RSparseMatrix

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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]
RowsCount[_RSparseMatrix]
ColumnsCount[_RSparseMatrix]
RowSums[_RSparseMatrix]
ColumnSums[_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.
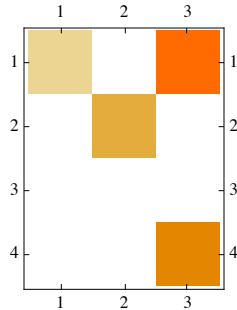
The package can be loaded from GitHub [3]:

```
In[284]:= Import[
    "https://raw.githubusercontent.com/antononcube/MathematicaForPrediction/master/Misc/
     RSparseMatrix.m"]
```

Implementation (and explanations)

Tests and experiments

◾ **SparseArrays to compare with**

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



```
Grid[{{MatrixForm[mat], MatrixForm[Join[mat, mat]],
   MatrixForm[Transpose@Join[Transpose[mat], Transpose[mat]]]}}]
```

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

◾ **Creation**

```
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"}]
```

$Failed

```
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"}];
```

```
rmat // MatrixForm
```

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

```
rmat = ToRSparseMatrix[SparseArray[rmat], "ColumnNames" → {"a", "b", "c", "d"},
   "RowNames" → {"A", "B", "C", "D"}, "DimensionNames" → {"U", "V"}];
```

```
rmat // MatrixForm
```

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

■ **Query methods**

```
RowNames[rmat]
ColumnNames[rmat]
DimensionNames[rmat]
```
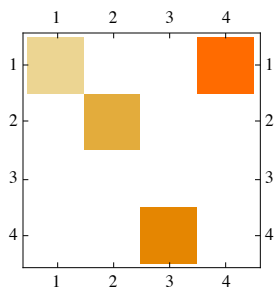
{A, B, C, D}

{a, b, c, d}

{U, V}

```
Dimensions[rmat]
```

{4, 4}

```
ArrayRules[rmat]
```

{{1, 1} → 1, {1, 4} → 4, {2, 2} → 2, {4, 3} → 3, {_, _} → 0}

```
MatrixPlot[rmat]
```



```
MatrixForm[rmat]
```

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

■ **Transpose**

```
MatrixForm[Transpose[rmat]]
```

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

```
DimensionNames[Transpose[rmat]]
```

{V, U}

■ **Sums**

```
Total[rmat, 2]
```

10

```
RowSums[rmat]
```

{1, 2, 3, 4}

```
ColumnSums[rmat]
```

{5, 2, 0, 3}

■ Dot product

```
MatrixForm[rmat.mat]
```

$$
\begin{pmatrix}
A & 1 & 0 & 16 \\
B & 0 & 4 & 0 \\
C & 0 & 0 & 0 \\
D & 0 & 0 & 0
\end{pmatrix}
$$

```
MatrixForm[Transpose[mat].rmat]
```

$$
\begin{pmatrix}
a & b & c & d \\
1 & 0 & 0 & 4 \\
0 & 4 & 0 & 0 \\
4 & 0 & 9 & 16
\end{pmatrix}
$$

```
Grid[{{MatrixForm[rmat.rmat], MatrixForm[rmat.Transpose[rmat]]}}]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
A & 1 & 0 & 12 & 4 \\
B & 0 & 4 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 0 & 0
\end{pmatrix}
\begin{pmatrix}
 & A & B & C & D \\
A & 17 & 0 & 0 & 0 \\
B & 0 & 4 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 0 & 9
\end{pmatrix}
$$

```
MatrixForm[(rmat.rmat).rmat]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
A & 1 & 0 & 12 & 4 \\
B & 0 & 8 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 0 & 0
\end{pmatrix}
$$

```
Grid[{{MatrixForm[rmat], MatrixForm[rmat.rmat.rmat]}}]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
A & 1 & 0 & 0 & 4 \\
B & 0 & 2 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 3 & 0
\end{pmatrix}
\begin{pmatrix}
 & a & b & c & d \\
A & 1 & 0 & 12 & 4 \\
B & 0 & 8 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 0 & 0
\end{pmatrix}
$$

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

```
DimensionNames[rmat.Transpose[rmat]]
```

{U}

■ Arithmetic operations

```
MatrixForm[rmat + 1]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
A & 2 & 1 & 1 & 5 \\
B & 1 & 3 & 1 & 1 \\
C & 1 & 1 & 1 & 1 \\
D & 1 & 1 & 4 & 1
\end{pmatrix}
$$

```
MatrixForm[rmat - 1]
```

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

```
MatrixForm[rmat * 2.33]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
A & 2.33 & 0. & 0. & 9.32 \\
B & 0. & 4.66 & 0. & 0. \\
C & 0. & 0. & 0. & 0. \\
D & 0. & 0. & 6.99 & 0.
\end{pmatrix}
$$

```
Grid[{MatrixForm /@ {rmat, rmat + 2, rmat * 10, 100 * rmat + 2.33 * rmat}}]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 1 & 0 & 0 & 4 \\
B & 0 & 2 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 3 & 0
\end{pmatrix}
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 3 & 2 & 2 & 6 \\
B & 2 & 4 & 2 & 2 \\
C & 2 & 2 & 2 & 2 \\
D & 2 & 2 & 5 & 2
\end{pmatrix}
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 10 & 0 & 0 & 40 \\
B & 0 & 20 & 0 & 0 \\
C & 0 & 0 & 0 & 0 \\
D & 0 & 0 & 30 & 0
\end{pmatrix}
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 102.33 & 0. & 0. & 409.32 \\
B & 0. & 204.66 & 0. & 0. \\
C & 0. & 0. & 0. & 0. \\
D & 0. & 0. & 306.99 & 0.
\end{pmatrix}
$$

```
Grid[{MatrixForm /@ {rmat, Transpose[rmat], rmat + Transpose[rmat], rmat * Transpose[rmat]}}]
```

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

◼ Part

```
MatrixForm[rmat[["A"]]]]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 1 & 0 & 0 & 4
\end{pmatrix}
$$

```
MatrixForm[rmat[[RotateLeft[RowNames[rmat], 2]]]]
```

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

```
MatrixForm[rmat[[RotateLeft[RowNames[rmat], 2], RotateLeft[ColumnNames[rmat], 2]]]]
```

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

```
MatrixForm[rmat[[{"A", "B"}, {"a", "c", "d"}]]]
```

$$
\begin{pmatrix}
 & a & c & d \\
\hline
A & 1 & 0 & 4 \\
B & 0 & 0 & 0
\end{pmatrix}
$$

```
MatrixForm[rmat[[2 ;; 3, 1 ;; 2]]]
```

$$
\begin{pmatrix}
 & a & b \\
\hline
B & 0 & 2 \\
C & 0 & 0
\end{pmatrix}
$$

```
MatrixForm[rmat[[{"A", "B"}]]]
```

$$
\begin{pmatrix}
 & a & b & c & d \\
\hline
A & 1 & 0 & 0 & 4 \\
B & 0 & 2 & 0 & 0
\end{pmatrix}
$$

```
MatrixForm[rmat[[{"A", "B"}, 1 ;; 2]]]
```

$$
\begin{pmatrix}
 & a & b \\
\hline
A & 1 & 0 \\
B & 0 & 2
\end{pmatrix}
$$

```
MatrixForm[rmat[[All, {"a", "c"}]]]
```

$$
\begin{pmatrix}
 & a & c \\
\hline
A & 1 & 0 \\
B & 0 & 0 \\
C & 0 & 0 \\
D & 0 & 3
\end{pmatrix}
$$

■ RowBind, ColumnBind

```
MatrixForm[RowBind[rmat, rmat]]
```

	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

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

	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

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

	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

```
MatrixForm[RowBind[rmat, rmat2]]
```

	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

```
{MatrixForm[ColumnBind[rmat, rmat2]], MatrixForm[ColumnBind[rmat, rmat3]]}
```

{

	a.1	b.1	c.1	d.1	a.2	b.2	c.2	d.2
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

,

	a	b	c	d	t.a	t.b	t.c	t.d
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

}

Profiling

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

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

```
n = 100;
tres =
 AbsoluteTiming[
  Do[sres = smat.Transpose[smat], {i, n}]
  ]
tres[[1]] / n
```

{5.33297, Null}

0.0533297

```
tres =
 AbsoluteTiming[
  Do[rres = rmat.Transpose[rmat], {i, n}]
  ]
tres[[1]] / n
```

{5.3034, Null}

0.053034

```
Norm[sres[[1 ;; 120, 1 ;; 120]] - SparseArray[rres[[1 ;; 120, 1 ;; 120]]]]
```

0.

```
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, *Mathematica*ForPrediction project at GitHub, (2015).
   URL: https://github.com/antononcube/MathematicaForPrediction/blob/master/Misc/RSparseMatrix.m .