Mathematica Module for ARAP Interpolation

MARAP User's Manual
Version 0.24
17 November 2016

Editor: Yoshihiro Mizoguchi, Kyushu University.

`Ver. 0.1` 13 September 2016

Table of Contents

1 Introduction

This is a Mathematica Module for investigating an interpolation in Computer Graphics, called the ARAP (as rigid as possible) interpolation. Our module contains about 100 functions of lementary matrix operations, matrix and polygon interpolatins and drawing polygons.

To use this package "ARAPlibv024`", users should set a directory where the modules is stored.

```
[Example]

SetDirectory[FileNameJoin[$HomeDirectory, "--- Some Folder ---"]];
<< ARAPlibv024`;
```

This module was used and introduced in the followings:

[1] S.Kaji, S.Hirose, S.Sakata, Y.Mizoguchi, Mathematical analysis on affine maps for 2D shape interpolagion (http://dl.acm.org/citation.cfm?id=2422368), SCA '12 Proceedings of the ACM SIGGRAPH/Eurographics Symposium on Computer Animation, pp.71-76.

[2] Y. Mizoguchi, Mathematical Aspects of Interpolation Technique for Computer Graphics, Forum "Math-for-Industry" 2012, Information Recovery and Discovery, 22 October 2022. http://fmi2012.imi.kyushu-u.ac.jp/

[3] T.Hirano, A.hirakawa, N.Miyaki, C.Matsufuji and Y.Mizoguchi. Mathematica Module for ARAP Interpolation https://github.com/KyushuUniversityMathematics/MathematicaARAP

2 Basic Functions

2.1 `MakePolygon`

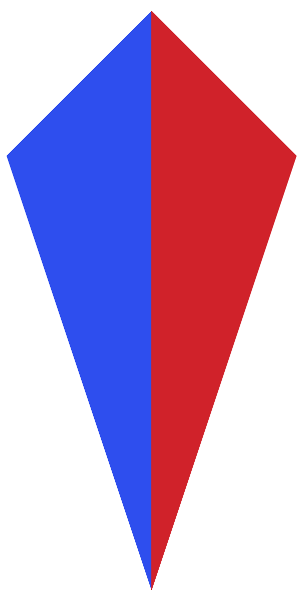
`MakePolygon[`*V*`,`*tindex*`]`
:: Make polygon

V vertex set

tindex constitution of triangle

return polygon

```
[Example]
Graphics[MakePolygon[dataS2,dataT2]]
```



2.2 `HorizontalSnake`

`HorizontalSnake[`*n*`]`
:: Make vertexes of horizontally long rectangle

n rectangle size

return vertex set of rectangle

```
[Example]
HorizontalSnake[5]
={{0, 0}, {0, 1}, {1, 0}, {1, 1}, {2, 0}, {2, 1}, {3, 0}, {3, 1}, {4, 0}, {4, 1}}
```

2.3 VerticalSnake

`VerticalSnake[n]`

:: Make vertexes of vertically long rectangle

n rectangle size

return vertex set

```
[Example]
VerticalSnake[5]
={{1, 0}, {0, 0}, {1, 1}, {0, 1}, {1, 2}, {0, 2}, {1, 3}, {0, 3}, {1, 4}, {0, 4}}
```

2.4 SnakeTriangle

`SnakeTriangle[n]`

:: Triangulate Horizontal/Vertex Snake

n rectangle size

return constitution of triangle

```
[Example]

Graphics[MakePolygon[HorizontalSnake[10], SnakeTriangle[10]]]
```

```
Graphics[MakePolygon[VerticalSnake[10], SnakeTriangle[10]]]
```

2.5 AnimationRange

`AnimationRange[conf]`

:: size of Display conforming with polygon

conf { start vertex set , end vertex set}

return coordinates of display

```
[Example]

AnimationRange[Configuration2]
={{-2, 4}, {-3, 5}}
```

2.6 Polar

`Polar[a]` :: Convert cartesian coordinates to polar coordinates

a cartesian coordinates

return polar coordinates

```
[Example]
Polar[{0,1}]
={1,2π}
```

2.7 Cartesian

`Cartesian[a]`
:: Convert polar coordinates to cartesian coordinates

a polar coordinates

return cartesian coordinate

```
[Example]
Cartesian[{1,2π}]
={0,1}
```

2.8 LinearInterpolate

`LinearInterpolate[a,b,t]`
:: Perform linear interpolation of point

a a start point

b an end point

t time

return an interpolated point

```
[Example]
LinearInterpolate[{1, 1}, {2, 2}, 0.5]
={1.5, 1.5}
```

2.9 LinearInterpolation

`LinearInterpolation[p,q,t]`
:: Perform linear interpolation of vertex set

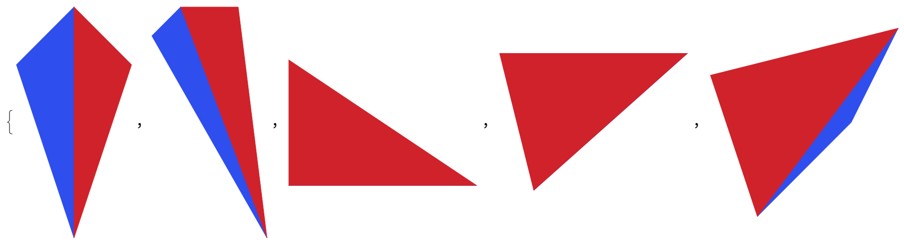
p start vertex set

q end vertex set

t time

return interpolated vertex set

```
[Example]
Graphics[MakePolygon[LinearInterpolation[dataS2, dataE2, #], dataT2]] & /
{0, 0.25, 0.5, 0.75, 1}
```



2.10 PolarInterpolate

`PolarInterpolate[a,b,t]`
:: Perform Polar interpolation of point

a a start point

b an end point

t time

return an interpolated point

```
[Example]
PolarInterpolate[{1, 1}, {2, 2}, 0.5]
={1.5, 1.5}
```

2.11 PolarInterpolation

`PolarInterpolation[p,q,t]`
:: Perform Polar interpolation of vertex set

p start vertex set

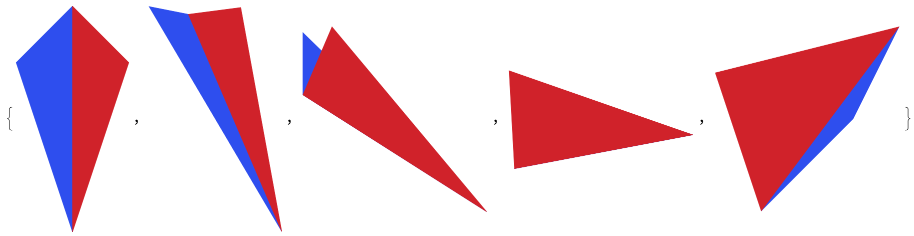
q end vertex set

t time

return interpolated vertex set

```
[Example]
```

```
Graphics[MakePolygon[PolarInterpolation[dataS2, dataE2, #], dataT2]] & /
{0, 0.25, 0.5, 0.75, 1}
```



2.12 LinearInterpolateSnake2D

`LinearInterpolateSnake2D[`*n*`,`*t*`]`

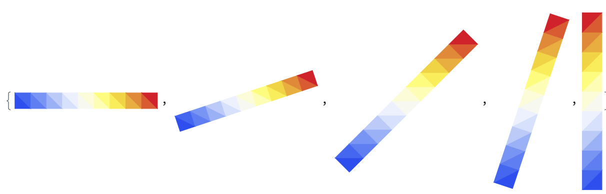
:: aiueo

n Snake size

t time (0~1)

return interpolated snake rectangle

```
[Example]
Graphics[LinearInterpolateSnake2D[10, #]] & / {0, 0.25, 0.5, 0.75, 1}
```



2.13 PolarInterpolateSnake2D

`PolarInterpolateSnake2D[`*n*`,`*t*`]`

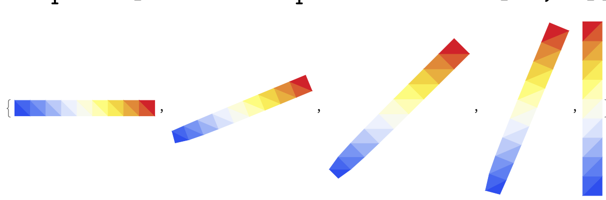
:: aiueo

n Snake size

t time (0~1)

return interpolated snake rectangle

```
[Example]
Graphics[PolarInterpolateSnake2D[10, #]] & / {0, 0.25, 0.5, 0.75, 1}
```



2.14 PolarDecomposition

`PolarDecomposition[`*m*`]`
:: Perform polar decomposition

m matrix

return orthogonal matrix and positive-semidefinite matrix

```
[Example]
PolarDecomposition[{{1, 1}, {-1, -1}}]
={{{0., 1.}, {-1., 0.}}, {{1., 1.}, {1., 1.}}}
```

2.15 PolarDecompositionPlus

`PolarDecompositionPlus[`*m*`]`
:: aiueo

m aiueo

return aiueo

```
[Example]
PolarDecompositionPlus[m_]
```

2.16 RotateAngle

`RotateAngle[`*m*`]`
:: Compute angle of Rotation matrix that is performed polar decomposition

m matrix

return angle

```
[Example]
RotateAngle[{{1, 2}, {3, 4}}]
=ArcTan[3]
```

2.17 CogTrans

`CogTrans[`*pl*`]`
:: aiueo

pl aiueo

return aiueo

```
[Example]
CogTrans[pl_]
```

2.18 PolygonToTriangles

`PolygonToTriangles[`*l*`]`
:: aiueo

l aiueo

return aiueo

```
[Example]
PolygonToTriangles[l_]
```

2.19 TrianglesToTriangles

`TrianglesToTriangles[`*offset*`,`*cog*`]`
:: aiueo

offset aiueo

cog aiueo

return aiueo

```
[Example]
TrianglesToTriangles[offset_,cog_]
```

2.20 TrianglesToPolygon

`TrianglesToPolygon[`*tl*`]`
:: aiueo

tl aiueo

return aiueo

```
[Example]
TrianglesToPolygon[tl_]
```

2.21 ValNames

`ValNames[`*n*`]`
:: Name variable

n number of variable

return neme of variable

```
[Example]
ValNames[3]
={{v1x, v1y}, {v2x, v2y}, {v3x, v3y}}
```

2.22 NormF

`NormF[`*m*`]` :: Calculate Frobenius norm

m matrix

return resultant value of Frobenius norm

```
[Example]
NormF[1,2,3,4]
=30
```

3 Matrix Functions

3.1 QuadraticFormVariableMatrix

`QuadraticFormVariableMatrix[`*vl*`]`

:: QuadraticFormVariableMatrix

vl list of values

return matrix

```
[Example]
QuadraticFormVariableMatrix[{1,2,3}]
{{1, 2, 3}, {2, 4, 6}, {3, 6, 9}}
```

3.2 Div2if

`Div2if[`*n*`,`*l*`]`

:: divide all elements except n-th element of l by 2

n,l index,list of values

return vector divided all elements except n-th element of l by 2

```
[Example]
Div2if[3, {3, 6, 7, 5, 1}]
{3/2, 3, 7, 5/2, 1/2}
```

3.3 Div2Matrix

`Div2Matrix[`*m*`]`

:: divide all elements except diagonal ones of m by 2

m matrix

return matrix divided all elements except diagonal ones of m by 2

```
[Example]
Div2Matrix[{{1, 3}, {7, 4}}]
{{1, 3/2}, {7/2, 4}}
```

3.4 QuadraticFormMatrix

`QuadraticFormMatrix[`*poly*`,`*vl*`]`

:: QuadraticFormMatrix

poly,vl polynomial,list of values

return QuadraticFormMatrix

```
[Example]
QuadraticFormMatrix[(a*x^2 + b*x + c-y)^2, {a, b, c}]
{{x^4, x^3, x^2}, {x^3, x^2, x}, {x^2, x, 1}}
```

3.5 LinearFormVector

`LinearFormVector[`*poly*`,`*vl*`]`
:: LinearFormVector

poly,vl polynominal,list of values

return LinearFormVector

```
[Example]
LinearFormVector[(a*x^2 + b*x + c - y)^2, {a, b, c}]
{-2 x^2 y, -2 x y, -2 y}
```

3.6 VtoTriangle

`VtoTriangle[`*V*`,`*t*`]`
:: return coordinates of triangle

V,t list of vertices,list of triangulation

return list of coordinates of vertices of triangle

```
[Example]
VtoTriangle[{{-1, 1}, {0, -2}, {1, 1}, {0, 2}}, {1, 2, 4}]
{{-1, 1}, {0, -2}, {0, 2}}
```

3.7 VtoTriangles

`VtoTriangles[`*V*`,`*T*`]`
:: return coordinates of triangles

V,T list of vertices,list of triangulation

return list of coordinates of vertices of triangles

```
[Example]
VtoTriangles[{{-1, 1}, {0, -2}, {1, 1}, {0, 2}}, {{1, 2, 3}, {1, 2, 4}, {2, 3, 4}}]
{{{-1, 1}, {0, -2}, {1, 1}}, {{-1, 1}, {0, -2}, {0, 2}}, {{0, -2}, {1,1}, {0, 2}}}
```

3.8 Cog

`Cog[`*P*`]` :: return triangle center

P triangle

return triangle center of P

```
[Example]
Cog[{{-1, 1}, {0, -2}, {0, 2}}]
{-(1/3), 1/3}
```

3.9 Trans

`Trans[P,l]`
:: parallel shift by l

P,l triangle,vector

return triangle

```
[Example]
Trans[{{1, 2}, {5, -3}, {-4, 1}}, {5, 6}]
{{-4, -4}, {0, -9}, {-9, -5}}
```

3.10 FindMatrix

`FindMatrix[P1,P2]`
:: find matrix converts P1 to P2

P1,P2 triangles whose center is origin

return matrix convert P1 to P2

```
[Example]
P11 = {{0, 2}, {-3, -1}, {3, -1}};
P21 = {{-4, 3}, {1, -2}, {3, -1}};
FindMatrix[P11, P21]
{{1/3, -2}, {1/6, 3/2}}
```

3.11 FindMatrix1

`FindMatrix1[P1,P2]`
:: find matrix converts P1 to P2

P1,P2 triangles whose center is origin

return matrix convert P1 to P2

```
[Example]
P11 = {{0, 2}, {-3, -1}, {3, -1}};
P21 = {{-4, 3}, {1, -2}, {3, -1}};
FindMatrix1[P11, P21]
{{1/3, -2}, {1/6, 3/2}}
```

3.12 FindMatrices

`FindMatrices[V1,V2,T]`
:: find matrices converts each triangles represented by V1 and T to ones represented by V2 and T

V1,V2,T V1,V2:list of vertices T:list of triangulation

return matrices

```
[Example]
V1 = {{-1, 1}, {0, 2}, {1, -3}, {4, -5}};
```

```
V2 = {{-3, 3}, {-2, 5}, {2, 1}, {3, 1}};
T = {{1, 2, 3}, {1, 2, 4}, {2, 3, 4}};
FindMatrices[V1, V2, T]
{{{3/2, -(1/2)},{1, 1}},
 {{12/11, -(1/11)}, {10/11, 12/11}},
 {{-(3/13), -(11/13)},{8/13, 12/13}}}
```

3.13 FindAffineMatrix

FindAffineMatrix[*P1*,*P2*]
:: find affine matrix converts P1 to P2

P1,*P2* triangles

return matrix converts P1 to P2

```
[Example]
FindAffineMatrix[{{-1, 1}, {0, -2}, {0, 2}}, {{-4, 3}, {1, -2}, {3, 0}}]
```

3.14 FindAffineMatrices

FindAffineMatrices[*V1*,*V2*,*T*]
:: find affine matrix convert each triangles

V1,*V2*,*T* V1,V2:list of vertices T:list of triangulation

return matrices

```
[Example]
V1 = {{-1, 1}, {0, 2}, {1, -3}, {4, -5}};
V2 = {{-3, 3}, {-2, 5}, {2, 1}, {3, 1}};
T = {{1, 2, 3}, {1, 2, 4}, {2, 3, 4}};
FindAffineMatrices[V1, V2, T]
{{{3/2, -(1/2), -1}, {1, 1, 3}, {0, 0, 1}},
{{12/11, -(1/11), -(20/11)}, {10/11, 12/11, 31/11}, {0, 0, 1}},
{{-(3/13), -(11/13), -(4/13)}, {8/13, 12/13, 41/13}, {0, 0, 1}}}
```

3.15 F1a

F1a[{{*a1x*,*a1y*},{*b1x*,*b1y*},{*c1x*,*c1y*}},{{*m11*,*m12*},{*m21*,*m22*}}]
:: compute quadratic form matrix

{{*a1x*,*a1y*},{*b1x*,*b1y*},{*c1x*,*c1y*}},{{*m11*,*m12*},{*m21*,*m22*}}
triangle,matrix

return quadratic form matrix

```
[Example]
F1a[{{-1, 0}, {1, 1}, {2, -3}}, {{1, 3}, {4, 2}}]
{{17/81, -(5/27), -(2/81)},
 {-(5/27), 2/9, -(1/27)},
 {-(2/81), -(1/27), 5/81}}
```

3.16 F2a

`F1a[{{a1x,a1y},{b1x,b1y},{c1x,c1y}},{{m11,m12},{m21,m22}}]`
:: compute quadratic form matrix

{{a1x,a1y},{b1x,b1y},{c1x,c1y}},{{m11,m12},{m21,m22}}
triangle,matrix

return quadratic form matrix

```
[Example]
F2a[{{-1, 0}, {1, 1}, {2, -3}}, {{1, 3}, {4, 2}}]
{{137/2430, 0, -(7/405), -(1/27), -(19/486), 1/27},
 {0, 137/2430, 1/27, -(7/405), -(1/27), -(19/486)},
 {-(7/405), 1/27, 4/135, 0, -(1/81), -(1/27)},
 {-(1/27), -(7/405), 0, 4/135, 1/27, -(1/81)},
 {-(19/486), -(1/27), -(1/81), 1/27, 25/486, 0},
 {1/27, -(19/486), -(1/27), -(1/81), 0, 25/486}}
```

3.17 EmbedMatrix

`EmbedMatrix[n,i,j,M]`
:: embed 2-degree matrix M in n-degree 0 matrix

n,i,j,M degree,index,index,matrix

return matrix

```
[Example]
EmbedMatrix[6, 2, 4, {{1, 2}, {3, 4}}]
{{0, 0, 0, 0, 0, 0},
 {0, 1, 0, 2, 0, 0},
 {0, 0, 0, 0, 0, 0},
 {0, 3, 0, 4, 0, 0},
 {0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0}}
```

3.18 EmbedMatrix

`EmbedMatrix[n,i,j,k,M]`
:: embed 2-degree matrix M in n-degree 0 matrix

n,i,j,k,M degree,index,index,index,matrix

return matrix

```
[Example]
EmbedMatrix[8, 2, 4, 7, {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}]
{{0, 0, 0, 0, 0, 0, 0, 0},
 {0, 1, 0, 2, 0, 0, 3, 0},
 {0, 0, 0, 0, 0, 0, 0, 0},
 {0, 4, 0, 5, 0, 0, 6, 0},
 {0, 0, 0, 0, 0, 0, 0, 0},
```

```
 {0, 0, 0, 0, 0, 0, 0, 0},
 {0, 7, 0, 8, 0, 0, 9, 0},
 {0, 0, 0, 0, 0, 0, 0, 0}}
```

3.19 EmbedMatrix2

`EmbedMatrix2[n,i,j,k,M]`
:: embed 6-degree matrix M in 2n-degree 0 matrix

n,i,j,k,M n:size, i,j,k:index M:matrix

return matrix

```
[Example]
A = EmbedMatrix[6, 1, 3, 5, {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}] +
  EmbedMatrix[6, 2, 4, 6, {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}}]

  {{1, 0, 2, 0, 3, 0},
   {0, 1, 0, 2, 0, 3},
   {4, 0, 5, 0, 6, 0},
   {0, 4, 0, 5, 0, 6},
   {7, 0, 8, 0, 9, 0},
   {0, 7, 0, 8, 0, 9}}

EmbedMatrix2[4, 1, 3, 4, A]

{{1, 0, 0, 0, 2, 0, 3, 0},
 {0, 1, 0, 0, 0, 2, 0, 3},
 {0, 0, 0, 0, 0, 0, 0, 0},
 {0, 0, 0, 0, 0, 0, 0, 0},
 {4, 0, 0, 0, 5, 0, 6, 0},
 {0, 4, 0, 0, 0, 5, 0, 6},
 {7, 0, 0, 0, 8, 0, 9, 0},
 {0, 7, 0, 0, 0, 8, 0, 9}}
```

3.20 F1v

`F1v[{{a1x,a1y},{b1x,b1y},{c1x,c1y}},{{m11,m12},{m21,m22}}]`
:: compute linear form vector

{{a1x,a1y},{b1x,b1y},{c1x,c1y}},{{m11,m12},{m21,m22}}
triangle,matrix

return linear form vector

```
[Example]
F1v[{{-1, 0}, {1, 1}, {2, -3}}, {{1, 3}, {4, 2}}]
{14/9, 4, -(8/3), -4, 10/9, 0}
```

3.21 EmbedVector

`EmbedVector[`*n*`,`*i*`,`*j*`,`*k*`,`*V*`]`
:: embed vector V in 2n-degree 0 vector

n,i,j,k,V n:size i,j,k:index V:vector

return vector

```
[Example]
EmbedVector[5, 1, 3, 4, {-6, 7, 28, 19, -4, 31}]
{-6, 7, 0, 0, 28, 19, -4, 31, 0, 0}
```

4 Local Interpolations

4.1 RotateAngle

`RotateAngle[`*m_*`,`*flag_*`]`
::controlled rotate angle of m by flag

m

flag 1 or 0 or -1, control the rotate angle

return angle

```
[Example]
RotateAngle[m,1]
```

4.2 NewFindMatrices

`NewFindMatrices[`*conf_*`]`
::find matrices converted each triangles

conf configuration

return matrices

```
[Example]
NewFindMatrices[Configuration2]
```

4.3 LocalLinear

`LocalLinear[`*m_*`]`
::compute a local linear interpolations depend on time

m matrices computed by NewFindMatrices[*conf_*]

return matrices of local linear interpolation

```
[Example]
LocalLiner[NewFindMatrices[Configuration2]]
```

4.4 LocalPolar

`LocalPolar[`*m_*`]`
::compute a local polar interpolations depend on time

m matrices computed by NewFindMatrices[*conf_*]

return matrices of local polar interpolation

```
[Example]
LocalPolar[NewFindMatrices[Configuration2]]
```

4.5 LocalAlexa

`LocalAlexa[m_]`

::compute a local ARAP interpolations depend on time

m matrices computed by NewFindMatrices[*conf_*]

return matrices of local alexa interpolation

```
[Example]
LocalAlexa[NewFindMatrices[Configuration2]]
```

4.6 LocalLogExp

`LocalLogExp[m_]`

::compute a local log-exp interpolations depend on time

m matrices computed by NewFindMatrices[*conf_*]

return matrices of local log-exp interpolation

```
[Example]
LocalLogExp[NewFindMatrices[Configuration2]]
```

4.7 LocalInterpolations

`LocalInterpolations[local_,conf_]`

::compute local interpolations that you choice

local LocalLinear/LocalPolar/LocalAlexa/LocalLogExp

conf configuration

return

```
[Example]
LocalInterpolations[LocalPolar,Configuration2]
```

5 Grobal Interpolations

5.1 Constraint Function and Energy Function

5.1.1 ConstMatrix

`ConstMatrix[`*m*_`,`*st*_`]`

::

m choice of vertex

st list of start coordinates

return matrix

```
[Example]
ConstMatrix[1,dataS2]
```

5.1.2 ConstVector

`ConstVector[`*m*_`,`*st*_`,`*en*_`,`*t*_`]`

::

m choice of vertex

st list of start coordinates

en list of end coordinates

t parameter of time(0...1)

return vector

```
[Example]
ConstVector[1,dataS2,dataE2,0.5]
```

5.1.3 ConstMatrixM

`ConstMatrixM[`*st*_`,`*en*_`,`*tri*_`,`*t*_`]`

::

st list of start coordinates

en list of end coordinates

tri list of triangulation

t parameter of time(0...1)

return matrix

```
[Example]
ConstMatrixM[dataS2,dataE2,dataT2,0.5]
```

5.1.4 ConstVectorM

`ConstVectorM[`*st_*`,`*en_*`,`*tri_*`,`*t_*`]`

::

st	list of start coordinates
en	list of end coordinates
tri	list of triangulation
t	parameter of time(0...1)
return	vector

```
[Example]
ConstVectorM[dataS2,dataE2,dataT2,0.5]
```

5.1.5 ConstMatrix2

`ConstMatrix2[`*n_*`,`*k_*`,`*l_*`]`

::

n	weight of constraint function
k,l	Choice two numbers you want to fix.
return	matrix

```
[Example]
ConstMatrix2[2,1,2]
```

5.1.6 ConstfixMatrix

`ConstfixMatrix[`*n_*`,`*k_*`,`*l_*`,`*st_*`]`

::

n	weight of constraint function
k,l	Choice two numbers you want to fix.
st	list of start coordinates
return	matrix

```
[Example]
ConstfixMatrix[2,1,2,dataS2]
```

5.1.7 ConstfixVector

`ConstfixVector[`*n_*`,`*k_*`,`*l_*`,`*st_*`]`

::

n	weight of constraint function
k,l	Choice two numbers you want to fix.
st	list of start coordinates
return	vector

```
[Example]
ConstfixVector[2,1,2,dataS2]
```

5.1.8 Constfix2Vector

`Constfix2Vector[`*n_*`,`*k_*`,`*l_*`,`*st_*`,`*t_*`]`

::

n weight of constraint function

k,l Choice two numbers you want to fix.

st list of start coordinates

t parameter of time(0...1)

return vector

```
[Example]
Constfix2Vector[1,1,2,dataS2,0.5]
```

5.1.9 ConstPair

`ConstPair[`*m_*`]`

::

m choice of vertex

return {matrix,vector}

```
[Example]
ConstPair[1]
```

5.1.10 ConstPair

`ConstPair[`*m_*`,`*n_*`]`

::

m,n choice of vertex

return {matrix,vector}

```
[Example]
ConstPair[1,2]
```

5.1.11 DoubleMatrix

`DoubleMatrix[`*m_*`]`

::

m matrix

return matrix

```
[Example]
DoubleMatrix[]
```

5.2 Grobal Interpolations

5.2.1 `QuadraticFormAlexa`

`QuadraticFormAlexa[`*`local_`*`,`*`conf_`*`]`

::

local choice of local interpolation

conf configuration

return {matrix,vector}

```
[Example]
QuadraticFormAlexa[LocalPolar,Configuration2]
```

5.2.2 `QuadraticFormSim`

`QuadraticFormSim[`*`local_`*`,`*`conf_`*`]`

::

local choice of local interpolation

conf configuration

return {matrix,vector}

```
[Example]
QuadraticFormSim[LocalLogExp,Configuration2]
```

5.2.3 `ARAP`

`ARAP[`*`local_`*`,`*`energy_`*`,`*`const_`*`,`*`conf_`*`]`

::

local choice of local interpolation

energy choice of energy function

const choice of constraint function

conf configuration

return {matrix,vector}

```
[Example]
ARAP[LocalPolar,QuadraticFormAlexa,Const[1],Configuration2]
```

6 Draw Animation

6.1 ShowStatus

`ShowStatus[`*`st`*`,`*`en`*`,`*`tri`*`,`*`plotrange`*`]`
:: Draw start and end of Graphic

st start state of vertex set

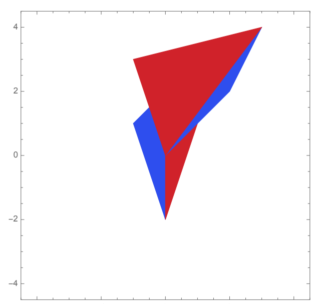
en end state of vertex set

tri constitution of triangle

plotrange Display range

return graph of start and end status

```
[Example]
ShowStatus[dataS2, dataE2, dataT2, 4.5]
```



6.2 DrawAnimation

`DrawAnimation[`*`local`*`,`*`energy`*`,`*`const`*`,`*`conf`*`]`
:: aiueo

local Choice of local interpolation

energy Choice of energy interpolation

const Choice of constraint interpolation

conf {start vertex set,end vertex set,constitution of triangle}

return animation

```
[Example]
DrawAnimation[LocalAlexa, FrobeniusEnergy, Const2, Configuration2]
```

6.3 ListAnimation

`ListAnimation[`*k*`,`*local*`,`*energy*`,`*const*`,`*conf*`]`
:: aiueo

k number of frame division

local Choice of local interpolation

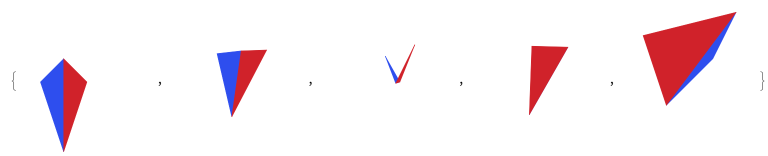
energy Choice of energy interpolation

const Choice of constraint interpolation

conf {start vertex set,end vertex set,constitution of triangle}

return list of graph

```
[Example]
ListAnimation[k_,n_,c_,e_,st_,en_,tri_,plotrange]
```



Index