Computer Vision Experiments in Crowdsourced Astronomy

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Introduction

The contributions of amateur observers and citizen scientists in astronomy have become more meaningful in doing "real science" through both crowdsourced data analysis and telescope observations. There remains huge untapped potential in crowdsourcing amateur observations on the internet and extracting meaningful scientific data from them. Some laborious attempts tailored towards particular objects (e.g. comets) have proven successful, but there remains work to be done in generalizing the crowdsourcing process and improving the way data is retrieved and consolidated. This project uses computer vision methods to mine and process images from AstroBin, a website where amateur and professional astronomers can share their observations. Because of the quality and quanitity of the data, it may be possible to create reconstructions of solar system objects for crowdsourced data analysis.

Methods

Using the AstroBin API, we search for images with titles or descriptions containing "jupiter" and download the resulting 7,872 images. We take a structure-from-motion (SfM) approach to analyzing and combining the images[1]. Typical SfM techniques work by detecting defining structural characteristics (e.g. edges) and matching them to other images in the dataset. By observing how the images are transformed relative to one another, a reconstruction of the original object can be made. Feature detection and matching is run on the images[2], then a sparse scene reconstruction is created by modeling camera viewpoints that are best suited for each image in 3D space[3]. Once the sparse reconstruction is complete, a dense point cloud reconstruction can be created by projecting the sparse reconstruction's features onto one another in space[4,5]. We then take the dense 3D point cloud and convert it to a 3D mesh. We can re-project the original textures from the images onto this 3D mesh to create a visual 3D model of our object.

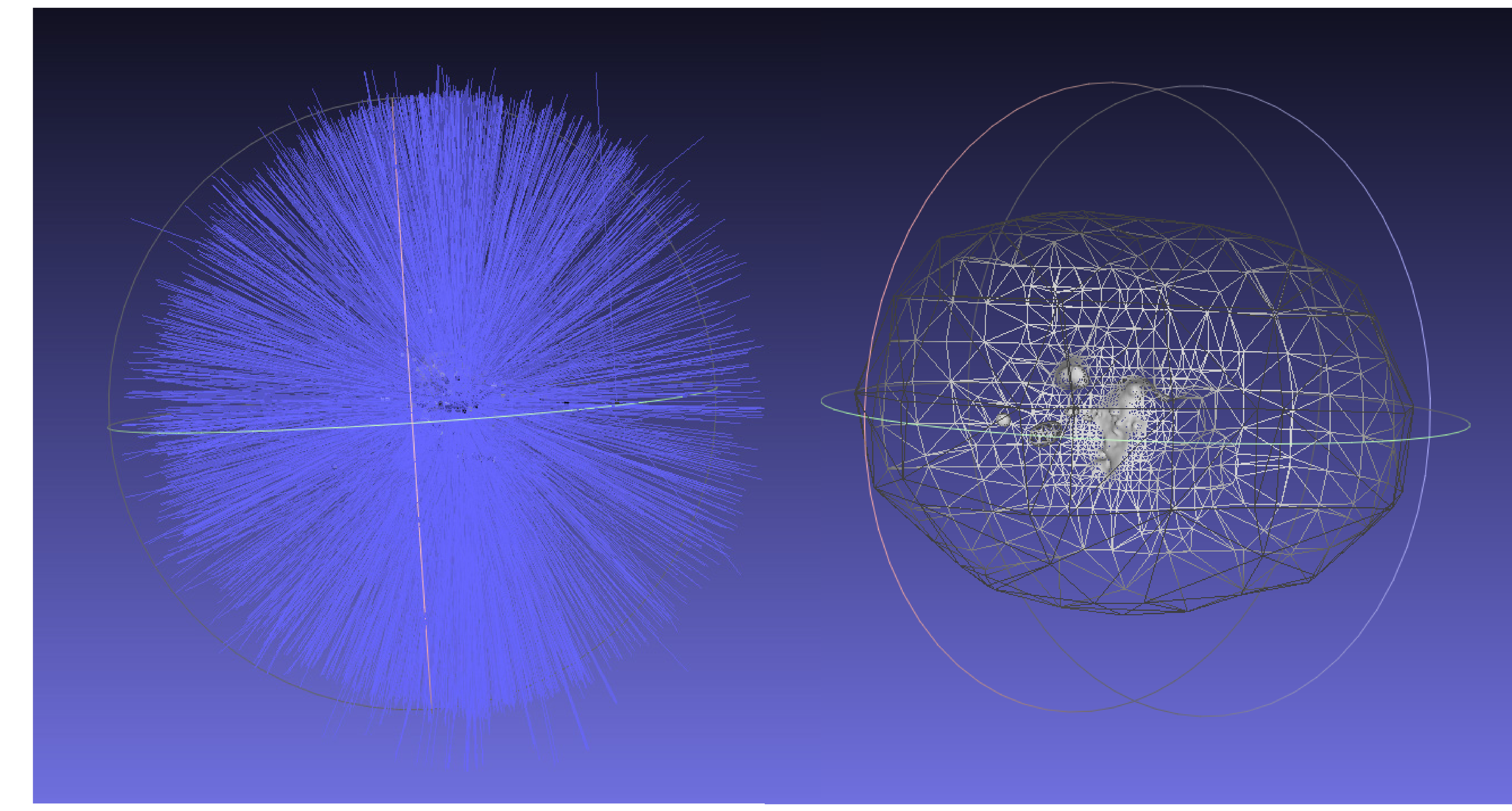

Figure 2 A point cloud reconstruction with normal vectors attached to each point (left), and its resulting mesh reconstruction (right). The spherical shape of Jupiter from the projected images is evident, but the shape of the mesh is imperfect. The equatorial angles of Jupiter for which we can clearly detect features are favored. Other more computationally expensive SfM methods may yield better results.

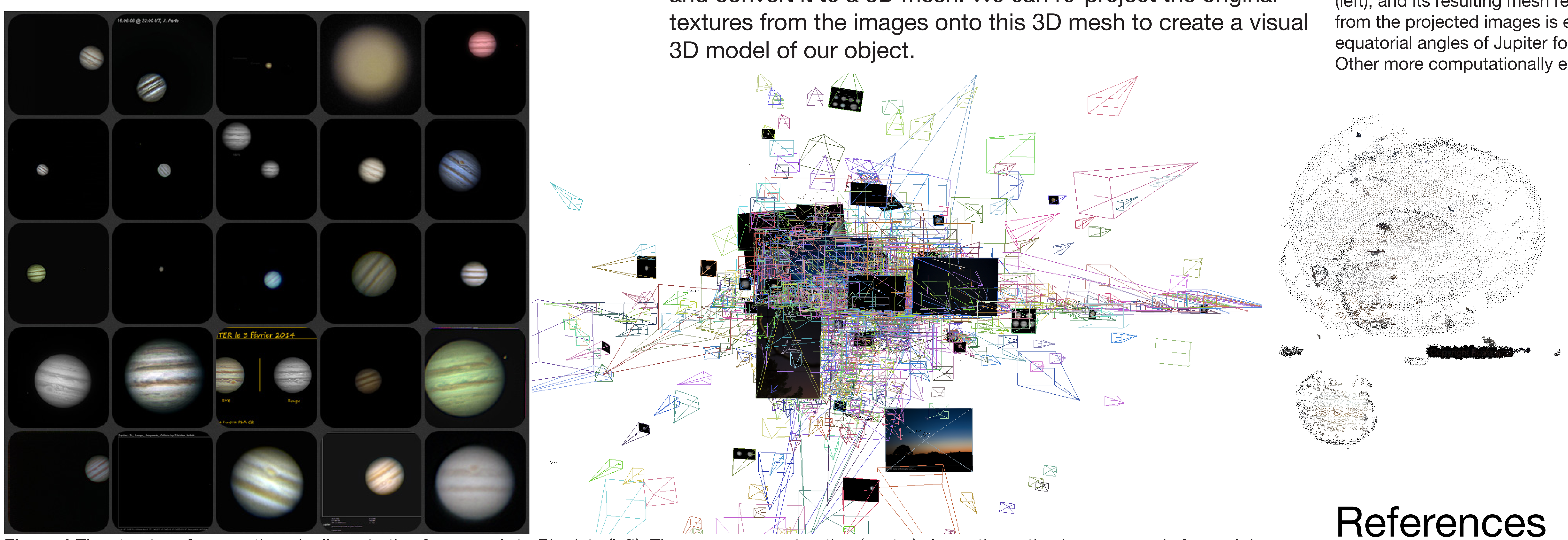

Figure 1 The structure-from-motion pipeline, starting from raw AstroBin data (left). The sparse reconstruction (center) shows the optimal camera angle for each image based on the key features identified in the model. The dense reconstruction (right) combines and projects points from these images to recreate the scene of Jupiter.

animated figures

Results and Discussion

We have successfuly reconstructed a 3D mesh model of Jupiter only using images crowdsourced from AstroBin. This reconstruction was done in a few days on a typical laptop using basic structure-from-motion methods. With newer SfM methods and more powerful computing resources, more complete reconstructions and 3D mesh models can be generated. This analysis only takes spatial information into account. With enough images and the inclusion of timestamps from image metadata, it may be possible to perform time series analysis on the data after placing it into the structure[6]. Potential applications could range from simple time-lapse videos to transient object detection. Though this project relies solely on data from AstroBin, the methods used can be applied to a more general dataset of solar system objects from many online sources. As computer vision methods continue to improve, crowdsourced images may become a more valuable source of scientific data.

References

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