# Towards Compliant End-Effectors for Space Applications Based on Recursive Geometry

Georges Kremer, Miguel Olivares-Mendez, Carol Martinez
georges.kremer.002@student.uni.lu, carol.martinezluna@uni.lu

SpaceR
*Space Robotics Research Group*

## Compliant Mechanisms in Space

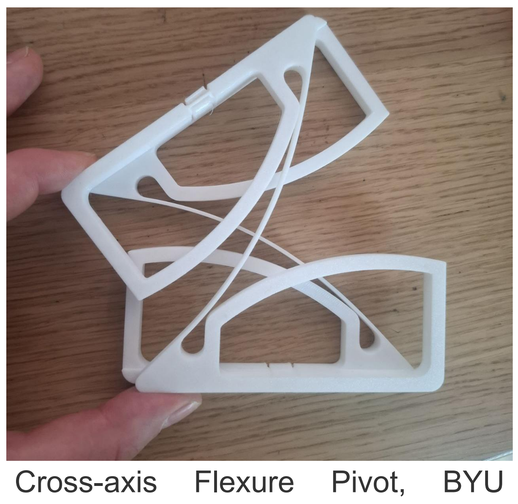
- Monolithic mechanisms
- Use the natural flexibility of materials

### Challenges

- Force & Motion design
- Stress relaxation
- Fatigue
- Limited motion

### Opportunities

- Lightweight
- Minimal backlash
- No lubricant
- Few parts
- Reduced friction



Cross-axis Flexure Pivot, BYU Research Group


Monolithic 2 DOF fully compliant space pointing mechanism by E.G. Merriam et al.

### Applications:

- In-Orbit Servicing
- Sample Collection
- In-Space Assembly and Manufacturing
- Space Debris Retrieval

## Recursive Geometry

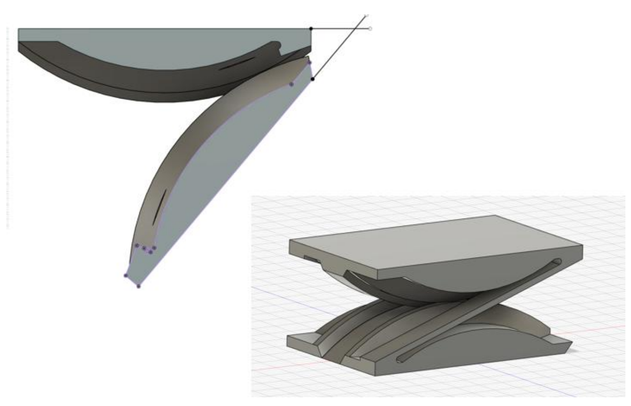
### Inspired by fractal vise

- Adaptation to organic objects
- Grasping unknown shapes
- High compliance


Fractal Vise by TeachingTech

### Fractal module

- Base shape for gripper
- Deflection +-50°
- Low stiffness
- Inclusion of sensing capabilities possible



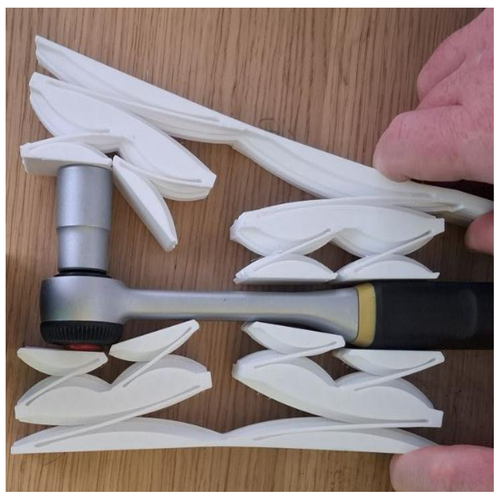
## Proof of Concept End Effector

### Recursive use of a fractal module

- Parallel gripper configuration
- Fully 3D printable
- Monolithic design
- Scalable
- Made from PETG
- Length: 300 mm

## Results

- Successful shape adaptation and object grasp
- Deflection in the desired DoF achieved
- Deflection in undesired DoC observed
- Increased stiffness per fractal layer required
- Monolithic manufacturing achieved



## Future Work

### Model-based design

- Beam Constraint Model
- Pseudo-Rigid Body Models
- Portability between materials

### Integration Tactile Sensing & Feedback Loop

uSkin Sensors by Xela Robotics