Autonomous Pose Estimation for In-Orbit Self-Assembly of the Intelligent Self-powered Modules

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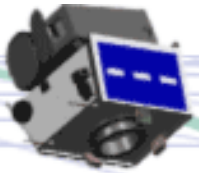


Content

Intelligent Self-powered Modules (ISM)	ISM Docking	ISM Pose Estimation
• Motivation • Applications • ISM Mission Scenario	• Electromagnetic Flat Docking System • Torque/Force Model	• Relative Position • Relative Attitude • Results

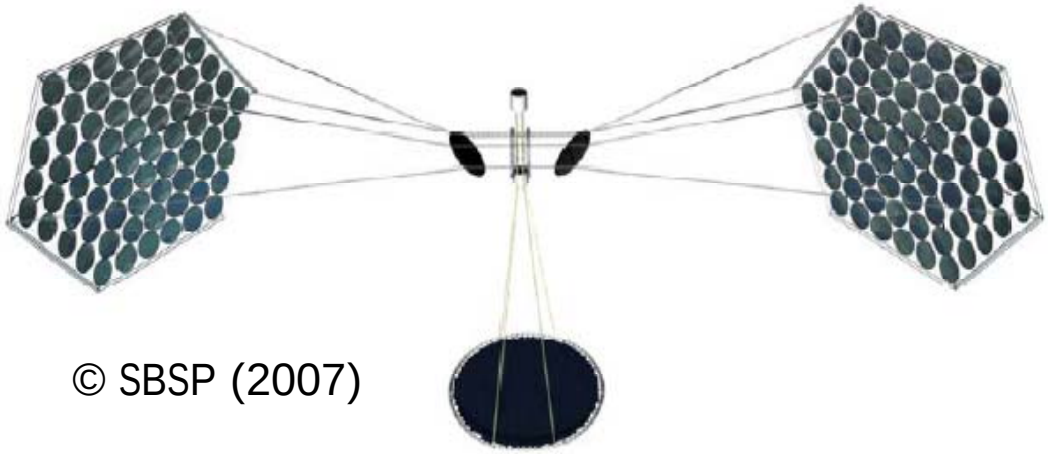
Motivation

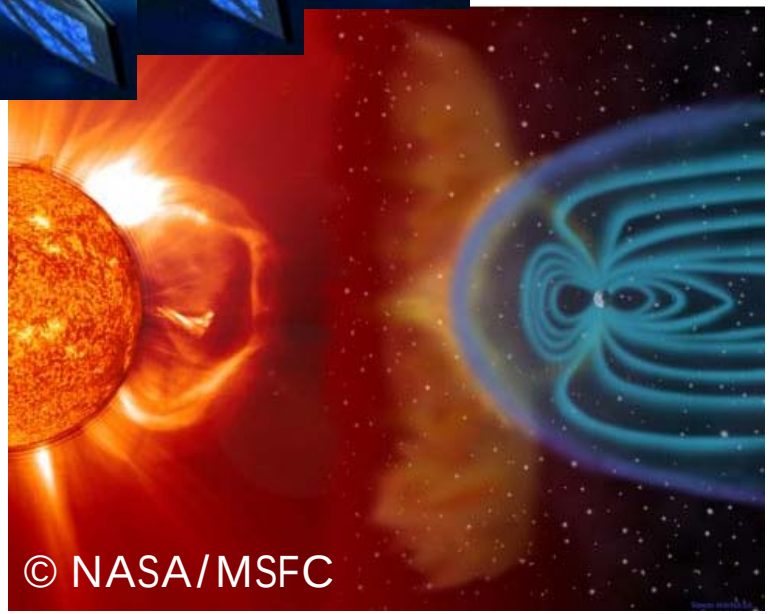
- Small, light and cost- efficient satellites
- Large space structures
- Interchangeability, upgrading and maintenance in orbit

In-orbit assembly of modular spacecraft

Applications

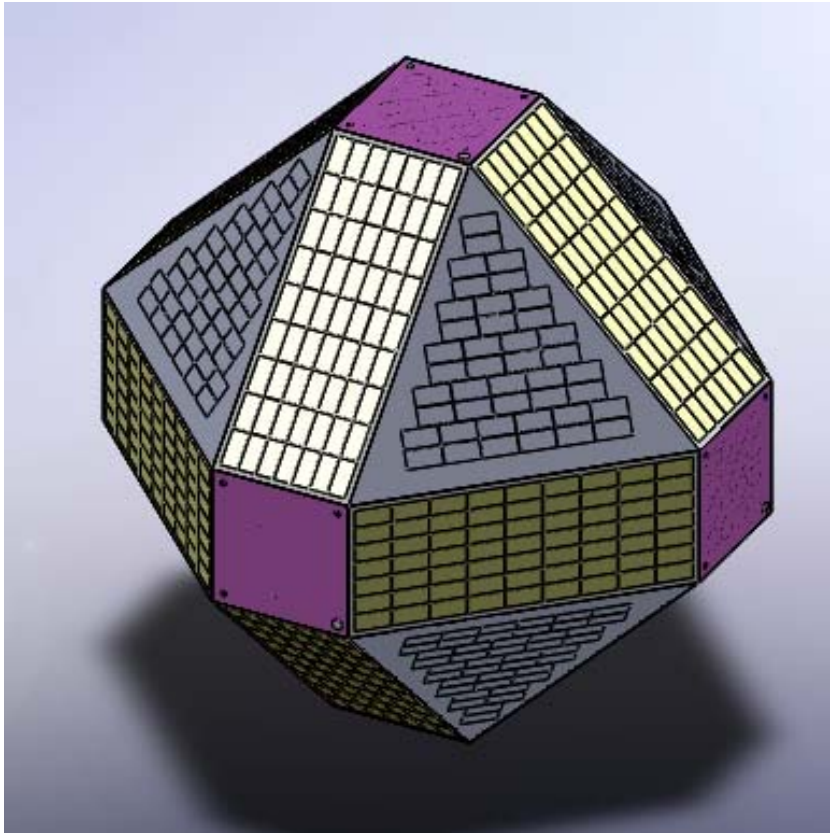
- Multiple Spacecraft Docking Missions:
  - magnetic shielding
  - large telescopic mirrors
  - large solar panels.





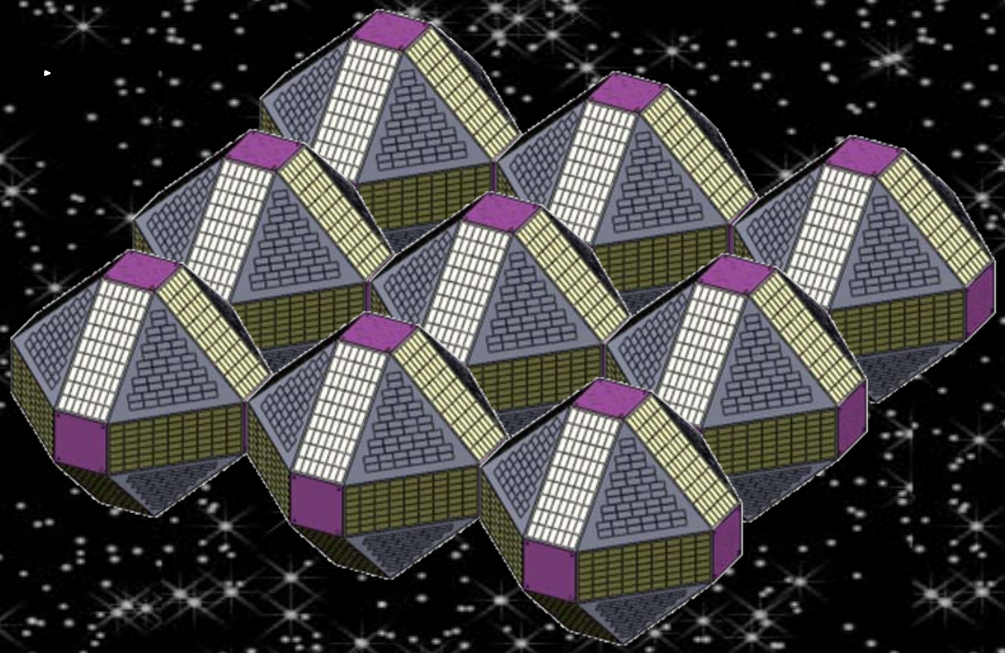
Intelligent Self-powered Modules (ISM)

- Cubic Core
  --> Electronics
- Electromagnetic Flat Docking System
- Solar cells



ISM Mission Scenario

- other –satellite
-



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Docking Systems

Docking Systems

Cone / Probe

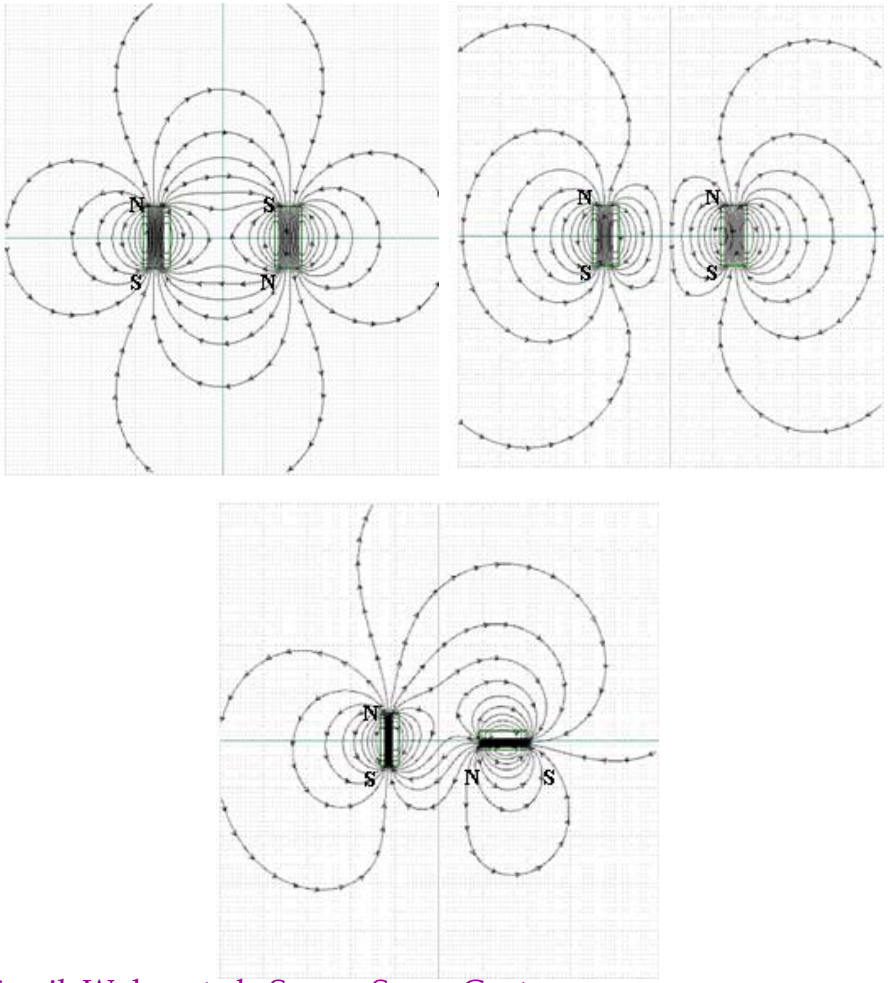
- Requires fine alignment
- Smooth contact
- Plume impingement effects.

Propellant-less

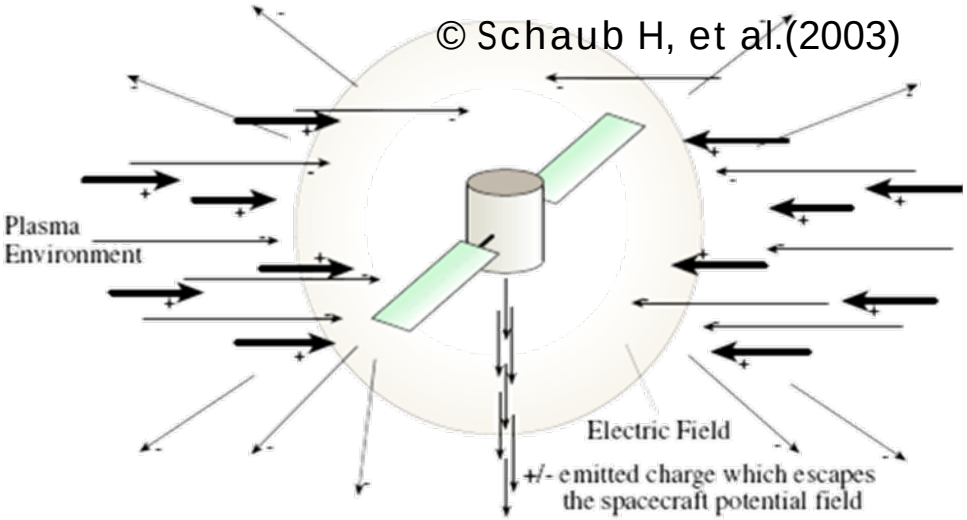
- capture using EM forces
- Controlled contact
- No extra propellant
- No plume impingement effects.

Propellant-less Docking

Electro-magnetic Forces



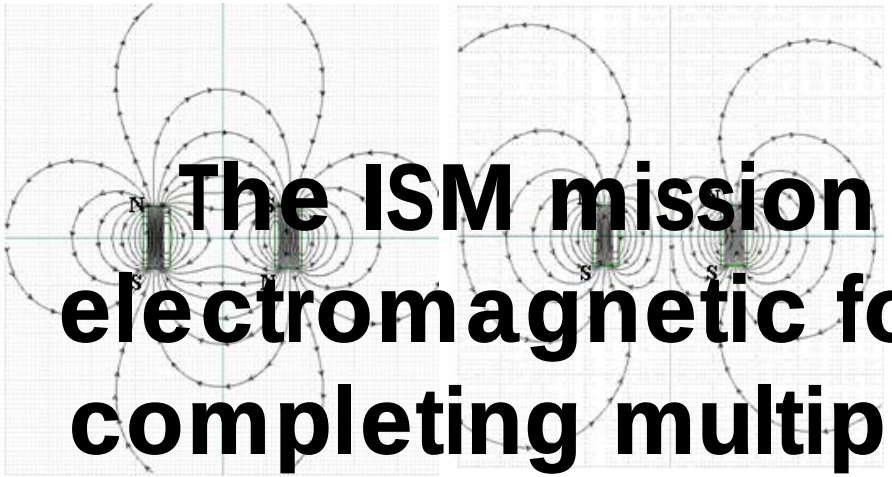
Electro-static Forces

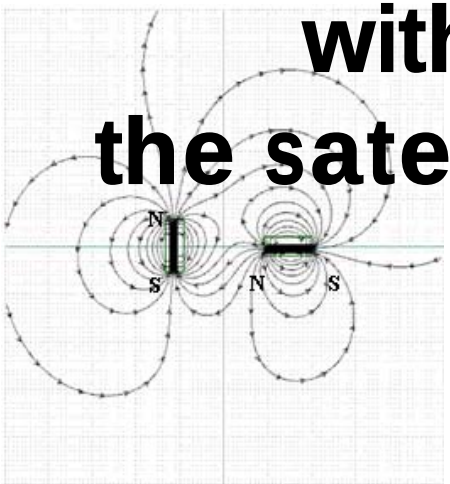


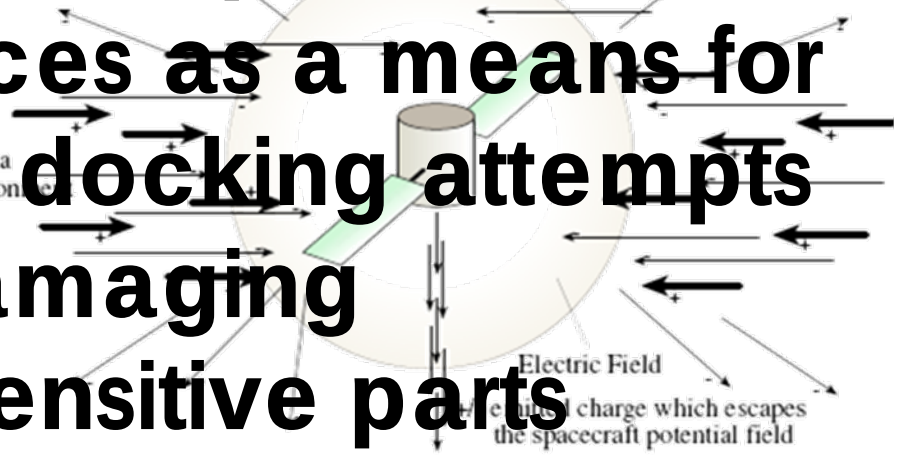
Propellant-less Docking

Electro-magnetic Forces

Electro-static Forces







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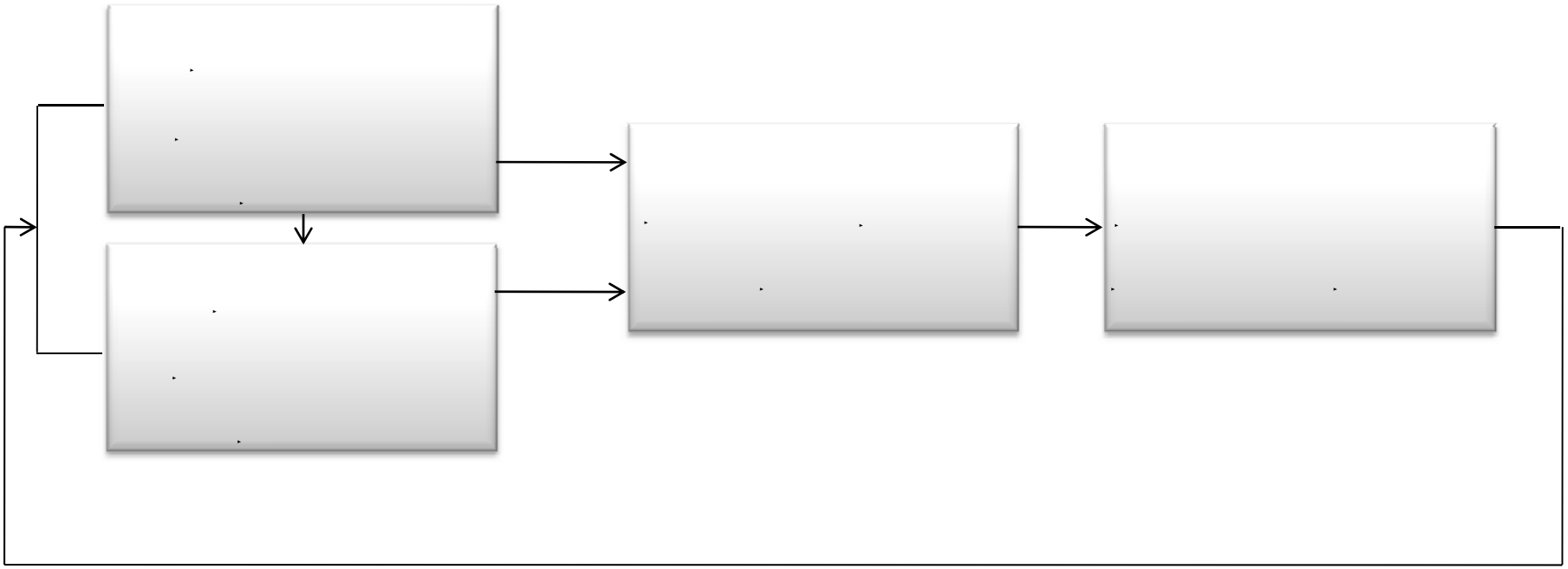
The ISM mission concept uses the electromagnetic forces as a means for completing multiple docking attempts without damaging the satellites' sensitive parts

Electromagnetic Docking



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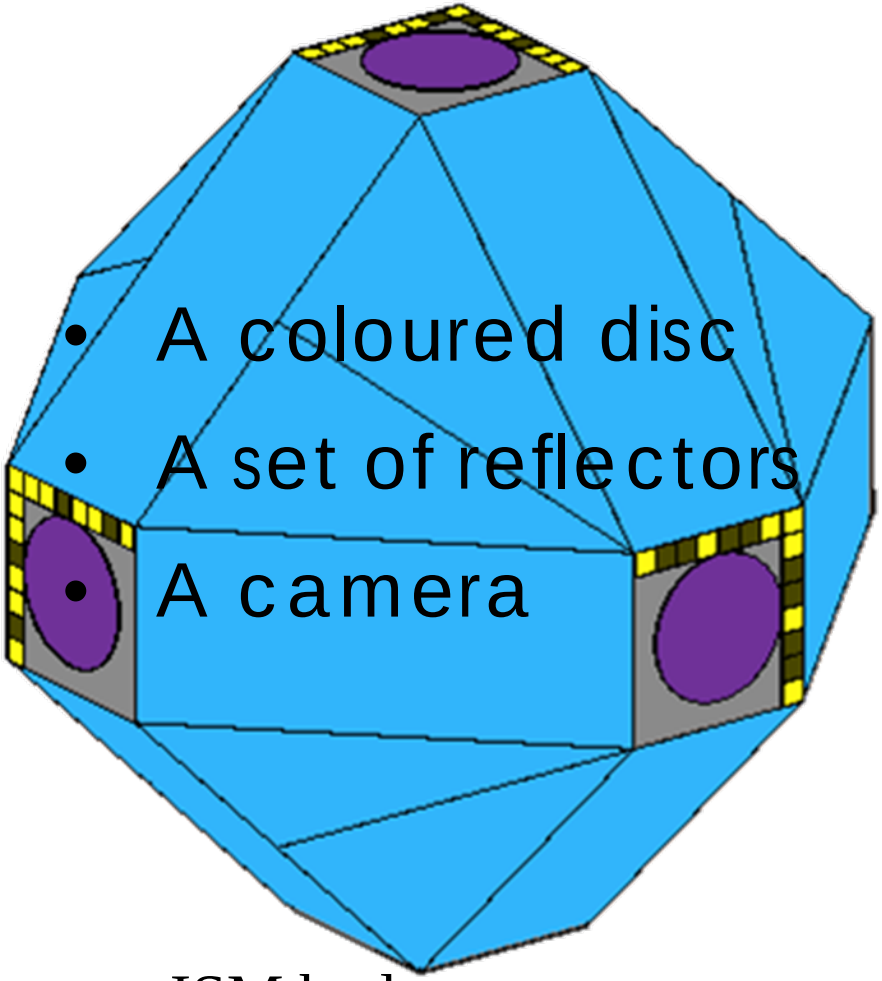
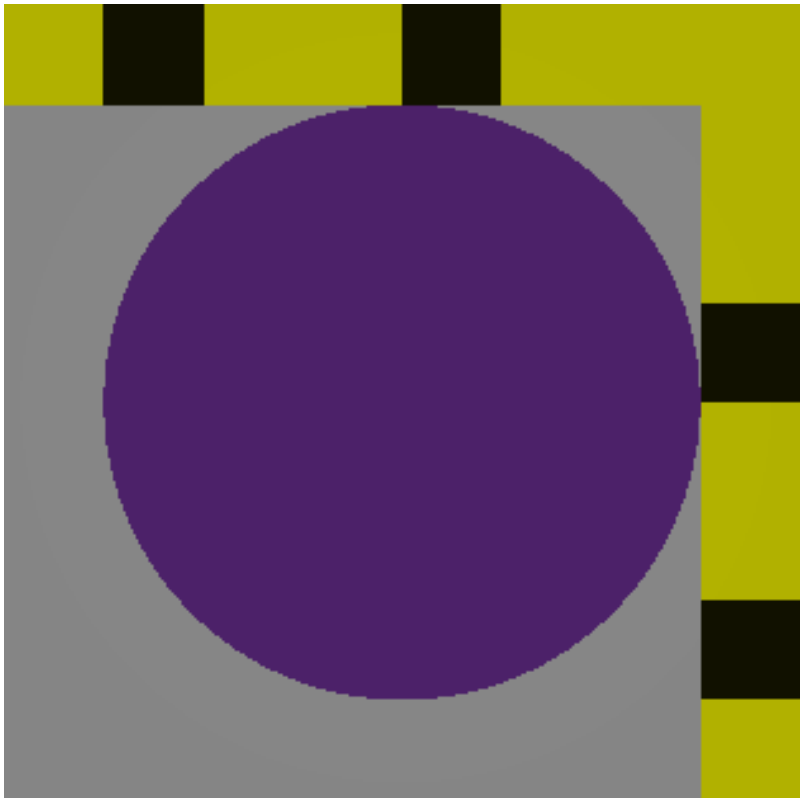
ISM Pose Estimation

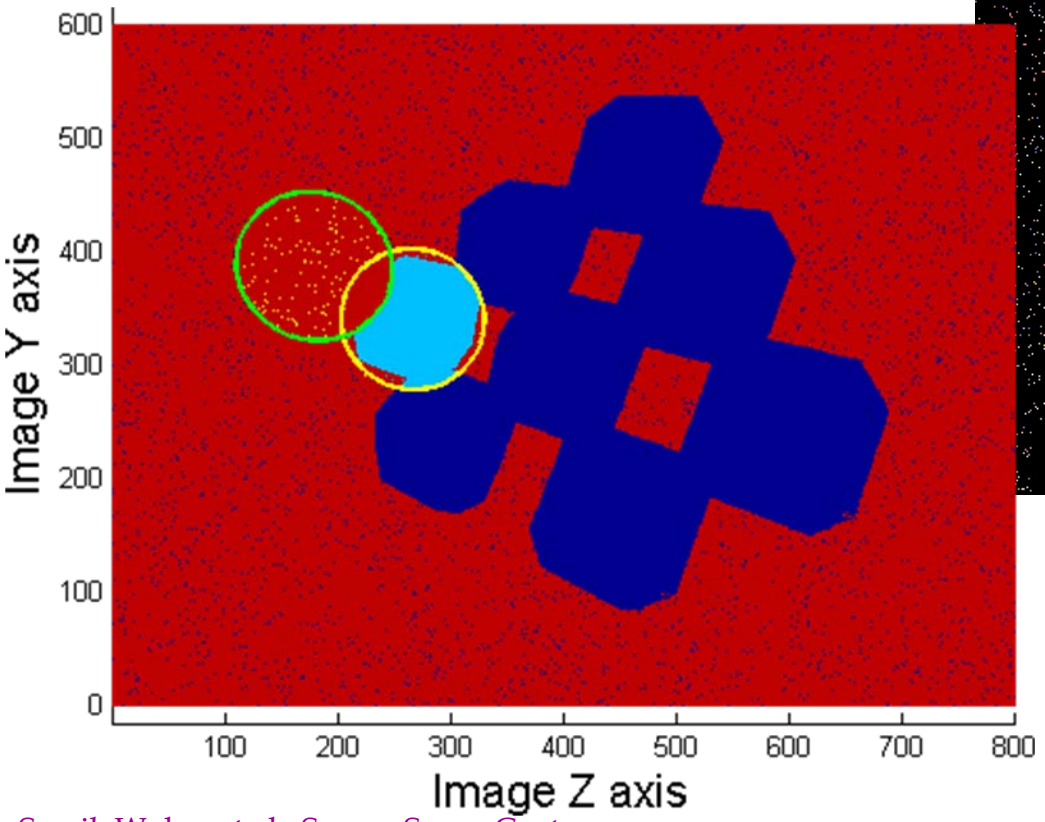


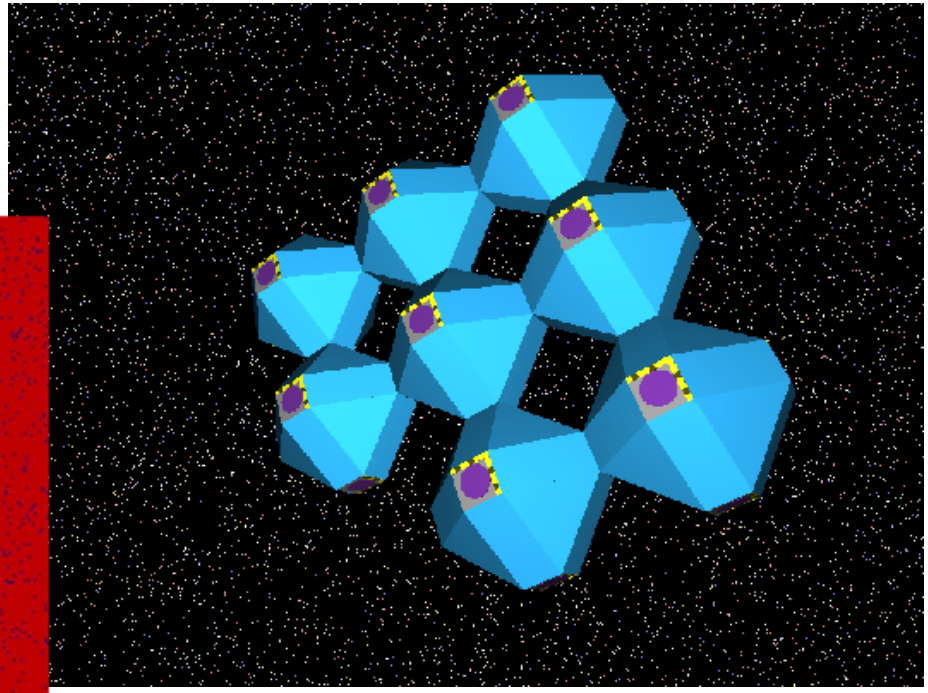
ISM body structure



ISM axial facet

Relative Position





Partial Occlusion

False estimates

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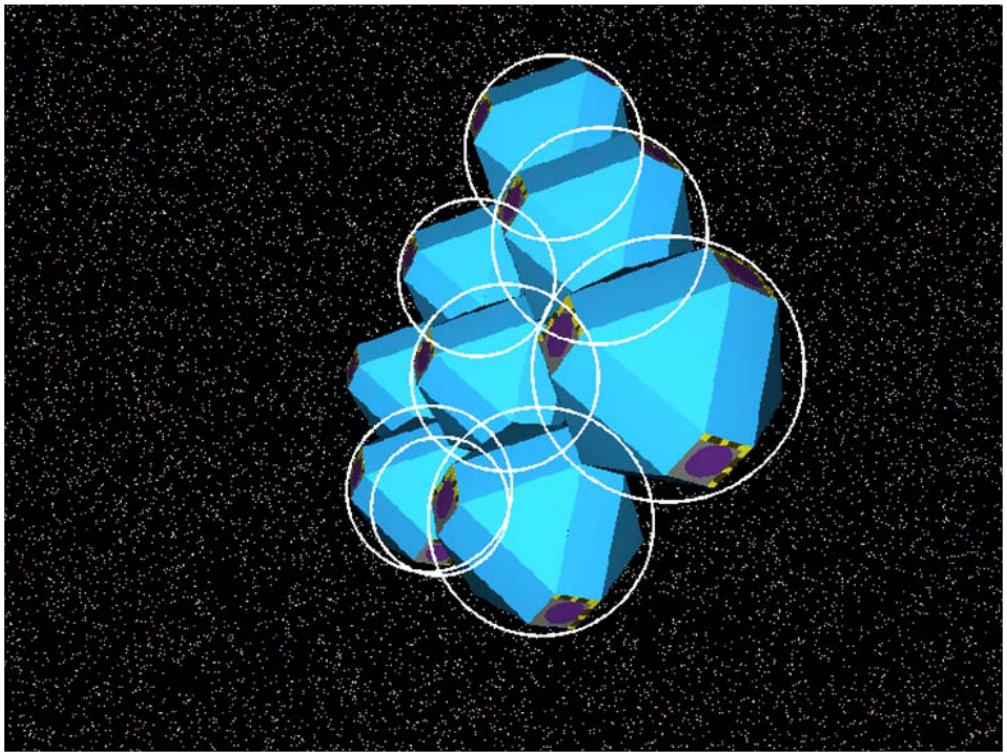
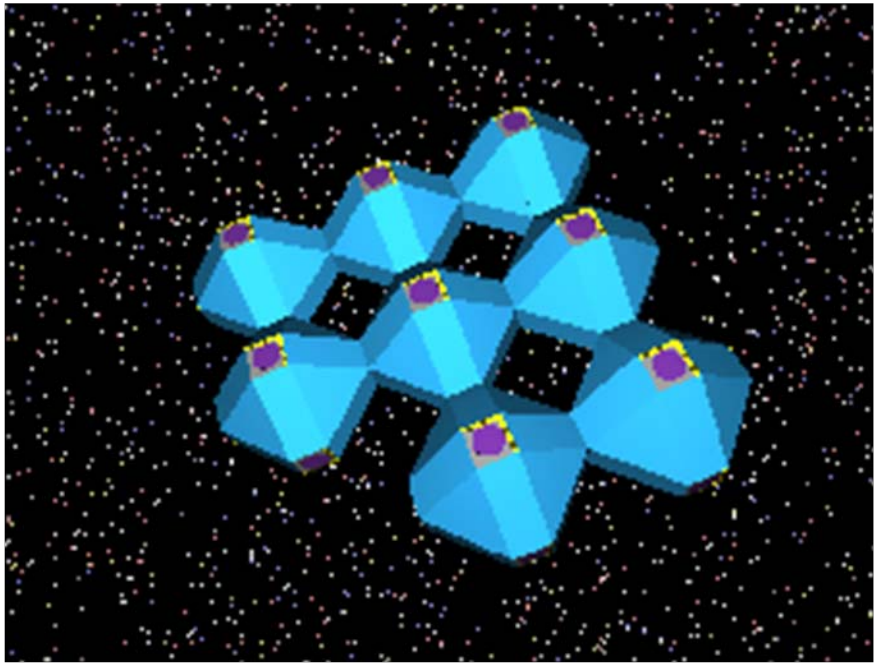
|

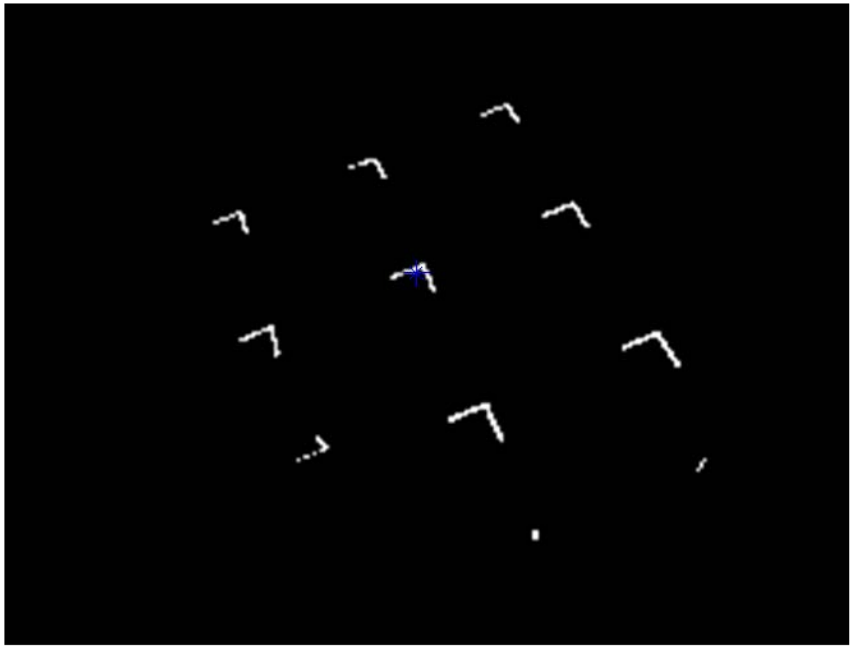
|

Partial occlusion



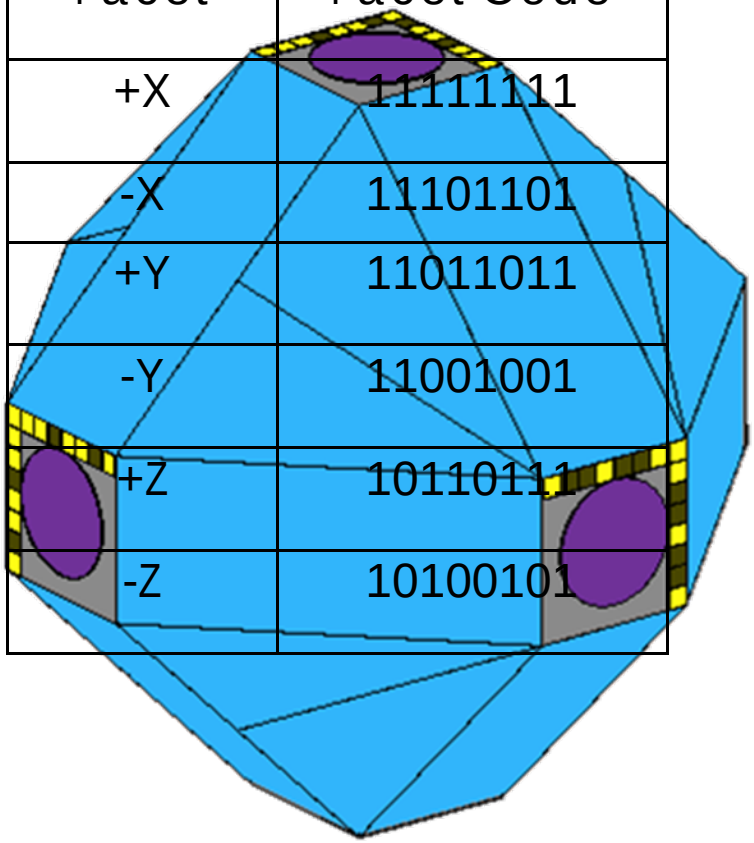
Relative Attitude

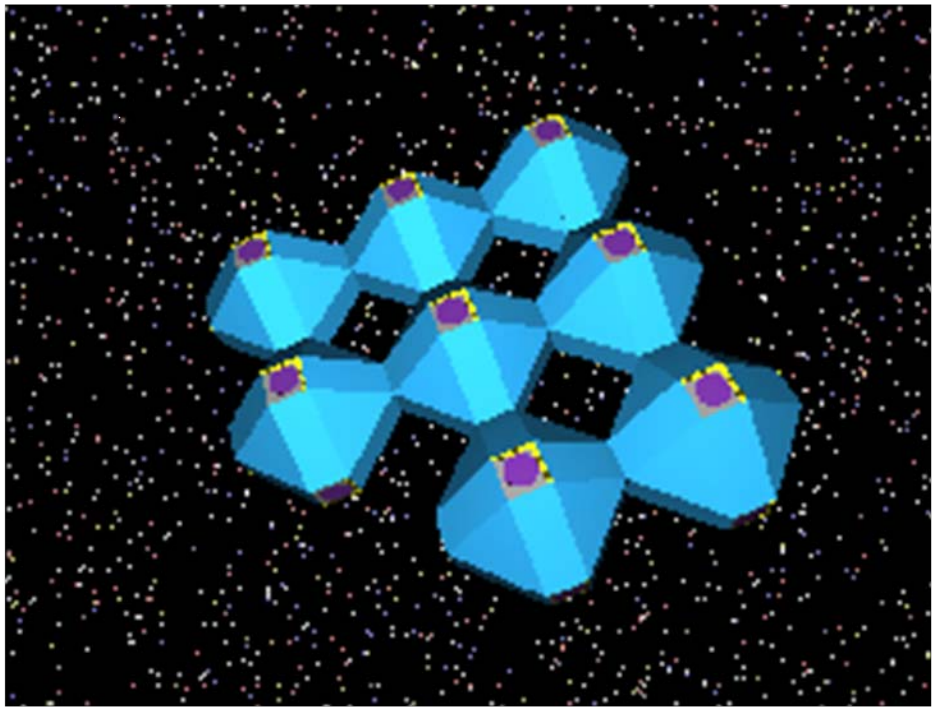




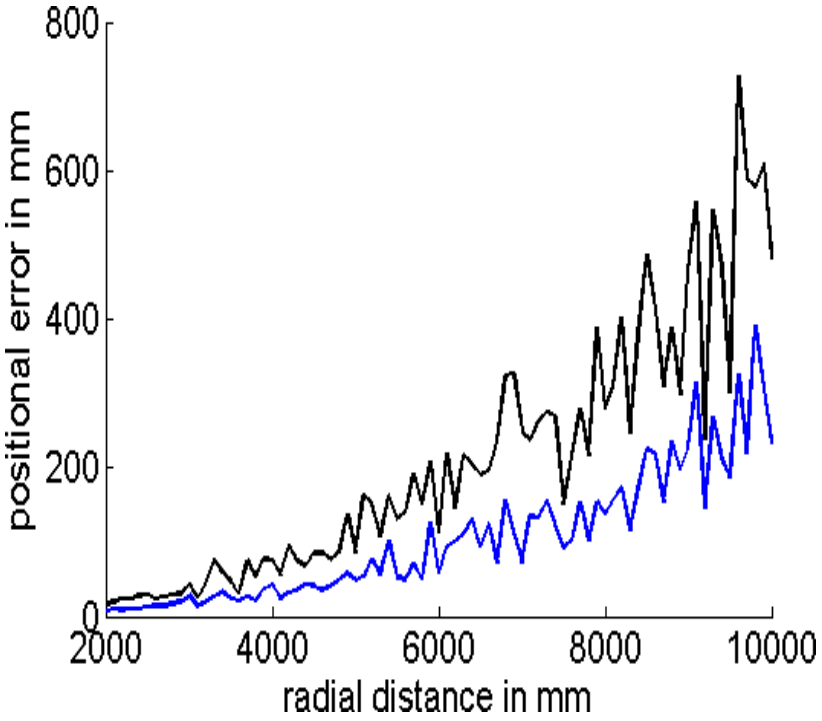
Facet detection

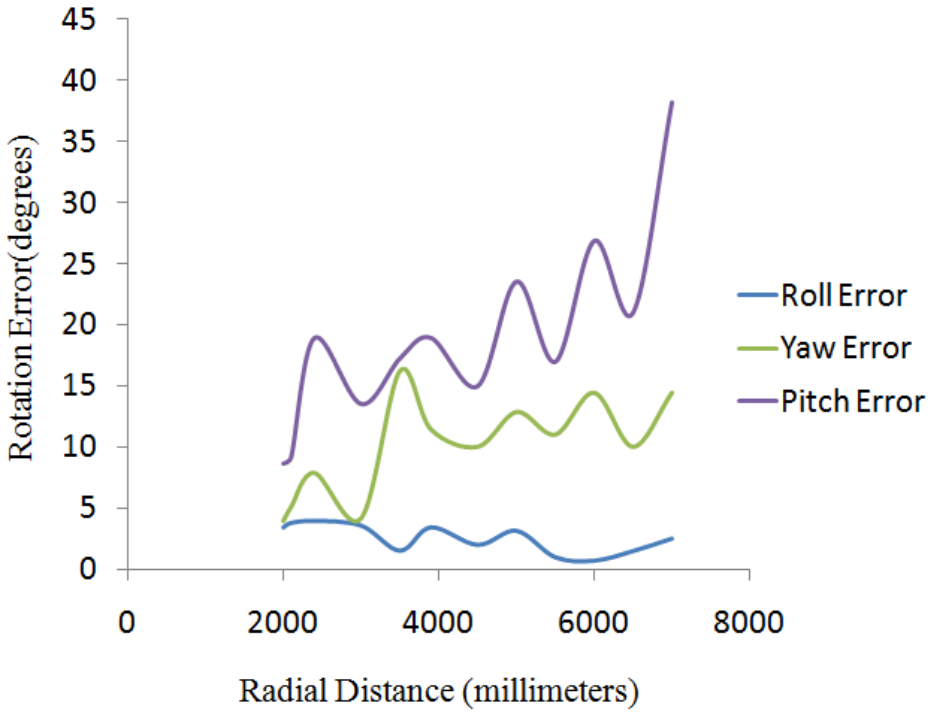
Facet	Facet Code
+X	11111111
-X	11101101
+Y	11011011
-Y	11001001
+Z	10110111
-Z	10100101



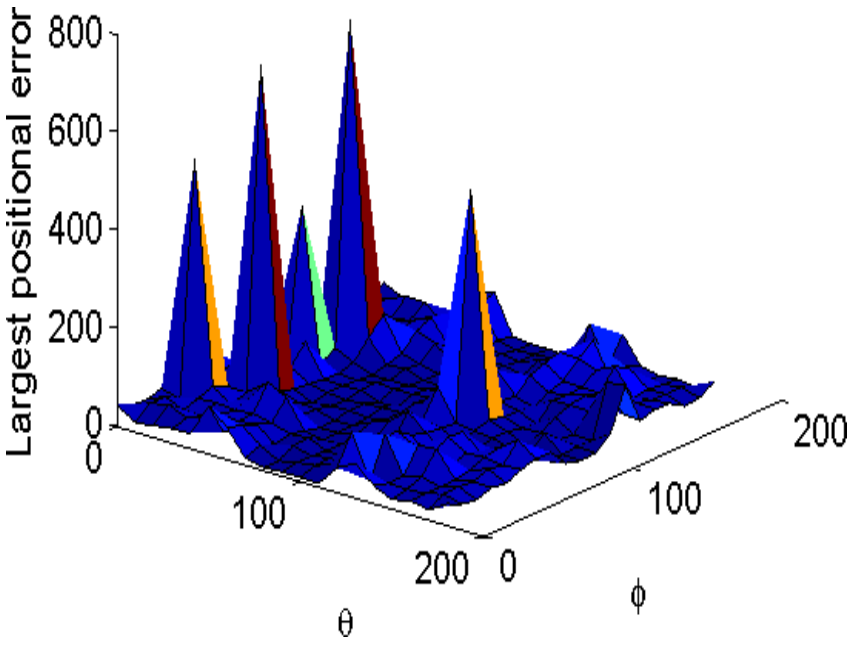


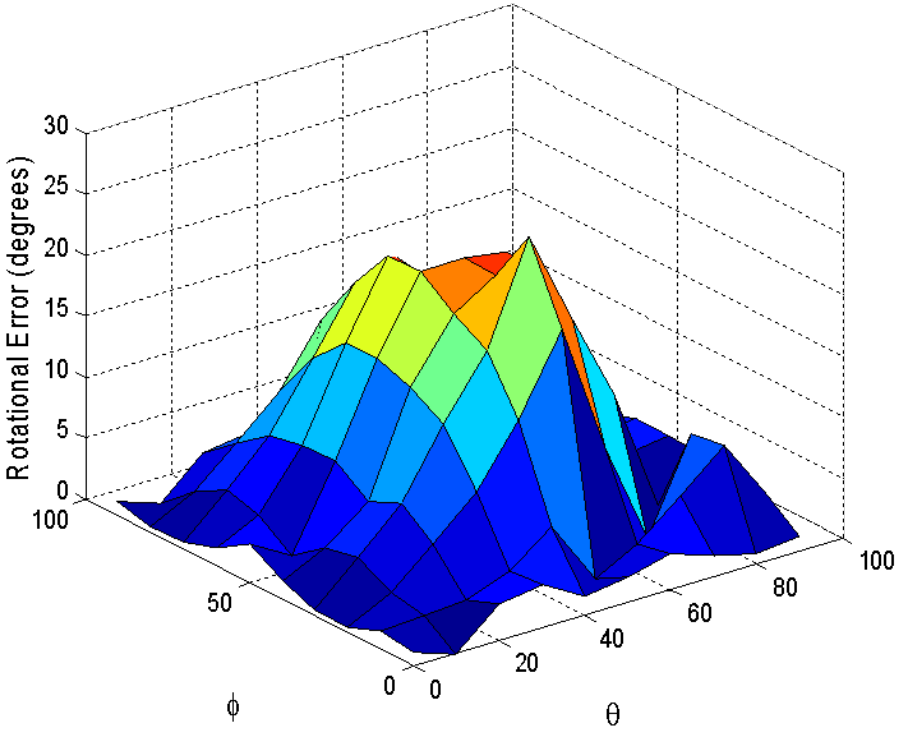
Results


800
600
400
200
0
positional error in mm
2000
4000
6000
8000
10000
radial distance in mm


45
40
35
30
25
20
15
10
5
0
Rotation Error(degrees)
0
2000
4000
6000
8000
Radial Distance (millimeters)
Roll Error
Yaw Error
Pitch Error

Results


Largest positional error
800
600
400
200
0
0
100
200
θ
0
100
200
ϕ


Rotational Error (degrees)
30
25
20
15
10
5
0
100
50
0
ϕ
0
20
40
60
80
100
θ

Conclusion

- The pose of a neighbouring ISM structure was determined
  - Relative position - - - > passive
  - Relative attitude - - - > active
- Algorithm tested on a 3-by-3 structure
- Accuracy depends on the camera specifications

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THANK YOU!

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