

numC

1.0

Generated by Doxygen 1.8.13

Contents

1 Bug List	1
2 Data Structure Index	1
2.1 Data Structures	1
3 File Index	1
3.1 File List	1
4 Data Structure Documentation	2
4.1 Matrix Class Reference	2
4.1.1 Detailed Description	3
5 File Documentation	3
5.1 Matrix.C File Reference	3
5.1.1 Detailed Description	4
5.1.2 Function Documentation	4
5.2 Matrix.h File Reference	13
5.2.1 Detailed Description	13
5.2.2 Function Documentation	14
5.3 Stats.C File Reference	23
5.3.1 Detailed Description	23
5.3.2 Function Documentation	24
5.4 Stats.h File Reference	31
5.4.1 Detailed Description	32
5.4.2 Function Documentation	33
Index	41

1 Bug List

File **Matrix.h**

No known bugs.

File **Stats.h**

No known bugs.

2 Data Structure Index

2.1 Data Structures

Here are the data structures with brief descriptions:

Matrix **2**

3 File Index

3.1 File List

Here is a list of all documented files with brief descriptions:

Matrix.C	
Various matrix operations	3
Matrix.h	
Header file for Matrix algebra	13
Matrix_gsl.C	??
Matrix_gsl.h	??
Stats.C	
Statistics tools	23
Stats.h	
Statistics tools	31
Utils.C	??
Utils.h	??

4 Data Structure Documentation

4.1 Matrix Class Reference

Public Member Functions

- **Matrix** (std::string name="New")
- **Matrix** (int n, int m, std::string name="New")
- **Matrix** (const **Matrix** &A)
- void **init** (int, int, std::string name="New")
- **Matrix** & **operator=** (const **Matrix** &A)
- **Matrix** **operator%** (const **Matrix** &A)
- **Matrix** **operator+** (const **Matrix** &A)
- **Matrix** **operator-** (const **Matrix** &A)
- **Matrix** & **operator*= **(double a)****
- **Matrix** **operator/= **(double a)****
- void **printM** (std::string="matrix")
- **Matrix** **flat** ()
- double **trace** ()
- **Matrix** **T** ()
- void **asMat** (double **)
- **Matrix** **diag** ()
- **Matrix** **clip** (double, std::string="upper")
- **Matrix** **inv** ()
- double **det** ()
- void **eig** ()
- double **min** (std::string="matrix")
- double **max** (std::string="matrix")

Data Fields

- int **shape** [2]
- double ** **matrix**
- double ** **eigval**
- double ** **eigvec**
- std::string **name**

4.1.1 Detailed Description

Definition at line 9 of file Matrix_gsl.h.

The documentation for this class was generated from the following files:

- Matrix_gsl.h
- Matrix_gsl.C

5 File Documentation

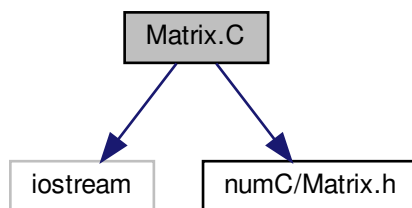
5.1 Matrix.C File Reference

Various matrix operations.

```
#include <iostream>
```

```
#include <numC/Matrix.h>
```

Include dependency graph for Matrix.C:



Functions

- double ** [sum](#) (double **mat1, double **mat2, int a, int b)
Elementwise summation.
- double ** [sub](#) (double **mat1, double **mat2, int a, int b)
Elementwise subtraction.
- double ** [matmul](#) (double **mat1, double **mat2, int a, int b, int c)
Matrix multiplication.
- double ** [transpose](#) (double **mat, int a, int b)
Matrix transpose.
- double ** [identity](#) (int a, double val)
Identity matrix.
- double ** [mat_copy](#) (double **mat, int a, int b)
Hard copy matrix.
- double ** [inverse](#) (double **A, int a, int b)
Matrix left inverse.
- double ** [zero](#) (int a, int b)
Initialize matrix.
- void [print](#) (double **A, int a, int b)
Print matrix.

5.1.1 Detailed Description

Various matrix operations.

Date

Mar 19, 2021

Author

C J Park

chanjure@snu.ac.kr

5.1.2 Function Documentation

5.1.2.1 identity()

```
double** identity (  
    int ,  
    double val = 1. )
```

Identity matrix.

create identity matrix of given size square matrix will be created

Parameters:

Parameters

<i>a</i>	(int) dimension of identity matrix
<i>val</i>	(double) value to initalize (default = 1.)

Returns:

Returns

result (double**) identity matrix

Example:

```
A = identity(3, 0.5);
```

Tag: identity initalize

Definition at line 88 of file Matrix.C.

Referenced by `inverse()`.

```

88                                     {
89     static double** result;
90
91     result = new double*[a];
92     for(int i=0;i<a;i++) *(result+i) = new double [a];
93
94     for(int i=0;i<a;i++){
95         for(int j=0;j<a;j++){
96             if(i==j) *(*(result+i)+j) = val;
97             else *(*(result+i)+j) = 0.;
98         }
99     }
100
101     return result;
102 }

```

5.1.2.2 inverse()

```

double** inverse (
    double **,
    int ,
    int )

```

[Matrix](#) left inverse.

[Matrix](#) left inverse using Gaussian reduction

Parameters:

Parameters

<i>A</i>	(double**) matrix to inverse
<i>a</i>	(int) number of rows of A
<i>b</i>	(int) number of columns of A

Returns:

Returns

result (double**) left inverse of A

Example:

```
A_inv = inverse(A,2,2);
```

Tag: left inverse gaussian reduction

Definition at line 117 of file Matrix.C.

References [identity\(\)](#), [mat_copy\(\)](#), [matmul\(\)](#), [print\(\)](#), and [transpose\(\)](#).

```

117                                     {
118
119     static double** result; // output matmul(invsqA, A.T)
120     double** sqA; // squarized matrix = matmul(A.transpose, A)
121     double** invsqA; // inverse of squared A
122     double** A_t; // Transposed matrix
123     double* row; // Temporary row container
124     double* invrow; // Temporary row container for inverse matrix - memorize sort order

```

```

125     double det; // determinant
126     double pivot;
127
128     const double tol = 1e-14;
129
130     result = new double*[b];
131     for(int i=0;i<b;i++) *(result+i) = new double [a];
132
133     sqA = new double*[b];
134     for(int i=0;i<b;i++) *(sqA+i) = new double [b];
135
136     invsqA = new double*[b];
137     for(int i=0;i<b;i++) *(invsqA+i) = new double [b];
138
139     row = new double [b];
140
141     // Initially identity matrix for inverse matrix container.
142     invsqA = identity(b);
143
144     // Initialize transposed matrix.
145     A_t = new double*[b];
146     for(int i=0; i<b;i++) *(A_t+i) = new double [b];
147
148     if(a!=b){
149         A_t = transpose(A,a,b);
150         // Squarize the matrix
151         for(int i=0;i<b;i++){
152             for(int j=0;j<b;j++){
153                 for(int k=0;k<a;k++){
154                     *(*(sqA+i)+j) = *(*(A_t+i)+k) * (*(*(A+k)+j));
155                 }
156             }
157         }
158     }
159     else{
160         A_t = identity(a);
161         sqA = mat_copy(A,a,a);
162     }
163
164     // Sort pivot
165     for(int j=0;j<b;j++){
166         int i = 1;
167         while(*(*(sqA+j)+j) <=tol && i<b){
168             // Save zero pivot row
169             row = *(sqA+j);
170             invrow = *(invsqA+j);
171
172             // Exchange with row below
173             *(sqA+j) = *(sqA+j+i);
174             *(invsqA+j) = *(invsqA+j+i);
175
176             *(sqA+j+i) = row;
177             *(invsqA+j+i) = invrow;
178
179             i++;
180         }
181     }
182     print(sqA,3,3);
183
184     // Gauss Jordan method
185     for(int i=0;i<b;i++){
186         // Scale
187         pivot = *(*(sqA+i)+i);
188         printf("pivot : %f\n",pivot);
189         if(pivot!=1.){
190             for(int j=0;j<b;j++){
191                 *(*(invsqA+i)+j)/=pivot;
192                 *(*(sqA+i)+j)/=pivot;
193             }
194         }
195         // Subtraction
196         for(int j=0;j<b;j++){
197             if(j!=i){
198                 double target = *(*(sqA+j)+i);
199                 for(int k=0;k<b;k++){
200                     *(*(invsqA+j)+k) -= *(*(invsqA+i)+k) * target;
201                     *(*(sqA+j)+k) -= *(*(sqA+i)+k) * target;
202                 }
203             }
204         }
205     }
206
207     result = matmul(invsqA, A_t, b,b,a);
208
209     return result;
210 }

```

5.1.2.3 mat_copy()

```
double** mat_copy (
    double **,
    int ,
    int )
```

Hard copy matrix.

create hard copy of given matrix

Parameters:

Parameters

<i>mat</i>	(double**) matrix to copy
<i>a</i>	(int) number of rows of mat
<i>b</i>	(int) number of columns of mat

Returns:

Returns

result (double**) hard copy of mat

Example:

A = mat_copy(B,3,3);

Tag: ftn

Definition at line 104 of file Matrix.C.

Referenced by inverse().

```
104                                     {
105     static double** result;
106
107     result = new double*[a];
108     for(int i=0;i<a;i++) *(result+i) = new double [b];
109
110     for(int i=0;i<a;i++){
111         for(int j=0;j<b;j++) *(*result+i+j) = *(*mat+i+j);
112     }
113
114     return result;
115 }
```

5.1.2.4 matmul()

```
double** matmul (
    double **,
    double **,
    int ,
    int ,
    int )
```

[Matrix](#) multiplication.

mat1 * mat2 = result number of column of mat1 must match number of column of mat2

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be multiplied
<i>a</i>	(int) number of rows of mat1
<i>b</i>	(int) number of folumns of mat1 = number of rows of mat2
<i>c</i>	(int) number of columns of mat2

Returns:

Returns

result (double**) matrix of dimension a x c

Example:

```
A = matmul(A,B,2,3,2);
```

Tag: multiplication

Definition at line 45 of file Matrix.C.

Referenced by `chisqr()`, and `inverse()`.

```

45                                     {
46
47     static double** result;
48
49     result = new double*[a];
50     for(int i=0;i<a;i++) *(result + i) = new double [c];
51
52     for(int i=0;i<a;i++){
53         for(int j=0;j<c;j++) *(*result+i+j) = 0.;
54     }
55
56     for(int i=0;i<a;i++){
57         for(int j=0;j<c;j++){
58             for(int k=0;k<b;k++){
59                 *(*result+i+j) += *(*mat1+i+k) * *(*mat2+k+j);
60             }
61         }
62     }
63
64     return result;
65 }
```

5.1.2.5 print()

```

void print (
    double **,
    int ,
    int )
```

Print matrix.

print matrix of given size

Parameters:

Parameters

<i>A</i>	(double**) matrix to print
<i>a</i>	(int) number of rows of A
<i>b</i>	(int) number of columns of A

Returns:

Returns

stdout(matrix A)

Example:

```
print(A,2,3);
```

Tag: print

Definition at line 225 of file Matrix.C.

Referenced by inverse().

```

225                                     {
226     for(int i=0;i<a;i++){
227         for(int j=0;j<b;j++) printf("%10.4e ", *(A+i+j));
228         printf("\n");
229     }
230 }
```

5.1.2.6 sub()

```
double** sub (
    double ** ,
    double ** ,
    int ,
    int )
```

Elementwise subtraction.

mat1 - mat2 = result Two input matrices must be in same shape axb

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be subtracted
<i>a</i>	(int) number of rows of mat1 and mat2
<i>b</i>	(int) number of columns of mat1 and mat2

Returns:

Returns

result (double**)

Example:

A = sub(A,B,2,2);

Tag: subtract, element wise

Definition at line 31 of file Matrix.C.

Referenced by chisqr().

```

31                                     {
32
33     static double** result;
34
35     result = new double*[a];
36     for(int i=0;i<a;i++) *(result+i) = new double [b];
37
38     for(int i=0;i<a;i++){
39         for(int j=0;j<b;j++) (*(result+i)+j) = (*(mat1+i)+j) - (*(mat2+i)+j);
40     }
41
42     return result;
43 }
```

5.1.2.7 sum()

```

double** sum (
    double **,
    double **,
    int ,
    int )
```

Elementwise summation.

mat1 + mat2 = result Two input matrices must be in same shape axb

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be added
<i>a</i>	(int) number of rows of mat1 and mat2
<i>b</i>	(int) number of columns of mat1 and mat2

Returns:

Returns

result (double**)

Example:

`A = sum(A,B,2,2);`

Tag: add, sum, element wise

Definition at line 17 of file Matrix.C.

```

17                                     {
18
19     static double** result;
20
21     result = new double*[a];
22     for(int i=0;i<a;i++) *(result+i) = new double [b];
23
24     for(int i=0;i<a;i++){
25         for(int j=0;j<b;j++) *(*result+i)+j) = *(*mat1+i)+j) + *(*mat2+i)+j);
26     }
27
28     return result;
29 }
```

5.1.2.8 transpose()

```

double** transpose (
    double **,
    int ,
    int )
```

[Matrix](#) transpose.

mat^T

Parameters:

Parameters

<i>mat</i>	(double**) matrix to be transposed
<i>a</i>	(int) number of rows of mat
<i>b</i>	(int) number of columns of mat

Returns:

Returns

result (double**) transposed mat

Example:

`A_T = transpose(A,2,2);`

Tag: transpose

Definition at line 67 of file Matrix.C.

Referenced by `inverse()`.

```

67                                     {
68
69     static double** result;
70
71     result = new double*[b];
72     for(int i=0;i<b;i++) *(result+i) = new double [a];
73
74     for(int i=0;i<a;i++){
75         for(int j=0;j<b;j++){
76             (*(result+j)+i) = (*(mat+i)+j);
77         }
78     }
79
80     return result;
81 }

```

5.1.2.9 zero()

```

double** zero (
    int ,
    int )

```

Initialize matrix.

Create and initialize matrix elements to zero

Parameters:

Parameters

<i>a</i>	(int) number of rows
<i>b</i>	(int) number of columns

Returns:

Returns

result (double**) zero matrix of size axb

Example:

A = zero(2,3);

Tag: initialize zero

Definition at line 212 of file Matrix.C.

```

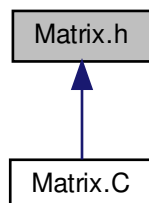
212                                     {
213     static double** result;
214
215     result = new double*[a];
216     for(int i=0;i<a;i++) *(result+i) = new double [b];
217
218     for(int i=0;i<a;i++){
219         for(int j=0;j<b;j++) (*(result+i)+j) = 0.;
220     }
221
222     return result;
223 }

```

5.2 Matrix.h File Reference

Header file for [Matrix](#) algebra.

This graph shows which files directly or indirectly include this file:



Functions

- double ** [sum](#) (double **, double **, int, int)
Elementwise summation.
- double ** [sub](#) (double **, double **, int, int)
Elementwise subtraction.
- double ** [matmul](#) (double **, double **, int, int, int)
Matrix multiplication.
- double ** [transpose](#) (double **, int, int)
Matrix transpose.
- double ** [inverse](#) (double **, int, int)
Matrix left inverse.
- double ** [identity](#) (int, double val=1.)
Identity matrix.
- double ** [mat_copy](#) (double **, int, int)
Hard copy matrix.
- double ** [zero](#) (int, int)
Initialize matrix.
- void [print](#) (double **, int, int)
Print matrix.

5.2.1 Detailed Description

Header file for [Matrix](#) algebra.

Date

Mar 19, 2021

Author

C J Park
chanjure@snu.ac.kr

Bug No known bugs.

Version

0.1

5.2.2 Function Documentation**5.2.2.1 identity()**

```
double** identity (  
    int ,  
    double val = 1. )
```

Identity matrix.

create identity matrix of given size square matrix will be created

Parameters:

Parameters

<i>a</i>	(int) dimension of identity matrix
<i>val</i>	(double) value to initialize (default = 1.)

Returns:

Returns

result (double**) identity matrix

Example:

```
A = identity(3, 0.5);
```

Tag: identity initialize

Definition at line 88 of file Matrix.C.

Referenced by `inverse()`.

```

88     {
89     static double** result;
90
91     result = new double*[a];
92     for(int i=0;i<a;i++) *(result+i) = new double [a];
93
94     for(int i=0;i<a;i++){
95         for(int j=0;j<a;j++){
96             if(i==j) *(*(result+i)+j) = val;
97             else *(*(result+i)+j) = 0.;
98         }
99     }
100
101     return result;
102 }

```

5.2.2.2 inverse()

```

double** inverse (
    double **,
    int ,
    int )

```

[Matrix](#) left inverse.

[Matrix](#) left inverse using Gaussian reduction

Parameters:

Parameters

<i>A</i>	(double**) matrix to inverse
<i>a</i>	(int) number of rows of A
<i>b</i>	(int) number of columns of A

Returns:

Returns

result (double**) left inverse of A

Example:

```
A_inv = inverse(A,2,2);
```

Tag: left inverse gaussian reduction

Definition at line 117 of file Matrix.C.

References [identity\(\)](#), [mat_copy\(\)](#), [matmul\(\)](#), [print\(\)](#), and [transpose\(\)](#).

```

117     {
118
119     static double** result; // output matmul(invsqA, A.T)
120     double** sqA; // squarized matrix = matmul(A.transpose, A)
121     double** invsqA; // inverse of squared A
122     double** A_t; // Transposed matrix
123     double* row; // Temporary row container
124     double* invrow; // Temporary row container for inverse matrix - memorize sort order

```



```

125     double det; // determinant
126     double pivot;
127
128     const double tol = 1e-14;
129
130     result = new double*[b];
131     for(int i=0;i<b;i++) *(result+i) = new double [a];
132
133     sqA = new double*[b];
134     for(int i=0;i<b;i++) *(sqA+i) = new double [b];
135
136     invsqA = new double*[b];
137     for(int i=0;i<b;i++) *(invsqA+i) = new double [b];
138
139     row = new double [b];
140
141     // Initially identity matrix for inverse matrix container.
142     invsqA = identity(b);
143
144     // Initialize transposed matrix.
145     A_t = new double*[b];
146     for(int i=0; i<b;i++) *(A_t+i) = new double [b];
147
148     if(a!=b){
149         A_t = transpose(A,a,b);
150         // Squarize the matrix
151         for(int i=0;i<b;i++){
152             for(int j=0;j<b;j++){
153                 for(int k=0;k<a;k++){
154                     *(*(sqA+i)+j) = *(*(A_t+i)+k) * (*(A+k)+j);
155                 }
156             }
157         }
158     }
159     else{
160         A_t = identity(a);
161         sqA = mat_copy(A,a,a);
162     }
163
164     // Sort pivot
165     for(int j=0;j<b;j++){
166         int i = 1;
167         while(*(*(sqA+j)+j) <=tol && i<b){
168             // Save zero pivot row
169             row = *(sqA+j);
170             invrow = *(invsqA+j);
171
172             // Exchange with row below
173             *(sqA+j) = *(sqA+j+i);
174             *(invsqA+j) = *(invsqA+j+i);
175
176             *(sqA+j+i) = row;
177             *(invsqA+j+i) = invrow;
178
179             i++;
180         }
181     }
182     print(sqA,3,3);
183
184     // Gauss Jordan method
185     for(int i=0;i<b;i++){
186         // Scale
187         pivot = *(*(sqA+i)+i);
188         printf("pivot : %f\n",pivot);
189         if(pivot!=1.){
190             for(int j=0;j<b;j++){
191                 *(*(invsqA+i)+j)/=pivot;
192                 *(*(sqA+i)+j)/=pivot;
193             }
194         }
195         // Subtraction
196         for(int j=0;j<b;j++){
197             if(j!=i){
198                 double target = *(*(sqA+j)+i);
199                 for(int k=0;k<b;k++){
200                     *(*(invsqA+j)+k) -= *(*(invsqA+i)+k) * target;
201                     *(*(sqA+j)+k) -= *(*(sqA+i)+k) * target;
202                 }
203             }
204         }
205     }
206
207     result = matmul(invsqA, A_t, b,b,a);
208
209     return result;
210 }

```

5.2.2.3 mat_copy()

```
double** mat_copy (
    double **,
    int ,
    int )
```

Hard copy matrix.

create hard copy of given matrix

Parameters:

Parameters

<i>mat</i>	(double**) matrix to copy
<i>a</i>	(int) number of rows of mat
<i>b</i>	(int) number of columns of mat

Returns:

Returns

result (double**) hard copy of mat

Example:

A = mat_copy(B,3,3);

Tag: ftn

Definition at line 104 of file Matrix.C.

Referenced by inverse().

```
104                                     {
105     static double** result;
106
107     result = new double*[a];
108     for(int i=0;i<a;i++) *(result+i) = new double [b];
109
110     for(int i=0;i<a;i++){
111         for(int j=0;j<b;j++) *(*result+i+j) = *(*mat+i+j);
112     }
113
114     return result;
115 }
```

5.2.2.4 matmul()

```
double** matmul (
    double **,
    double **,
    int ,
    int ,
    int )
```

[Matrix](#) multiplication.

mat1 * mat2 = result number of column of mat1 must match number of column of mat2

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be multiplied
<i>a</i>	(int) number of rows of mat1
<i>b</i>	(int) number of folumns of mat1 = number of rows of mat2
<i>c</i>	(int) number of columns of mat2

Returns:

Returns

result (double**) matrix of dimension a x c

Example:

```
A = matmul(A,B,2,3,2);
```

Tag: multiplication

Definition at line 45 of file Matrix.C.

Referenced by `chisqr()`, and `inverse()`.

```

45                                     {
46
47     static double** result;
48
49     result = new double*[a];
50     for(int i=0;i<a;i++) *(result + i) = new double [c];
51
52     for(int i=0;i<a;i++){
53         for(int j=0;j<c;j++) *(*result+i+j) = 0.;
54     }
55
56     for(int i=0;i<a;i++){
57         for(int j=0;j<c;j++){
58             for(int k=0;k<b;k++){
59                 *(*result+i+j) += *(*mat1+i+k) * *(*mat2+k+j);
60             }
61         }
62     }
63
64     return result;
65 }
```

5.2.2.5 print()

```

void print (
    double **,
    int ,
    int )
```

Print matrix.

print matrix of given size

Parameters:

Parameters

<i>A</i>	(double**) matrix to print
<i>a</i>	(int) number of rows of A
<i>b</i>	(int) number of columns of A

Returns:

Returns

stdout(matrix A)

Example:

```
print(A,2,3);
```

Tag: print

Definition at line 225 of file Matrix.C.

Referenced by inverse().

```

225                                     {
226     for(int i=0;i<a;i++){
227         for(int j=0;j<b;j++) printf("%10.4e ", *(A+i+j));
228         printf("\n");
229     }
230 }
```

5.2.2.6 sub()

```
double** sub (
    double ** ,
    double ** ,
    int ,
    int )
```

Elementwise subtraction.

mat1 - mat2 = result Two input matrices must be in same shape axb

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be subtracted
<i>a</i>	(int) number of rows of mat1 and mat2
<i>b</i>	(int) number of columns of mat1 and mat2

Returns:

Returns

result (double**)

Example:

A = sub(A,B,2,2);

Tag: subtract, element wise

Definition at line 31 of file Matrix.C.

Referenced by chisqr().

```

31                                     {
32
33     static double** result;
34
35     result = new double*[a];
36     for(int i=0;i<a;i++) *(result+i) = new double [b];
37
38     for(int i=0;i<a;i++){
39         for(int j=0;j<b;j++) (*(result+i)+j) = (*(mat1+i)+j) - (*(mat2+i)+j);
40     }
41
42     return result;
43 }
```

5.2.2.7 sum()

```

double** sum (
    double **,
    double **,
    int ,
    int )
```

Elementwise summation.

mat1 + mat2 = result Two input matrices must be in same shape axb

Parameters:

Parameters

<i>mat1,mat2</i>	(double**) matrices to be added
<i>a</i>	(int) number of rows of mat1 and mat2
<i>b</i>	(int) number of columns of mat1 and mat2

Returns:

Returns

result (double**)

Example:

`A = sum(A,B,2,2);`

Tag: add, sum, element wise

Definition at line 17 of file Matrix.C.

```

17                                     {
18
19     static double** result;
20
21     result = new double*[a];
22     for(int i=0;i<a;i++) *(result+i) = new double [b];
23
24     for(int i=0;i<a;i++){
25         for(int j=0;j<b;j++) *(*result+i)+j) = *(*mat1+i)+j) + *(*mat2+i)+j);
26     }
27
28     return result;
29 }
```

5.2.2.8 transpose()

```

double** transpose (
    double **,
    int ,
    int )
```

[Matrix](#) transpose.

mat^T

Parameters:

Parameters

<i>mat</i>	(double**) matrix to be transposed
<i>a</i>	(int) number of rows of mat
<i>b</i>	(int) number of columns of mat

Returns:

Returns

result (double**) transposed mat

Example:

`A_T = transpose(A,2,2);`

Tag: transpose

Definition at line 67 of file Matrix.C.

Referenced by `inverse()`.

```

67                                     {
68
69     static double** result;
70
71     result = new double*[b];
72     for(int i=0;i<b;i++) *(result+i) = new double [a];
73
74     for(int i=0;i<a;i++){
75         for(int j=0;j<b;j++){
76             (*(result+j)+i) = (*(mat+i)+j);
77         }
78     }
79
80     return result;
81 }

```

5.2.2.9 zero()

```

double** zero (
    int ,
    int )

```

Initialize matrix.

Create and initialize matrix elements to zero

Parameters:

Parameters

<i>a</i>	(int) number of rows
<i>b</i>	(int) number of columns

Returns:

Returns

result (double**) zero matrix of size axb

Example:

A = zero(2,3);

Tag: initialize zero

Definition at line 212 of file Matrix.C.

```

212                                     {
213     static double** result;
214
215     result = new double*[a];
216     for(int i=0;i<a;i++) *(result+i) = new double [b];
217
218     for(int i=0;i<a;i++){
219         for(int j=0;j<b;j++) (*(result+i)+j) = 0.;
220     }
221
222     return result;
223 }

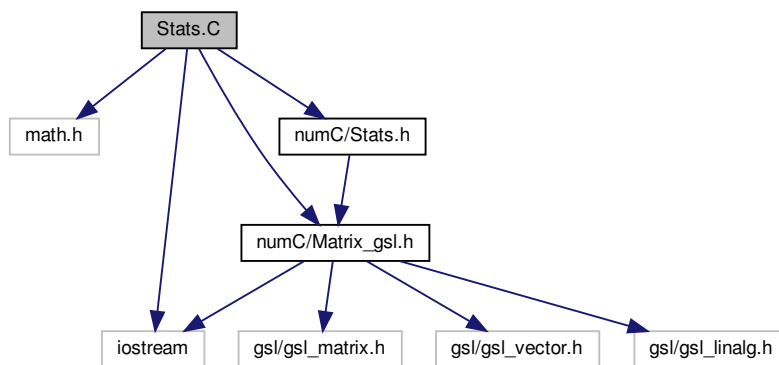
```

5.3 Stats.C File Reference

Statistics tools.

```
#include <math.h>
#include <numC/Matrix_gsl.h>
#include <numC/Stats.h>
#include <iostream>
```

Include dependency graph for Stats.C:



Functions

- **Matrix ave** (**Matrix** A, int axis)
Matrix average.
- **Matrix var** (**Matrix** A, int axis)
Matrix variance.
- **Matrix cov** (**Matrix** A, int axis)
Covariance matrix.
- **Matrix * JK_resample** (**Matrix** A, int axis)
Jackknife resample.
- **Matrix sample_ave** (**Matrix** *A, int l)
Sample average.
- **Matrix JK_error** (**Matrix** *A, int l)
Jackknife standard deviation.
- **Matrix BS_error** (**Matrix** *A, int l)
Bootstrap standard deviation.
- double **chisqr** (**Matrix** y_bar, **Matrix** c_inv, **Matrix** f)
Chi square.

5.3.1 Detailed Description

Statistics tools.

5.3.2 Function Documentation

5.3.2.1 ave()

```
Matrix ave (
    Matrix A,
    int axis = 1 )
```

Matrix average.

Calculate average along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix to calculate
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result (Matrix) a vector (collapsed Matrix)

Example:

```
B = ave(A, 0);
```

Tag: average vector matrix

Definition at line 13 of file Stats.C.

Referenced by cov(), and var().

```
13                                     {
14
15     int n = A.shape[0];
16     int m = A.shape[1];
17
18     if(axis == 1){
19
20         Matrix result(n,1,"ave");
21
22         for(int i=0;i<n;i++){
23             for(int j=0;j<m;j++){
24                 result.matrix[i][0] += A.matrix[i][j]/(1.*m);
25             }
26         }
27
28         return result;
29     }
30     else if (axis == 0){
31
32         Matrix result(1,m);
33
34         for(int i=0;i<n;i++){
35             for(int j=0;j<m;j++) result.matrix[0][j] += A.matrix[i][j]/(1.*n);
36         }
37
38         return result;
39     }
40 }
```

5.3.2.2 BS_error()

```
Matrix BS_error (
    Matrix * A,
    int l )
```

Bootstrap standard deviation.

Calculate standard deviation(sqrt(var), error) of Bootstrap resampled data

Parameters:

Parameters

<i>A</i>	(Matrix*) Bootstrap resampled data
<i>l</i>	(int) number of BS samples

Returns:

Returns

result (Matrix) collapsed array of Matrices

Example:

```
A = BS_error(B, 500);
```

Tag: Bootstrap standard deviation error

Definition at line 163 of file Stats.C.

References `sample_ave()`.

```
163                                     {
164     int n = A[0].shape[0];
165
166     Matrix A_ave(n,1);
167     A_ave = sample_ave(A, l);
168
169     Matrix result(n,1);
170
171     for(int i=0;i<n;i++){
172         for(int j=0;j<l;j++) result.matrix[i][0] += pow(A[j].matrix[i][0] - A_ave.matrix[i][0],2.) / (l-1.);
173     }
174
175     for(int i=0;i<n;i++) result.matrix[i][0] = sqrt(result.matrix[i][0]);
176
177     return result;
178 }
```

5.3.2.3 chisqr()

```
double chisqr (
    Matrix y_bar,
    Matrix c_inv,
    Matrix f )
```

Chi square.

Calculate chi-square of given data $\chi^2 = (\mathbf{y_bar} - \mathbf{f})^T \mathbf{C}^{-1} (\mathbf{y_bar} - \mathbf{f})$

Parameters:

Parameters

<i>y_bar</i>	(Matrix) vector containing an average of the data
<i>c_inv</i>	(Matrix) inverse of covariance matrix
<i>f</i>	(Matrix) vector of fitting function values

Returns:

Returns

result (double) χ^2 of given data and fitting function

Example:

```
chisq = chiqr(Y_bar, C_inv, F);
```

Tag: chi-square fitting

Definition at line 180 of file Stats.C.

References `matmul()`, and `sub()`.

```

180                                     {
181
182     double result;
183
184     result = matmul(matmul(sub(y_bar, f).T(), c_inv), sub(y_bar, f)).matrix[0][0];
185
186     return result;
187 }
```

5.3.2.4 cov()

```

Matrix cov (
    Matrix A,
    int axis = 0 )
```

Covariance matrix.

Calculate covariance along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix of data
<i>axis</i>	(int) axis to calculate default = 0

Returns:

Returns

result ([Matrix](#)) covariance of vectors along axis

Example:

```
C = cov(A, 0);
```

Tag: covariance vector matrix

Definition at line 70 of file Stats.C.

References [ave\(\)](#).

```

70                                     {
71     // Default : sample covariance
72
73     int n = A.shape[0];
74     int m = A.shape[1];
75
76     if(axis == 0){
77         Matrix A_ave;
78         A_ave = ave(A, 1);
79
80         Matrix result(n,n);
81
82         for(int i=0;i<n;i++){
83             for(int j=0;j<n;j++){
84                 for(int k=0;k<m;k++){
85                     result.matrix[i][j] += (A.matrix[i][k] - A_ave.matrix[i][0]) * (A.matrix[j][k] - A_ave.matrix[j][
86                     0]) / (1.*m) / (m-1.);
87                 }
88             }
89
90             return result;
91         }
92     else if(axis == 1){
93         Matrix A_ave = ave(A, 0);
94
95         Matrix result(m,m);
96
97         for(int i=0;i<m;i++){
98             for(int j=0;j<m;j++){
99                 for(int k=0;k<n;k++){ result.matrix[i][j] += (A.matrix[k][i] - A_ave.matrix[0][i]) * (A.matrix[k][j]
100                 - A_ave.matrix[0][j]) / (1.*m) / (m-1.);
101             }
102         }
103         return result;
104     }
105 }
```

5.3.2.5 JK_error()

```

Matrix JK_error (
    Matrix * A,
    int l )
```

Jackknife standard deviation.

Calculate standard deviation(sqrt(var), error) of Jackknife resampled data

Parameters:

Parameters

<i>A</i>	(Matrix*) Jackknife resampled data
<i>I</i>	(int) number of JK samples (N)

Returns:

Returns

result (Matrix) collapsed array of Matrices

Example:

```
A = JK_error(B, 200);
```

Tag: Jackknife standard deviation error

Definition at line 145 of file Stats.C.

References sample_ave().

```

145                                     {
146
147     int n = A[0].shape[0];
148
149     Matrix A_ave(n,1);
150     A_ave = sample_ave(A, 1);
151
152     Matrix result(n, 1);
153
154     for(int i=0;i<n;i++){
155         for(int j=0;j<1;j++) result.matrix[i][0] += pow(A[j].matrix[i][0] - A_ave.matrix[i][0], 2.) / (1.*1)*(1-
156         1.);
157     }
158     for(int i=0;i<n;i++) result.matrix[i][0] = sqrt(result.matrix[i][0]);
159
160     return result;
161 }
```

5.3.2.6 JK_resample()

```

Matrix* JK_resample (
    Matrix A,
    int axis = 1 )
```

Jackknife resample.

Resample along the given axis It samples maximum amount of data (N samples)

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix of data
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result (Matrix*) Array(Pointer) of matrix

Example:

X = JK_resample(A, 0);

Tag: Jackknife resampling

Definition at line 107 of file Stats.C.

```

107                                     {
108
109     int n = A.shape[0];
110     int m = A.shape[1];
111
112     Matrix *result;
113     result = new Matrix [m];
114     for(int i=0;i<m;i++) result[i].init(n, m-1);
115
116     int p=0;
117     for(int i=0;i<m;i++){
118         for(int j=0;j<n;j++){
119             p = 0;
120             for(int k=0;k<m;k++){
121                 if(i != k){
122                     result[i].matrix[j][p] = A.matrix[j][k];
123                     p++;
124                 }
125             }
126         }
127     }
128
129     return result;
130 }
```

5.3.2.7 sample_ave()

```

Matrix sample_ave (
    Matrix * A,
    int l )
```

Sample average.

Calculate average of array(pointer) of Matrices

Parameters:

Parameters

A	(Matrix*) Pointer to Matrix eg) resampled data
l	(int) number of JK samples (N)

Returns:

Returns

result ([Matrix](#)) collapsed array of Matrices

Example:

```
A = sample_ave(B, 200);
```

Tag: Jackknife average

Definition at line 132 of file Stats.C.

Referenced by `BS_error()`, and `JK_error()`.

```

132                                     {
133
134     int n = A[0].shape[0];
135
136     Matrix result(n,1);
137
138     for(int i=0;i<n;i++){
139         for(int j=0;j<1;j++) result.matrix[i][0] += A[j].matrix[i][0]/(1.*1);
140     }
141
142     return result;
143 }
```

5.3.2.8 var()

```

Matrix var (
    Matrix A,
    int axis = 1 )
```

[Matrix](#) variance.

Calculate variance along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix to calculate
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result ([Matrix](#)) a vector (collapsed [Matrix](#))

Example:

```
B = var(A,0);
```

Tag: variance vector matrix

Definition at line 42 of file Stats.C.

References `ave()`.

```

42                                     {
43     // Default : sample var
44
45     int n = A.shape[0];
46     int m = A.shape[1];
47
48     if(axis == 1){
49         Matrix A_ave = ave(A, 1);
50         Matrix result(n,1);
51
52         for(int i=0;i<n;i++){
53             for(int j=0;j<m;j++) result.matrix[i][0] += pow(A.matrix[i][j] - A_ave.matrix[i][0], 2.)/(1.*m)/(m -
54             1.);
55         }
56         return result;
57     }
58     else if(axis == 0){
59         Matrix A_ave = ave(A, 0);
60         Matrix result(1,m);
61
62         for(int i=0;i<n;i++){
63             for(int j=0;j<m;j++) result.matrix[0][j] += pow(A.matrix[i][j] - A_ave.matrix[0][j], 2.)/(1.*n)/(n -
64             1.);
65         }
66         return result;
67     }
68 }

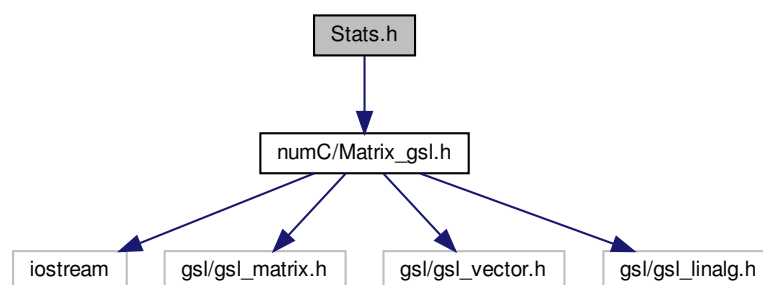
```

5.4 Stats.h File Reference

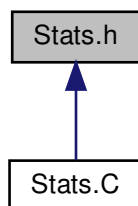
Statistics tools.

```
#include <numC/Matrix_gsl.h>
```

Include dependency graph for Stats.h:



This graph shows which files directly or indirectly include this file:



Functions

- **Matrix ave** (**Matrix** A, int axis=1)
Matrix average.
- **Matrix var** (**Matrix** A, int axis=1)
Matrix variance.
- **Matrix cov** (**Matrix** A, int axis=0)
Covariance matrix.
- **Matrix * JK_resample** (**Matrix** A, int axis=1)
Jackknife resample.
- **Matrix sample_ave** (**Matrix** *A, int l)
Sample average.
- **Matrix JK_error** (**Matrix** *A, int l)
Jackknife standard deviation.
- **Matrix BS_error** (**Matrix** *A, int l)
Bootstrap standard deviation.
- double **chisqr** (**Matrix** y_bar, **Matrix** c_inv, **Matrix** f)
Chi square.

5.4.1 Detailed Description

Statistics tools.

Date

Nov 22, 2021

Author

C J Park
chanjure@snu.ac.kr

Bug No known bugs.

Version

1.0

5.4.2 Function Documentation

5.4.2.1 ave()

```
Matrix ave (
    Matrix A,
    int axis = 1 )
```

Matrix average.

Calculate average along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix to calculate
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result (Matrix) a vector (collapsed Matrix)

Example:

```
B = ave(A, 0);
```

Tag: average vector matrix

Definition at line 13 of file Stats.C.

Referenced by cov(), and var().

```
13                                     {
14
15     int n = A.shape[0];
16     int m = A.shape[1];
17
18     if(axis == 1){
19
20         Matrix result(n,1,"ave");
21
22         for(int i=0;i<n;i++){
23             for(int j=0;j<m;j++){
24                 result.matrix[i][0] += A.matrix[i][j]/(1.*m);
25             }
26         }
27
28         return result;
29     }
30     else if (axis == 0){
31
32         Matrix result(1,m);
33
34         for(int i=0;i<n;i++){
35             for(int j=0;j<m;j++) result.matrix[0][j] += A.matrix[i][j]/(1.*n);
36         }
37
38         return result;
39     }
40 }
```

5.4.2.2 BS_error()

```
Matrix BS_error (
    Matrix * A,
    int l )
```

Bootstrap standard deviation.

Calculate standard deviation(sqrt(var), error) of Bootstrap resampled data

Parameters:

Parameters

<i>A</i>	(Matrix*) Bootstrap resampled data
<i>l</i>	(int) number of BS samples

Returns:

Returns

result (Matrix) collapsed array of Matrices

Example:

```
A = BS_error(B, 500);
```

Tag: Bootstrap standard deviation error

Definition at line 163 of file Stats.C.

References sample_ave().

```
163                                     {
164     int n = A[0].shape[0];
165
166     Matrix A_ave(n,1);
167     A_ave = sample_ave(A, l);
168
169     Matrix result(n,1);
170
171     for(int i=0;i<n;i++){
172         for(int j=0;j<l;j++){ result.matrix[i][0] += pow(A[j].matrix[i][0] - A_ave.matrix[i][0],2.) / (l-1.);
173     }
174
175     for(int i=0;i<n;i++) result.matrix[i][0] = sqrt(result.matrix[i][0]);
176
177     return result;
178 }
```

5.4.2.3 chisqr()

```
double chisqr (
    Matrix y_bar,
    Matrix c_inv,
    Matrix f )
```

Chi square.

Calculate chi-square of given data $\chi^2 = (\mathbf{y_bar} - \mathbf{f})^T \mathbf{C}^{-1} (\mathbf{y_bar} - \mathbf{f})$

Parameters:

Parameters

<i>y_bar</i>	(Matrix) vector containing an average of the data
<i>c_inv</i>	(Matrix) inverse of covariance matrix
<i>f</i>	(Matrix) vector of fitting function values

Returns:

Returns

result (double) χ^2 of given data and fitting function

Example:

```
chisq = chiqr(Y_bar, C_inv, F);
```

Tag: chi-square fitting

Definition at line 180 of file Stats.C.

References `matmul()`, and `sub()`.

```

180                                     {
181
182     double result;
183
184     result = matmul(matmul(sub(y_bar, f).T(), c_inv), sub(y_bar, f)).matrix[0][0];
185
186     return result;
187 }
```

5.4.2.4 cov()

```

Matrix cov (
    Matrix A,
    int axis = 0 )
```

Covariance matrix.

Calculate covariance along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix of data
<i>axis</i>	(int) axis to calculate default = 0

Returns:

Returns

result ([Matrix](#)) covariance of vectors along axis

Example:

```
C = cov(A, 0);
```

Tag: covariance vector matrix

Definition at line 70 of file Stats.C.

References [ave\(\)](#).

```

70     {
71     // Default : sample covariance
72
73     int n = A.shape[0];
74     int m = A.shape[1];
75
76     if(axis == 0){
77         Matrix A_ave;
78         A_ave = ave(A, 1);
79
80         Matrix result(n,n);
81
82         for(int i=0;i<n;i++){
83             for(int j=0;j<n;j++){
84                 for(int k=0;k<m;k++){
85                     result.matrix[i][j] += (A.matrix[i][k] - A_ave.matrix[i][0]) * (A.matrix[j][k] - A_ave.matrix[j][
86                     0]) / (1.*m) / (m-1.);
87                 }
88             }
89         }
90         return result;
91     }
92     else if(axis == 1){
93         Matrix A_ave = ave(A, 0);
94
95         Matrix result(m,m);
96
97         for(int i=0;i<m;i++){
98             for(int j=0;j<m;j++){
99                 for(int k=0;k<n;k++){ result.matrix[i][j] += (A.matrix[k][i] - A_ave.matrix[0][i]) * (A.matrix[k][j]
100                 - A_ave.matrix[0][j]) / (1.*m) / (m-1.);
101             }
102         }
103         return result;
104     }
105 }
```

5.4.2.5 JK_error()

```
Matrix JK_error (
    Matrix * A,
    int l )
```

Jackknife standard deviation.

Calculate standard deviation(sqrt(var), error) of Jackknife resampled data

Parameters:

Parameters

<i>A</i>	(Matrix*) Jackknife resampled data
<i>I</i>	(int) number of JK samples (N)

Returns:

Returns

result (Matrix) collapsed array of Matrices

Example:

```
A = JK_error(B, 200);
```

Tag: Jackknife standard deviation error

Definition at line 145 of file Stats.C.

References `sample_ave()`.

```

145                                     {
146
147     int n = A[0].shape[0];
148
149     Matrix A_ave(n,1);
150     A_ave = sample_ave(A, 1);
151
152     Matrix result(n, 1);
153
154     for(int i=0;i<n;i++){
155         for(int j=0;j<1;j++) result.matrix[i][0] += pow(A[j].matrix[i][0] - A_ave.matrix[i][0], 2.) / (1.*1)*(1-
156         1.);
157     }
158     for(int i=0;i<n;i++) result.matrix[i][0] = sqrt(result.matrix[i][0]);
159
160     return result;
161 }
```

5.4.2.6 JK_resample()

```

Matrix* JK_resample (
    Matrix A,
    int axis = 1 )
```

Jackknife resample.

Resample along the given axis It samples maximum amount of data (N samples)

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix of data
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result (Matrix*) Array(Pointer) of matrix

Example:

X = JK_resample(A, 0);

Tag: Jackknife resampling

Definition at line 107 of file Stats.C.

```

107                                     {
108
109     int n = A.shape[0];
110     int m = A.shape[1];
111
112     Matrix *result;
113     result = new Matrix [m];
114     for(int i=0;i<m;i++) result[i].init(n, m-1);
115
116     int p=0;
117     for(int i=0;i<m;i++){
118         for(int j=0;j<n;j++){
119             p = 0;
120             for(int k=0;k<m;k++){
121                 if(i != k){
122                     result[i].matrix[j][p] = A.matrix[j][k];
123                     p++;
124                 }
125             }
126         }
127     }
128
129     return result;
130 }
```

5.4.2.7 sample_ave()

```

Matrix sample_ave (
    Matrix * A,
    int l )
```

Sample average.

Calculate average of array(pointer) of Matrices

Parameters:

Parameters

A	(Matrix*) Pointer to Matrix eg) resampled data
l	(int) number of JK samples (N)

Returns:

Returns

result ([Matrix](#)) collapsed array of Matrices

Example:

```
A = sample_ave(B, 200);
```

Tag: Jackknife average

Definition at line 132 of file Stats.C.

Referenced by `BS_error()`, and `JK_error()`.

```

132                                     {
133
134     int n = A[0].shape[0];
135
136     Matrix result(n,1);
137
138     for(int i=0;i<n;i++){
139         for(int j=0;j<1;j++) result.matrix[i][0] += A[j].matrix[i][0]/(1.*1);
140     }
141
142     return result;
143 }
```

5.4.2.8 var()

```

Matrix var (
    Matrix A,
    int axis = 1 )
```

[Matrix](#) variance.

Calculate variance along the given axis

Parameters:

Parameters

<i>A</i>	(Matrix) Matrix to calculate
<i>axis</i>	(int) axis to calculate default = 1

Returns:

Returns

result ([Matrix](#)) a vector (collapsed [Matrix](#))

Example:

```
B = var(A,0);
```

Tag: variance vector matrix

Definition at line 42 of file Stats.C.

References `ave()`.


```
42                                     {
43     // Default : sample var
44
45     int n = A.shape[0];
46     int m = A.shape[1];
47
48     if(axis == 1){
49         Matrix A_ave = ave(A, 1);
50         Matrix result(n,1);
51
52         for(int i=0;i<n;i++){
53             for(int j=0;j<m;j++) result.matrix[i][0] += pow(A.matrix[i][j] - A_ave.matrix[i][0], 2.)/(1.*m)/(m -
54             1.);
55         }
56         return result;
57     }
58     else if(axis == 0){
59         Matrix A_ave = ave(A, 0);
60         Matrix result(1,m);
61
62         for(int i=0;i<n;i++){
63             for(int j=0;j<m;j++) result.matrix[0][j] += pow(A.matrix[i][j] - A_ave.matrix[0][j], 2.)/(1.*n)/(n -
64             1.);
65         }
66         return result;
67     }
68 }
```

Index

ave

Stats.C, [24](#)
Stats.h, [33](#)

BS_error

Stats.C, [24](#)
Stats.h, [33](#)

chisqr

Stats.C, [25](#)
Stats.h, [34](#)

cov

Stats.C, [26](#)
Stats.h, [35](#)

identity

Matrix.C, [4](#)
Matrix.h, [14](#)

inverse

Matrix.C, [5](#)
Matrix.h, [15](#)

JK_error

Stats.C, [27](#)
Stats.h, [36](#)

JK_resample

Stats.C, [28](#)
Stats.h, [37](#)

mat_copy

Matrix.C, [7](#)
Matrix.h, [17](#)

matmul

Matrix.C, [7](#)
Matrix.h, [17](#)

Matrix, [2](#)

Matrix.C, [3](#)

identity, [4](#)
inverse, [5](#)
mat_copy, [7](#)
matmul, [7](#)
print, [8](#)
sub, [9](#)
sum, [10](#)
transpose, [11](#)
zero, [12](#)

Matrix.h, [13](#)

identity, [14](#)
inverse, [15](#)
mat_copy, [17](#)
matmul, [17](#)
print, [18](#)
sub, [19](#)
sum, [20](#)
transpose, [21](#)
zero, [22](#)

print

Matrix.C, [8](#)
Matrix.h, [18](#)

sample_ave

Stats.C, [29](#)
Stats.h, [38](#)

Stats.C, [23](#)

ave, [24](#)
BS_error, [24](#)
chisqr, [25](#)
cov, [26](#)
JK_error, [27](#)
JK_resample, [28](#)
sample_ave, [29](#)
var, [30](#)

Stats.h, [31](#)

ave, [33](#)
BS_error, [33](#)
chisqr, [34](#)
cov, [35](#)
JK_error, [36](#)
JK_resample, [37](#)
sample_ave, [38](#)
var, [39](#)

sub

Matrix.C, [9](#)
Matrix.h, [19](#)

sum

Matrix.C, [10](#)
Matrix.h, [20](#)

transpose

Matrix.C, [11](#)
Matrix.h, [21](#)

var

Stats.C, [30](#)
Stats.h, [39](#)

zero

Matrix.C, [12](#)
Matrix.h, [22](#)