

RSparseMatrix

Anton Antonov

MathematicaForPrediction at GitHub

MathematicaForPrediction blog at WordPress.com

May 2015

October 2015

Introduction

This notebook has the function implementations for manipulating objects with head `RSparseMatrix` that behave like `SparseArray` objects but have the added functionalities to use row names and column names in a manner similar to that of the sparse arrays objects from the base library `Matrix` [2] for the programming language `R` [1].

The idea is fairly simple: we can use associations or replacement rules to map row names and column names into integers. Similarly to how it is done in `R`, `RSparseMatrix` handles only strings as row names and column names.

The following function signatures are implemented:

```
RowNames[_RSparseMatrix]
ColumnNames[_RSparseMatrix]
DimensionNames[_RSparseMatrix]
Dimensions[_RSparseMatrix]
RowCount[_RSparseMatrix]
ColumnCount[_RSparseMatrix]
RowSum[_RSparseMatrix]
ColumnSum[_RSparseMatrix]
Total[_RSparseMatrix, ___]
ArrayRules[_RSparseMatrix]
Transpose[_RSparseMatrix]
MatrixForm[_RSparseMatrix]
MatrixPlot[_RSparseMatrix]
Times[_RSparseMatrix, _RSparseMatrix]
Times[_RSparseMatrix]
Times[_RSparseMatrix, _]
Plus[_RSparseMatrix, _RSparseMatrix]
Plus[_RSparseMatrix]
Plus[_RSparseMatrix, _]
Dot[_RSparseMatrix, _RSparseMatrix]
Dot[_RSparseMatrix]
Dot[_RSparseMatrix, _]
Part[_RSparseMatrix, _String | {_String ..}, ___]
Part[_RSparseMatrix, _, _String | {_String ..}]
Part[_RSparseMatrix, _String | {_String ..}, _String | {_String ..}]
RowBind[_RSparseMatrix, _RSparseMatrix]
ColumnBind[_RSparseMatrix, _RSparseMatrix]
```

Note that assignment (with `Set[___]`) is not implemented.

The package can be loaded from GitHub [3]:

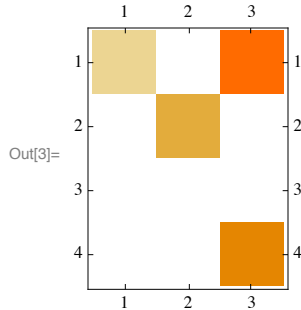
```
In[1]:= Import [
  "https://raw.githubusercontent.com/antononcube/MathematicaForPrediction/master/Misc/
  RSparseMatrix.m"]
```

Implementation (and explanations)

Tests and experiments

■ SparseArrays to compare with

```
In[2]:= mat = SparseArray[{{1, 1} → 1, {2, 2} → 2, {4, 3} → 3, {1, 3} → 4}];
MatrixPlot[mat]
```



```
In[4]:= Grid[{{MatrixForm[mat], MatrixForm[Join[mat, mat]],
MatrixForm[Transpose@Join[Transpose[mat], Transpose[mat]]]}}}]
```

Out[4]=

$$\begin{pmatrix} 1 & 0 & 4 \\ 0 & 2 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 3 \end{pmatrix} \begin{pmatrix} 1 & 0 & 4 \\ 0 & 2 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 3 \end{pmatrix} \begin{pmatrix} 1 & 0 & 4 & 1 & 0 & 4 \\ 0 & 2 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 3 & 0 & 0 & 3 \end{pmatrix}$$

■ Creation

```
In[5]:= rmat = MakeRSparseMatrix[
  {{1, 1} → 1, {2, 2} → 2, {4, 3} → 3, {1, 4} → 4}, "ColumnNames" → {"a", "b", "c"},
  "RowNames" → {"A", "B", "C"}, "DimensionNames" → {"U", "V"}]
```

Out[5]= \$Failed

```
In[6]:= rmat = MakeRSparseMatrix[
  {{1, 1} → 1, {2, 2} → 2, {4, 3} → 3, {1, 4} → 4}, "ColumnNames" → {"a", "b", "c", "d"},
  "RowNames" → {"A", "B", "C", "D"}, "DimensionNames" → {"U", "V"}];
```

```
In[7]:= rmat // MatrixForm
```

Out[7]//MatrixForm=

$$\begin{pmatrix} & \text{a} & \text{b} & \text{c} & \text{d} \\ \text{A} & 1 & 0 & 0 & 4 \\ \text{B} & 0 & 2 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 3 & 0 \end{pmatrix}$$

```
In[8]:= SparseArray[rmat] // MatrixForm
```

Out[8]//MatrixForm=

$$\begin{pmatrix} 1 & 0 & 0 & 4 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 3 & 0 \end{pmatrix}$$

```
In[9]:= SparseArray[rmat[All, RotateLeft@ColumnNames[rmat]]] // MatrixForm
```

Out[9]//MatrixForm=

$$\begin{pmatrix} 0 & 0 & 4 & 1 \\ 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \end{pmatrix}$$

■ Query methods

```
In[10]:= RowNames[rmat]
ColumnNames[rmat]
DimensionNames[rmat]
```

```
Out[10]= {A, B, C, D}
```

```
Out[11]= {a, b, c, d}
```

```
Out[12]= {U, V}
```

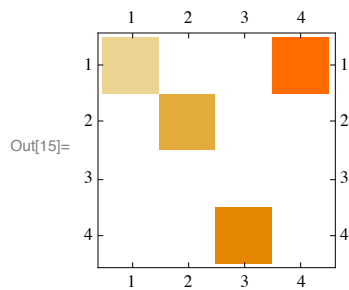
```
In[13]:= Dimensions[rmat]
```

```
Out[13]= {4, 4}
```

```
In[14]:= ArrayRules[rmat]
```

```
Out[14]= {{1, 1} → 1, {1, 4} → 4, {2, 2} → 2, {4, 3} → 3, {_, _} → 0}
```

```
In[15]:= MatrixPlot[rmat]
```



```
In[16]:= MatrixForm[rmat]
```

```
Out[16]//MatrixForm=
```

$$\begin{pmatrix} & \begin{matrix} a & b & c & d \end{matrix} \\ \begin{matrix} A \\ B \\ C \\ D \end{matrix} & \begin{pmatrix} 1 & 0 & 0 & 4 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 3 & 0 \end{pmatrix} \end{pmatrix}$$

■ Transpose

```
In[17]:= MatrixForm[Transpose[rmat]]
```

```
Out[17]//MatrixForm=
```

$$\begin{pmatrix} & \begin{matrix} A & B & C & D \end{matrix} \\ \begin{matrix} a \\ b \\ c \\ d \end{matrix} & \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 3 \\ 4 & 0 & 0 & 0 \end{pmatrix} \end{pmatrix}$$

```
In[18]:= DimensionNames[Transpose[rmat]]
```

```
Out[18]= {V, U}
```

■ Sums

```
In[19]:= Total[rmat, 2]
```

```
Out[19]= 10
```

```
In[20]:= RowSum[rmat]
```

```
Out[20]= {1, 2, 3, 4}
```

```
In[21]:= ColumnSum[rmat]
```

```
Out[21]= {5, 2, 0, 3}
```

■ Dot product

In[22]:= **MatrixForm[rmat.mat]**

Out[22]//MatrixForm=

$$\left(\begin{array}{c|cccc} \text{A} & 1 & 0 & 16 & \\ \text{B} & 0 & 4 & 0 & \\ \text{C} & 0 & 0 & 0 & \\ \text{D} & 0 & 0 & 0 & \end{array}\right)$$

In[23]:= **MatrixForm[Transpose[mat].rmat]**

Out[23]//MatrixForm=

$$\left(\begin{array}{c|cccc} \text{a} & \text{b} & \text{c} & \text{d} & \\ 1 & 0 & 0 & 4 & \\ 0 & 4 & 0 & 0 & \\ 4 & 0 & 9 & 16 & \end{array}\right)$$

In[24]:= **Grid[{{MatrixForm[rmat.rmat], MatrixForm[rmat.Transpose[rmat]]}}]**

Out[24]=

$$\left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 1 & 0 & 12 & 4 \\ \text{B} & 0 & 4 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 0 & 0 \end{array}\right) \quad \left(\begin{array}{c|cccc} & \text{A} & \text{B} & \text{C} & \text{D} \\ \hline \text{A} & 17 & 0 & 0 & 0 \\ \text{B} & 0 & 4 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 0 & 9 \end{array}\right)$$

In[25]:= **MatrixForm[(rmat.rmat).rmat]**

Out[25]//MatrixForm=

$$\left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 1 & 0 & 12 & 4 \\ \text{B} & 0 & 8 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 0 & 0 \end{array}\right)$$

In[26]:= **Grid[{{MatrixForm[rmat], MatrixForm[rmat.rmat.rmat]}]}**

Out[26]=

$$\left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 1 & 0 & 0 & 4 \\ \text{B} & 0 & 2 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 3 & 0 \end{array}\right) \quad \left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 1 & 0 & 12 & 4 \\ \text{B} & 0 & 8 & 0 & 0 \\ \text{C} & 0 & 0 & 0 & 0 \\ \text{D} & 0 & 0 & 0 & 0 \end{array}\right)$$

Here Associations “swallows” the second value “U” because they are the same.

In[27]:= **DimensionNames[rmat.Transpose[rmat]]**

Out[27]= {U}

■ Arithmetic operations

In[28]:= **MatrixForm[rmat + 1]**

Out[28]//MatrixForm=

$$\left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 2 & 1 & 1 & 5 \\ \text{B} & 1 & 3 & 1 & 1 \\ \text{C} & 1 & 1 & 1 & 1 \\ \text{D} & 1 & 1 & 4 & 1 \end{array}\right)$$

In[29]:= **MatrixForm[rmat - 1]**

Out[29]//MatrixForm=

$$\left(\begin{array}{c|cccc} & \text{a} & \text{b} & \text{c} & \text{d} \\ \hline \text{A} & 0 & -1 & -1 & 3 \\ \text{B} & -1 & 1 & -1 & -1 \\ \text{C} & -1 & -1 & -1 & -1 \\ \text{D} & -1 & -1 & 2 & -1 \end{array}\right)$$

In[30]:= **MatrixForm**[**rmat** * 2.33]

Out[30]//MatrixForm=

$$\left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 2.33 & 0. & 0. & 9.32 \\ B & 0. & 4.66 & 0. & 0. \\ C & 0. & 0. & 0. & 0. \\ D & 0. & 0. & 6.99 & 0. \end{array} \right)$$

In[31]:= **Grid**[{**MatrixForm** /@ {**rmat**, **rmat** + 2, **rmat** * 10, 100 * **rmat** + 2.33 * **rmat**}}]

$$\text{Out[31]=} \left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 1 & 0 & 0 & 4 \\ B & 0 & 2 & 0 & 0 \\ C & 0 & 0 & 0 & 0 \\ D & 0 & 0 & 3 & 0 \end{array} \right) \left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 3 & 2 & 2 & 6 \\ B & 2 & 4 & 2 & 2 \\ C & 2 & 2 & 2 & 2 \\ D & 2 & 2 & 5 & 2 \end{array} \right) \left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 10 & 0 & 0 & 40 \\ B & 0 & 20 & 0 & 0 \\ C & 0 & 0 & 0 & 0 \\ D & 0 & 0 & 30 & 0 \end{array} \right) \left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 102.33 & 0. & 0. & 409.32 \\ B & 0. & 204.66 & 0. & 0. \\ C & 0. & 0. & 0. & 0. \\ D & 0. & 0. & 306.99 & 0. \end{array} \right)$$

In[32]:= **Grid**[{**MatrixForm** /@ {**rmat**, **Transpose**[**rmat**], **rmat** + **Transpose**[**rmat**], **rmat** * **Transpose**[**rmat**]}]}

$$\text{Out[32]=} \left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 1 & 0 & 0 & 4 \\ B & 0 & 2 & 0 & 0 \\ C & 0 & 0 & 0 & 0 \\ D & 0 & 0 & 3 & 0 \end{array} \right) \left(\begin{array}{c|cccc} & A & B & C & D \\ \hline a & 1 & 0 & 0 & 0 \\ b & 0 & 2 & 0 & 0 \\ c & 0 & 0 & 0 & 3 \\ d & 4 & 0 & 0 & 0 \end{array} \right) \left(\begin{array}{cccc} 2 & 0 & 0 & 4 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 3 \\ 4 & 0 & 3 & 0 \end{array} \right) \left(\begin{array}{cccc} 1 & 0 & 0 & 0 \\ 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{array} \right)$$

■ Part

In[33]:= **MatrixForm**[**rmat**[[{"A"}]]]

Out[33]//MatrixForm=

$$\left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 1 & 0 & 0 & 4 \end{array} \right)$$

In[34]:= **MatrixForm**[**rmat**[[{"A", "B"}, {"a", "c", "d"}]]]

Out[34]//MatrixForm=

$$\left(\begin{array}{c|ccc} & a & c & d \\ \hline A & 1 & 0 & 4 \\ B & 0 & 0 & 0 \end{array} \right)$$

In[35]:= **MatrixForm**[**rmat**[[2 ;; 3, 1 ;; 2]]]

Out[35]//MatrixForm=

$$\left(\begin{array}{c|cc} & a & b \\ \hline B & 0 & 2 \\ C & 0 & 0 \end{array} \right)$$

In[36]:= **MatrixForm**[**rmat**[[{"A", "B"}]]]

Out[36]//MatrixForm=

$$\left(\begin{array}{c|cccc} & a & b & c & d \\ \hline A & 1 & 0 & 0 & 4 \\ B & 0 & 2 & 0 & 0 \end{array} \right)$$

In[37]:= **MatrixForm**[**rmat**[[{"A", "B"}, 1 ;; 2]]]

Out[37]//MatrixForm=

$$\left(\begin{array}{c|cc} & a & b \\ \hline A & 1 & 0 \\ B & 0 & 2 \end{array} \right)$$

In[38]:= **MatrixForm**[**rmat**[[**All**, {"a", "c"}]]]

Out[38]//MatrixForm=

$$\left(\begin{array}{c|cc} & a & c \\ \hline A & 1 & 0 \\ B & 0 & 0 \\ C & 0 & 0 \\ D & 0 & 3 \end{array} \right)$$

■ RowBind, ColumnBind

```
In[39]:= MatrixForm[RowBind[rmat, rmat]]
```

Out[39]//MatrixForm=

	a	b	c	d
A.1	1	0	0	4
B.1	0	2	0	0
C.1	0	0	0	0
D.1	0	0	3	0
A.2	1	0	0	4
B.2	0	2	0	0
C.2	0	0	0	0
D.2	0	0	3	0

```
In[40]:= rmat2 = ToRSparseMatrix[rmat, "RowNames" → Map["s." <> # &, RowNames[rmat]]];
MatrixForm[rmat2]
```

Out[41]//MatrixForm=

	a	b	c	d
s.A	1	0	0	4
s.B	0	2	0	0
s.C	0	0	0	0
s.D	0	0	3	0

```
In[42]:= rmat3 = ToRSparseMatrix[rmat, "ColumnNames" → Map["t." <> # &, ColumnNames[rmat]]];
MatrixForm[rmat3]
```

Out[43]//MatrixForm=

	t.a	t.b	t.c	t.d
A	1	0	0	4
B	0	2	0	0
C	0	0	0	0
D	0	0	3	0

```
In[44]:= MatrixForm[RowBind[rmat, rmat2]]
```

Out[44]//MatrixForm=

	a	b	c	d
A	1	0	0	4
B	0	2	0	0
C	0	0	0	0
D	0	0	3	0
s.A	1	0	0	4
s.B	0	2	0	0
s.C	0	0	0	0
s.D	0	0	3	0

```
In[45]:= {MatrixForm[ColumnBind[rmat, rmat2]], MatrixForm[ColumnBind[rmat, rmat3]]}
```

Out[45]= $\left\{ \begin{array}{c|cccccccc} & a.1 & b.1 & c.1 & d.1 & a.2 & b.2 & c.2 & d.2 \\ \hline A & 1 & 0 & 0 & 4 & 1 & 0 & 0 & 4 \\ B & 0 & 2 & 0 & 0 & 0 & 2 & 0 & 0 \\ C & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ D & 0 & 0 & 3 & 0 & 0 & 0 & 3 & 0 \end{array} \right\}, \left\{ \begin{array}{c|cccccccc} & a & b & c & d & t.a & t.b & t.c & t.d \\ \hline A & 1 & 0 & 0 & 4 & 1 & 0 & 0 & 4 \\ B & 0 & 2 & 0 & 0 & 0 & 2 & 0 & 0 \\ C & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ D & 0 & 0 & 3 & 0 & 0 & 0 & 3 & 0 \end{array} \right\}$

Profiling

```
In[46]:= smat = SparseArray[RandomReal[{0, 1}, {1000, 120}]];
```

```
In[47]:= rmat =
  ToRSparseMatrix[smat, "RowNames" → Map["A" <> ToString[#] &, Range[Dimensions[smat][[1]]],
    "ColumnNames" → Map["b" <> ToString[#] &, Range[Dimensions[smat][[2]]]]];
```

```

In[48]:= n = 100;
tres =
  AbsoluteTiming[
    Do[sres = smat.Transpose[smat], {i, n}]
  ]
tres[[1]] / n
Out[49]= {5.33297, Null}

Out[50]= 0.0533297

In[51]:= tres =
  AbsoluteTiming[
    Do[rres = rmat.Transpose[rmat], {i, n}]
  ]
tres[[1]] / n
Out[51]= {5.3034, Null}

Out[52]= 0.053034

In[53]:= Norm[sres[[1 ;; 120, 1 ;; 120]] - SparseArray[rres[[1 ;; 120, 1 ;; 120]]]]
Out[53]= 0.

In[54]:= Grid[{{
  MatrixPlot[rres[[1 ;; 120, 1 ;; 120]], ImageSize -> 350],
  MatrixPlot[rres["A" <> ToString[#] & /@ Range[120], 1 ;; 120], ImageSize -> 350]}}]

```

References

- [1] The R Core Team, R Language Definition, (2015).
URL: <https://cran.r-project.org/doc/manuals/r-release/R-lang.pdf>
- [2] D. Bates, M. Maechler, Sparse and Dense Matrix Classes and Methods, Package ‘Matrix’, (2015).
URL: <https://cran.r-project.org/web/packages/Matrix/Matrix.pdf>.
- [3] A. Antonov, RSparseMatrix *Mathematica* packages, *MathematicaForPrediction* project at GitHub, (2015).
URL: <https://github.com/antononcube/MathematicaForPrediction/blob/master/Misc/RSparseMatrix.m>.