ENGINEERING

Light Curve Inversion: Determining the Shape of Human-Made Space Objects

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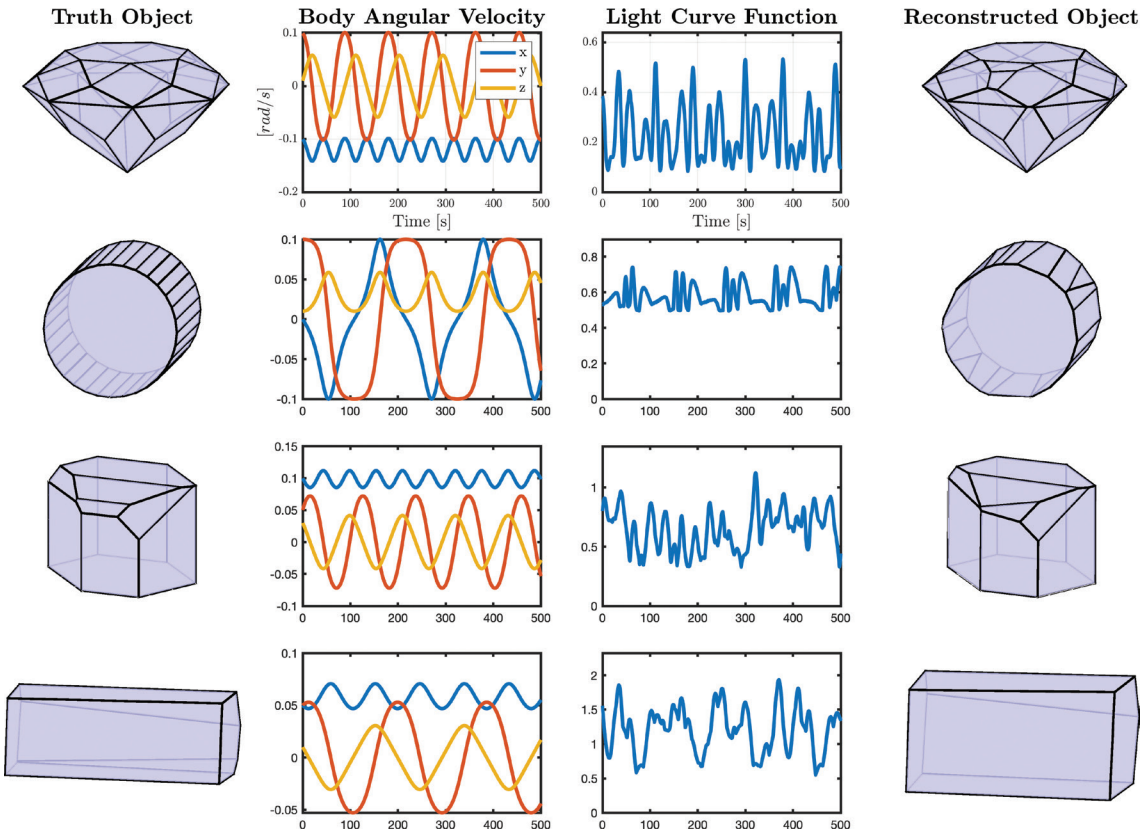
Humanity creates more space objects each year. These may be operational satellites, but also pieces of debris, such as spent rocket stages or the remains of catastrophic fragmentation events. To effectively characterize and catalog these objects, observers must determine fundamental quantities like position and velocity. A crucial question that is more difficult to answer is: What is the object's shape? Shape information is crucial to determine an object's current state and origin. As space objects are far away, only nonresolved measurements can be made, meaning we cannot see any details from the ground. A satellite in orbit reflects a small amount of sunlight, yielding brightness measurements that can be connected to form a light curve. Light curves may be used for determining shape in a process called light curve inversion. My research extends the work of Dr. Siwei Fan, a former PhD student in the Space Information Dynamics group at Purdue University, to accelerate the current process and address a class of nonconvex objects, which can cast shadows on themselves. Nearly all human-made satellites and large pieces of debris are nonconvex. To accomplish this, a new simulation environment was created to model the shadows cast by space objects. This improved simulated light curve quality and reduced run times by a factor of 10,000. A new method was developed allowing the object shape optimization and reconstruction processes to account for concave features, enabling the reconstruction of simple, nonconvex shapes with only a nonresolved light curve.

Research advisor Carolin Frueh writes: "With Liam's work, significant improvements have been made in the light curve inversion for shape. Liam made impressive progress that is all the more noteworthy for an undergraduate student."



Light curve inversions of space objects simulated by the author.

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