the code and manuals. Luke will provide me data of factory locations, simulated treatment schedules for all inventory plots for the whole country, and the matrix of distances between the factories and inventory plots. Luke will also provide me access to CSC supercomputers which are necessary for the whole country optimizations. CSC does not allow independent retirees to use its computers. I'm allowed to make a methodological paper from developments, whereafter I will provide Luke all the new and improved **J** functions and the developed **J** scripts. I had hoped that Luke had promised me access to Mela so I could study how Mela is doing interest rate computations, as I have suspects that these computations are not in order. I had asked Olli Salminen some Mela results to study my suspects, but he told, after some day considerations, that Luke is not willing to make such computations. I suspect that the reason is Luke wants to keep all possible Mela problems secret. I did not insist to get such permissions as Lauri thought that this would delay and complicate the **J** process. In the treaty it is said that the code files state that Juha Lappi and Natural Resources Institute Finland have the copyright for the code. In the last minutes before the signatures the lawyers tried to reverse the order of copyright owners. I did not, of course, accept the reversed order, because I have made the **J** really operable after my retirement. Now, the recent developments have made Lukes or Metlas contribution even smaller, and the overall influence of Luke has been negative. It must, however, be taken into account that Pekka Mäkinen has done valuable work in collecting data of factories and transportation costs, and this data greatly helps my work when I'm now allowed to start to develop factory optimization for the whole Finland.

### **30.7        Total balance with Luke**

At the signing of the peace treaty, Johanna Buchert told that there has not been any disagreement in this **J** business, and let bygones be bygones. From my point of view, I had six and half years fight to get permission to publish the results of my research. For Luke, there was no disagreement because Luke did not acknowledge that I even existed as a legal entity. How could Luke have disagreement with something which does not even

exist? For me, the behavior of the leaders of Luke was a 'me too' experience. In the heart of my researcher identity is the conviction that every researcher, at least in a government research institute, has the right and even the obligation to publish the results of his research let it be a statistical method or computer code or ordinary research publication. The leaders of Luke denied me the right to publish the results of my statistical work in our biometry book and the results of my software development. In this J case, the reason was that they wanted to publish my results themselves. This has been a very traumatic harassment experience. All the victims of sexual harassment are also told that 'let bygones be bygones'. As in the peace treaty I was given all responsibility of manuals, I'm now utilizing this responsibility in this story hoping that the leaders of Luke and perhaps also others would be more careful when making decisions which may not tolerate daylight,

From the legal perspective, the leaders of Luke have insisted that Luke has full copyright to all work I've done in Mela or Luke. So they can freely follow their whims and waste hundreds of thousands of euros taxpayers money used in the J project. With Lukes overhead multipliers we may speak about millions. Perhaps they should also pay attention to the by-law telling what is the duty of Luke. How has Luke promoted forest research and its utilization by prevented the development and utilization of J software for over six years? The leaders of Luke never gave any rational justification why Luke should prevent me to take care of the publication.

If I had been allowed to publish and develop J as I wanted, Luke and forest industry would have now available methods to analyze e.g. what can be done when timber import from Russia suddenly stops. Luke is also still doing static regional sustainability analyzes, which are not reasonable as they do not take factories into account. Mentally Luke is stuck to the German foresters from 1800's who rotated a fixed cutting area for each year. If Luke had let me publish the open-source software in 2015 Luke had been a forerunner in the open source publication, and I had praised it for its progressive attitude. Now Luke has established its status in the history of open-source as an institute which decided to open a software but keeps the decision and the code locked for several years because it did not allow the principal author to take care of or even participate in the publication.

## 30.8 Freedom

After the Olavinlinna peace treaty, I thought initially that I would like to publish the software before Christmas 2021. But when the iron cage around me disappeared, the pressure which had increased in my mind for seven

years did burst in intensive code development. This development had already started when negotiations with Lauri started to look promising, and I developed the program to make Latex files for manuals and script files for examples automatically from comments embedded within the code or from a separate text files.

After the peace treaty I have rewritten all the central parts of the software using simpler and more easily maintained solutions, and added many new properties. The most important was the rewriting of the interpreter which interprets the **J** code generated using the input programming capabilities. I had been shamed if the previous interpreter had be offered to the eyes of professional programmers. I did rewrite the precompiler so it takes only some seconds to do the precompilation, and the precompiler makes indentations and gives better error messages than Gfortran for mixed up ifthen or do- structures. I did put the matrix computations into a new level implementing all properties I had found useful in Matlab when providing a method for a client using Matlab codes. I added new tools for debugging and code development. Now **J** can treat nicely submatrices and do all arithmetic operations and logical operations on matrices in addition to scalars. The previous version of **J** could make rough figures using a separate program written in Intel fortran, which I do no more have available. Publication level figures could be done using R scripts generated by **J**. Now **J** is producing figures using Gnuplot which is automatically run from within **J**. Currently only basic 2D and 3D figures can be done, but this Gnuplot connection makes it possible to develop **J** into full scale interface to all Gnuplot properties. **J** can now generate random numbers from any continuous or discrete distribution providing new possibilities to study the effects of random errors in the simulation of treatment schedules or in optimization. It is now possible to run R scripts from within **J**. Now **J** can be used easily also as a subroutine. Lauri has utilized this property by calling **J** from R. This offers many new possibilities, which we will utilize when continuing the co-operation with the GAYA-group.

I made first cleaning of the important **jlp()** function in the spring of 2021 when correcting the fragility which prevented the solution of large problems which take several hours in a ordinary PC. There are many things to be done in **jlp()** function, but I start to work with them when developing factory optimization in CSC supercomputers. I know already how parallel computations can be utilized in **jlp()**-function. Previous versions of **J** had special functions for developing forest simulators and computing the simulated schedules. Now all simulators can be developed and utilized using standard properties of **J** transformations either for using stand level or tree level variables I have not yet made good examples to demonstrate these

properties. Because the new **J** provides a platform for making all kind of new developments, including integer optimization (i.e preventing treatment unit to be divided among several schedules), nonlinear objective function (which would utilize the capability of **J** to compute derivatives according to analytic derivation rules), it was difficult to breathe a little and make the new codes available for users. The codes now published contain many errors. I invite the users to help me to correct them. First users should have some patience with respect to errors. I claim that the bug percentage is smaller than estimated 23-27% bug percentage in the first version of Windows 1. Currently I can correct most bugs causing system crash in 5-10 minutes. It should be emphasized that Luke does not have any kind of responsibility of the errors. I take the full moral responsibility of the errors. Similarly, it should be emphasized that Luke has no responsibility of the code which works correctly. I take the main responsibility of the correctly working code, giving Reetta her fair share. It is easier for me to correct the errors while alive. This fundamental fact of life was ignored by Luke when it prevented the publication for seven years.

During the intensive work period after the Olavinlinna peace treaty, my deep 'me too' traumas have started to heal slowly. Probably this healing process takes a long time, and I cannot very soon say let bygones be by-gones.

Juha Lappi, Suonenjoki 22.4.2022

## 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. Usersâ 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>