# MIT Class 6.S080 (AUS) Mechanical Invention through Computation

**3-dimensional Expanding Structures** 

Mechanism – relation to base geometry

Linkages orthogonal to 3D surface

Linkages tangential to 3D surface





## Transformable Typology: Expanding Shapes



## Kinematic mode



## Icosahedron



## Radial expansion

Points on expanding shape move radially outwards.





## Turning surfaces into mechanisms







## Surface terminology



#### Original patent: angulated scissor



U.S. Patent

June 18, 1991

Sheet 1 of 12 5,024,031

## Original patent: expanding polygon



### Original patent: 3d loop linkage (3-sided)



Hubs create out of plane connections between linkages

#### Original patent: 3d loop linkage (4-sided)



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#### Original patent: 3d loop linkage (6-sided)







#### Original patent: expanding icosahedron



Fig. 20

# Mini Sphere







Mini sphere works with double scissor between hubs







#### Angulated scissor construction - review



#### Scissor frequency (between hubs)



As additional scissors are added, ratio of folded to unfolded size decreases

#### Hub and link assemblies (4-sided)



## Hub and link assembly (3-sided)



#### Base geometry

Core polyhedron Dual figure gives location of scissors

For structures with single scissors between adjacent hubs, circle tangency is required.





# Surface made up of tangential circles







#### Link construction from base geometry

Construct links as shown



## Wireframe



### Scissors shown without hubs

Need to allow space for hubs to avoid interferences







# Method to set hub geometry





## Hub construction (alternate method)



#### Double scissor construction



#### Mini sphere construction with double scissor





## Wireframe





## Product



• Surface Shape



- Surface Shape
- Tessellation



- Surface Shape
- Tessellation
- Normal Vectors



- Surface Shape
- Tessellation
- Normal Vectors
- Intersections





# Korean Aerospace Institute



# Korean Aerospace Institute



# Expanding Sphere, CBIT Conference, Hanover, 2010



# Expanding Sphere, CBIT Conference, Hanover, 2010



# Expanding



# Expanding Helicoid



## Museo Interactivo Mirador, Chile



#### Smith Haut Lafitte Bordeaux, France







## Detroit Auto Show 2012



# Hyperbolic parabaloid



# Hyperbolic parabaloid

