

Svante Björklund

RECVAR 3.5
A Software Package for New Data Structures in MATLAB
Reference Guide

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Reference Guide

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Abstract This document is a reference guide to a software package for new data structures in Matlab [®] that has been developed at the Defence Research Establishment (FOA) in Linköping, Sweden. The package offers record variables (same as structures in MATLAB 5), multidimensional matrices, lists, queues and stacks to MATLAB 4 and 5. Some of these data structures are now standard built-in data structures in MATLAB 5.		
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Sammanfattning <p> Detta dokument är en referenshandbok för ett programpaket för nya datastrukturer i Matlab[®], som har utvecklats på FOA i Linköping. Paketet tillhandahåller postvariabler (samma som strukturer i Matlab 5), flerdimensionella matriser, listor, köer och stackar till MATLAB 4 och 5. En del av dessa datastrukturer är nu standard i MATLAB 5. </p>		
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1 Introduction

This document is a reference guide to a software package for new data structures in Matlab[®] 4 and 5 that has been developed at the Defence Research Establishment (FOA) in Linköping, Sweden.

The package offers record variables (same as structures in MATLAB 5), multidimensional matrices, lists, queues and stacks to MATLAB 4 and 5. See the article [1] for an overview of and user guide for the package. Some of the data structures are now standard built-in data structures in MATLAB 5 (reference [3]) but some of the possibilities in the package could still be of interest for MATLAB 5 users.

When using the package with Matlab 4, a MEX file is needed. See [2] for more information about mex files. The MEX file has been compiled and tested on SUN workstations with Solaris 1 and Solaris 2 and on PC-computer with Windows 95. It should also run under Windows 3.x and NT without problems.

When using Matlab 5, the MEX file is not needed.

The current release is 3.5.

2 Overview

The package RECVAR for new data structures in Matlab consists of record variables, multidimensional matrices and lists. Queues and stacks are implemented using lists.

2.1 Record variables

RECVAR, A package for new data types in Matlab.

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Record variables in RECVAR

A record variable (called a structure in Matlab 5) enables the collection of different Matlab variables that belong to each other in one unit, a record variable. This concept is usual in programming languages like Pascal (record) and C/C++ (struct/class) and data bases but did not exist in Matlab prior to version 5.

A "record variable" consists of one or more "fields". For example a record variable 'person1' with the fields 'name' and 'age':

```
>> person1 = setr([], 'name', 'Tom');
>> person1 = setr(person1, 'age', 35);
```

Now one can handle the 'person1' with all its fields as one unit. One can get, for example, the age by:

```
>> getr(person1, 'age')
```

```
ans =
    35
```

The following functions are currently implemented:

```
setr : Creates record variables and creates and changes the
       contents of fields.
getr  : Gets the contents of fields.
showr : Prints the contents of all fields in a record variable
       on the screen. Similar to typing the name of a normal Matlab
       variable without a semicolon.
whosr : Like 'whos' but for the fields in a record variable.
recdir : Returns a Matlab matrix with the names of all fields
       in a record variable.
existr: Returns true if the specified field exists in the record
       variable.
isrecvar: Returns true if the argument is a record variable.
versionr: Returns version info. about the package for record variables.

tmatvar: A testprogram for testing this package.
```

For more information about the functions use 'help' for the corresponding function.

Overview

Matlab 4:

Allowed operation on record variables is:

assignment '=' of a whole record variable.

It is possible to use record variables as function parameters and as function return values. Making any other operation except for the functions below on a record variable may lead to unpredictable results, including a system crash.

Fields can be real or complex full Matlab matrices and Matlab strings. The possibility to have sparse matrices as fields is not implemented.

It is possible to use 'save' and 'load' directly with record variables on a fixed computer system. It is, however, recommended to pick out the fields with 'getr' and then save the field variables instead of the record variable. This because matrices may be represented in other ways on other computer systems or in other releases of Matlab.

With different matrix

representations for 'save' and 'load', the contents in a record variable will be corrupted and that may lead to unpredictable results, including a system crash.

Currently it is not possible to remove a field entirely but this possibility is planned. Today you can minimize the field size by assigning it an empty matrix [].

Matlab 5:

Record variables are implemented using Matlab 5's structures, see [1].

Other data structures in RECVAR:

Use 'help multimat' for information about multidimensional matrices, "multimatrices", (i.e. with more than two indices.).

Use 'help listhelp' for information about the data structure "list".

References:

[1] "Using Matlab Version 5", The MathWorks, Inc., 1997.

You can get the text above by typing:

```
>> help recvar
```

2.2 Binary trees

A data type `binaryTree` can be created with record variables with tree fields: `left` and `right` of type `binaryTree` and a field `data` with the useful information to be stored in the node. Binary trees can also be implemented using lists.

2.3 Multidimensional matrices

RECVAR, A package for new data types in Matlab.

(c) FOA 1998. See the file rvright.m for copyright notice.

Multidimensional matrices in RECVAR

A multidimensional matrix, "multimatrix" is a matrix with more than two indices. There is no direct way to access more than two dimensions in MATLAB 4. In Matlab 5 there exist multimatrices.

Ex:)

```
>> MM = zerosm([2 2 2]);% Create a 2*2*2 matrix.
>> MM = setm(MM,[1 2; 3 4], 1:2, ':', 1);% Fill the multimatrix.
>> MM = setm(MM,[5 6; 7 8], ':', ':', 2);% Fill the multimatrix.
>> getm(MM, ':', ':', 1)
ans =
1     2
3     4
>> getm(MM, 2 ,1:2 ,':')
ans =
3     4
7     8
>> getm(MM, ':', 2, ':')
ans =
2     6
4     8
>> getm(MM, 1, 2, ':')
ans =
2
6
>>
```

The following functions are currently implemented:

zerosm: To create an multimatrix. Should always be used first.
 setm : To assign a scalar, a vector or a two dimensional matrix to a part of a multimatrix.
 getm : To get a scalar, a vector or a two dimensional matrix from a part of a multimatrix.
 getm2: Like getm but behaviour same as squeeze(A(...)) in Matlab 5.
 sizem: Returns the size of a multimatrix.
 reshape: Like reshape but for multimatrices.
 ismulmat: Returns true if the argument is a multimatrix.

For more information about the functions use 'help' for the corresponding function.

Matlab 4:

It is possible to get slices of the multimatrix in different dimensions. The multimatrices can only contain complex numbers, no other datatypes. Presently there is a limit of six dimensions.

Overview

Sparse multimatrices are not implemented.

There are the same restrictions on the allowed operations on a multimatrix as on a record variable, since multimatrices are implemented using record variables. See help recvar.

Matlab 5:

recvars multimatrices are implemented using Matlab 5's multidimensional matrices, see [1].

Other data structures in RECVAR:

Use 'help recvar' for information record type variables.

Use 'help listhelp' for information about the data structure "list".

References:

[1] "Using Matlab Version 5", The MathWorks, Inc., 1997.

2.4 Lists

RECVAR, A package for new data types in Matlab.

(c) FOA 1998. See the file rvright.m for copyright notice.

Lists in RECVAR

Management of lists.

The lists can contain arbitrary data types (except sparse matrices) as elements.

Examples:

```
>> l1 = putlst1(5,[]);
>> l1 = putlst1(6,l1);
>> showl(l1)
```

```
6
5
```

```
>> l = makelist([1 2; 3 4], 5, 'hallo');
>> l = appendl(l,4);
>> showl(l)
```

```
[1 2; 3 4]
5
hallo
4
```

```
>> a = setr([], 'name', 'Tom');
>> a = setr(a, 'age', 43);
>> b = setr([], 'name', 'Julia');
```

Overview

```
>> b = setr(b,'age',39);
>> MM = zerosm([2 2 2]);
>> MM = setm(MM,[1 2; 3 4], 1:2, ':', 1);
>> MM = setm(MM,[5 6; 7 8], ':', ':', 2);
>> register = setr([], 'Type', 'Personel register');
>> personlist = makelist(a,b);
>> register = setr(register, 'persons', personlist);

>> l5 = makelist('hallo', [1 2; 3 4], [1; 2.5 + 3.75*i], a, MM, register);
>> dispr(l5)

...
```

The following functions are currently implemented:

makelist: Creates a list.

put1stl: Put an element first in the list. Can also create a list.

appendl: Appends an element last in the list.

get1stl: Gets the first element of a list.

getrestl: Returns a list with the first element removed.

islastl: Returns true if a list contains only one element.

islist: Returns true if the input parameter is a list.

reversel: Reverses the elements of a list.

showl : Shows the contents av all elements in a list on the screen.

list2rec: Converts a list to a record variable (Matlab 5 only).

There is also new function "dispr" for the display the contents of a variable on the screen. This function handles ordinary Matlab variables, record variables, multidimensional matrices and lists.

As an example of the use of list functions, the code for showl is below.:

```
function showl(list)
while (~islastl(list))
    disp(get1stl(list))
    list = getrestl(list);
end%while
disp(get1stl(list))
```

Matlab 4:

There are the same restrictions on the allowed operations on a list as on a record variable, since lists are implemented using record variables. See help recvar.

Matlab 5:

Lists are implemented using Matlab 5's cell arrays, se reference [1].

References:

[1] "Using Matlab Version 5", The MathWorks, Inc., 1997.

2.5 Queues and stacks

Queues and stacks are implemented using lists By using `appendl` and `get1stl` we get a queue data structure. By using `put1stl` and `get1stl` we get a stack data structure.

3 Functions

The following sections are the help texts of the Matlab 4 versions of the functions.

3.1 appendl

There are the following functions in the package:

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function outList = appendl(inList, data)
```

Appends an element last in the list. This function is slower than put1stl.

```
inList  ListT
data    Any Type
```

3.2 existr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function B = existr(recordvar, fieldname)
```

Returns true (1) if the specified field exists in the record variable, otherwise false (0).

```
B          BoolT
recordvar  RecVarT
fieldname  StringT
```

3.3 get1stl

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function data = get1stl(inList)
```

Gets the first element of a list.

```
inList  ListT
```


3.4 getm

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function Matrix = getm(multiMatrix, ix1, ix2, ix3, ix4, ix5, ix6)
```

Gets a two dimensional matrix from a part of a multidimensional matrix (multimatrix).

Matrix A normal 2D Matlab matrix.

multiMatrixT MultimatrixT

ix1, ix2, ix3, ix4, ix5, ix6: Index (integer row vectors or ':').

Ex:

```
b = getm(A, 1, 3:4, ':');
```

```
% Assigns to b the elements in A at indices: 1st dimension=1,  
2nd dimension=3:4 and 3rd dimension=all elements.
```

The first dimension whose index is a vector becomes different rows in the output matrix 'Matrix'.

Note that when the output matrix is a vector, it will always be a row vector.

This differs from squeeze(A(...)) in Matlab 5.

3.5 getm2

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function Matrix = getm2(multiMatrix, ix1, ix2, ix3, ix4, ix5, ix6)
```

Gets a two dimensional matrix from a part of a multidimensional matrix (multimatrix). Behaviour as Matlab 5.

Matrix A normal 2D Matlab matrix.

multiMatrixT MultimatrixT

ix1, ix2, ix3, ix4, ix5, ix6: Index (integer row vectors or ':').

The first dimension whose index is a vector becomes different rows in the output matrix 'Matrix'.

Note that when the output matrix is a vector, it will always be a row vector except for when ix2 is vector.

This function differs from the function getm in that way that getm2 returns the same output matrix as squeeze(A(...)) in Matlab 5.

The only difference is when ix2 is a vector and all other index variables are scalars.

The indexnumber ':' can be used to denote all elements in a dimension.

Ex:

```
b = getm(A, 1, 3:4, ':');
```

```
% Assigns to b the elements in A at indices: 1st dimension=1,  
2nd dimension=3:4 and 3rd dimension=all elements.
```

3.6 getm3

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function Matrix = getm3(multiMatrix, row, col, ix1, ix2, ix3, ix4, ix5, ix6)
```

Gets a two dimensional matrix from a part of a multidimensional matrix (multimatrix). The index (ix1, ix2, ..., or ix6) that will form different rows in the output matrix is specified with the input parameter "row".

Matrix A normal 2D Matlab matrix.

multiMatrix MultimatrixT

row

col

ix1, ix2, ix3, ix4, ix5, ix6: Index (integer row vectors or ':').

Currently the input parameter "col" is not used. If "row" index is no vector but there are two other vectors there should be an error message there is none. This may be a source to hard-to-find errors.

If the first index that is a vector is not the same as specified with "row" then transpose the output from "getm". If no index is a vector no transposition is done.

The indexnumber ':' can be used to denote all elements in a dimension.

3.7 getr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function M = getr(recordvar, fieldname)
```

Gets the contents of a field in a record variable.

recordvar RecVarT

fieldname StringT

3.8 getrestl

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function ouList = getrestl(inList)
```

Returns a list with the first element removed.

ouList, inList: ListT

3.9 isemptyl

RECVAR, A package for new data structures in Matlab.

(c) FOA 1998. See the file rvright.m for copyright notice.

```
function B = isemptyl(list)
```

Returns 1 if list is empty and 0 otherwise.

```
B      BoolT  
list   ListL
```

3.10 islastl

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function B = islastl(list)
```

Returns 1 if list contains only one element and 0 otherwise.

```
B      BoolT  
list   ListL
```

3.11 islist

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function B = islist(variable)
```

Returns 1 if the argument is a list and 0 otherwise.

```
B      BoolT  
variable Any type
```

3.12 ismulmat

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function B = ismulmat(variable)
```

Returns 1 if the argument is a multimatrix and 0 otherwise.

```
B      BoolT  
variable Any type
```

3.13 isrecvar

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function B = isrecvar(variable)
```

Returns 1 if the argument is a record variable and 0 otherwise.

B BoolT
variable Any type

3.14 list2rec

RECVAR, A package for new data structures in Matlab.

(c) FOA 1998. See the file rvright.m for copyright notice.

```
function outRecVar = list2rec(list)
```

Converts a list or a cell array to a record variable.

The list or cell array must contain pairs of field names (strings) and field values.

This function does not work with Matlab releases prior to release 5.

outRecVar RecVarT
list ListT

Example:

```
>> list2rec({'name','Tom', 'age',45, 'mat',[1 3; 3 4]})
```

```
ans =  
  name: 'Tom'  
  age: 45  
  mat: [2x2 double]
```

3.15 makelist

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function outList = makelist(data1, data2, data3, data4, data5, data6)
```

To create a list.

outList ListT
data1, data2, data3, data4, data5, data6: Arbitrary type in Matlab 5,
allowed field type in record variable in Matlab 4 (see help recvar).

3.16 prhead

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function prhead(recordvar)
```

Prints the contents of the internal structs in the record variable.
Only used for debugging.

recordvar RecVarT

3.17 put1stl

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function outList = put1stl(data, inList)
```

Put an element first in the list.

3.18 recdir

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function M = recdir(recvar)
```

Returns a Matlab matrix with the names of all fields in a record variable.
The order of the fields is not defined.

M StringVectorT
recvar RecVarT

3.19 reshapem

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function MMOut = reshapem(MMIn, newSize)
```

Works like 'reshape' but for multimatrices. The new indices are in a row vector 'newSize'. The first index is the "fastest loop" when shaping the new multimatrix.

MMOut, MMIn: MultimatrixT
newSize: Integer row vector with the new sizes of the dimensions.

3.20 reversel

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function outList = reversel(inList)
```

Reverses the elements of a list.

outList, inList: ListT

3.21 setm

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function Mout = setm(Min, 2Dmatrix, ix1, ix2, ix3, ix4, ix5, ix6)
```

Assigns a two-dimensional matrix to a part of a multidimensional matrix (multimatrix). The first index in the multidimensional matrix that is a vector will corresponds to different rows in the two-dimensional matrix. If the two-dimensional matrix in fact is a vector, the index in the vector corresponds the index in the multidimensional matrix that is a vector.

Mout MultimatrixT

multiMatrix MultimatrixT

M2d A normal 2D Matlab matrix.

ix1, ix2, ix3, ix4, ix5, ix6: Index (integer row vectors or ':').

Ex:

```
A = setm(A, [1 2; 3 4], 1, 3:4, 5:6);
```

```
% Assigns the [1 2; 3 4] to the elements A(1, 3:4, 5:6).
```

The indexnumber ':' can be used to denote all elements in a dimension.

3.22 setr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function M = setr(recordvar, fieldname, fieldvar)
```

Creates record variables and creates and changes the contents of fields.

M RecVarT

recordvar RecVarT or []

fieldname StringT

fieldvar Any type

Ex:

```
A = setr(A, 'frequency', 2800);
```

```
% Sets the field 'frequency' to the value 2800 in the record variable 'A'.
```

If 'recordvar' is not an record variable an error message is issued.

To create a new record variable use 'recordvar' = [].

3.23 showl

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function showl(list)
```

Shows the contents of all elements in a list on the screen. It is rather like typing the name of a normal Matlab matrix without an ending semicolon ';'.
list ListT

3.24 showr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function showr(recvar)
```

Shows the contents of all fields in a record variable on the screen. It is rather like typing the name of a normal Matlab matrix without an ending semicolon ';'.
recvar RecVarT

3.25 sizem

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function size = sizem(multiMatrix)
```

Returns the sizes of the multidimensional matrix in a row vector.

3.26 versionr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function S = versionr()
```

Returns version information about this package for record type variables and multidimensional matrices.
S StringT

3.27 whosr

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function whosr(recvar)
```

Shows information about the fields of a record variable: name, type, size, desity and complex values.

```
recvar RecVarT
```

3.28 zerosm

RECVAR, A package for new data types in Matlab 4.

(c) FOA 1997. See the file rvright.m for copyright notice.

```
function Mout = zerosm(size)
```

To create an multimatrix. zerosm should always be used before using a multimatrix.

size Row vector of sizes of the dimensions.

Ex)

```
A = zerosm([2 5 3 6])
```

```
% Creates a 4-dimensional array of size 2*5*3*6 elements.
```


4 Source code history

RECVAR, A package for new data types in Matlab.
(c) FOA 1998. See the file rvright.m for copyright notice.

This file contains important information about changes between releases of the toolbox. The file begins with the latest release.

Release R3-5 1998/05/12

Help texts are updated.

Release R3-4 1998/05/07

New representation of lists in Matlab5 with cell arrays.
New function "list2rec" that converts a list or a cell array to a record variable (works only in Matlab 5).

Release R3-3 1998/05/06

Small change of sizem for Matlab 5 compatibility.

Release R3-2 1997/12/29

New function getm2, which is like getm but has the same behaviour as squeeze(A(...)) in Matlab 5.

New function getm3, by which it is possible to specify which of the indices (ix1, x2, ..., or ix6) that will form different rows in the output matrix.

Correction of an error in getm, setm, matlab5/getm, matlab5/setm. Or was it an error in Matlab? The error occurred only when one of the indices was the scalar 58 (character code for ':').

Release R3-1 1997/12/08

Changed comments.

Release R3-0 1997/08/20

A new Matlab5 compatibility box. Everything except showr and whosr seems to work.

New is management of lists. There are the following functions:
makelist.m putlist.m appendl.m getlist.m getrestl.m islastl.m islist.m reversel.m showl.m
tlist.m listhelp.m

A new function for the display the contents of a variable on the screen. This function handles ordinary Matlab variables, record variables, multidimensional matrices and lists.

Release R2-4 1997/07/30

Source code history

Memory leakage found and removed in the mex file. The cause of the memory leakage was the Matlab function mxSetName.

Release R2-3 1997/07/25

Now an error message is issued when a field is not found using gettr. Earlier an empty matrix was returned without a message.

Kompilerat och testat på gauss (DEC Alpha) utan problem.

Release R2-2 1997/05/18

It is now possible to assign an empty matrix to a field in a record variable.

New copyright messages.

New files: readme, Makefile, history.txt.

Release R2-1 1996/11/25

All tests in tmatvar.m and tmulmat.m on curare and magic completed successfully.

Release Rx-x 1996/11/13

Changes done by Anders Gustafsson.

Release Rx-x 1996/11/11

Correction of an error in isrecvar. matvar revision 2.1.

Release Rx-x 1996/10/08

Multidimensional matrices are implemented.

5 Copyright notice

RECVAR, a software package for new data types in Matlab.
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RECVAR was written by Svante Björklund.
RECVAR was ported to Microsoft Windows for PC by Anders Gustafsson.

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References

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