OFFICIAL ABSTRACT and CERTIFICATION

Astronomy Will Not Trail Off: Novel Methods for Removing Satellite Trails From Celestial Images

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SpaceX's Starlink satellite network promises world-wide high-speed internet access. With up to 42,000 satellites to be deployed (Bowler, 2019), however, the Starlink satellite network will significantly degrade ground-based astronomical research and imaging due to trails (e.g., light reflections or emissions) from passing satellites. Removing satellite trail effects on night sky images is difficult because accurately identifying satellite trails is challenging, and satellite trails effect not only the brightness measurements of stars they pass in front of but also the brightness measurements of stars in the vicinity of the satellite trails. No known solution previously existed. Novel algorithms were developed and coded to accurately identify and remove satellite trails and their effects on photometry. An inventive approach was developed that implements platesolving to identify stars within an image, and an algorithm to determine the radius of each star identified. Identified star brightnesses are replaced with median image brightness values. Satellite trails are identified by examining each possible line traversing the image, with recursive sizing, using area interpolation, implemented for large images to reduce processing time. Area and/or cubic-spline interpolation is employed to optimize satellite trail modeling to within a tenth of a pixel. A Gaussian brightness profile is developed for the satellite trail to account for satellite trail effects across the entire image. The code returns original star brightnesses to the image and the satellite trail is removed by applying the additive inverse of the fitted Gaussian to every pixel in the image. Significant reductions in the effects of satellite trails on images captured using Earth-based equipment are observed while maintaining image photometric accuracy. Additional novel solutions for preserving star brightness directly under the satellite trails are explored, as is application of deep learning for satellite trail identification. The novel satellite-trail-removal methods not only salvage astrophotography images that otherwise would have been ruined by satellite trails but also preserve these images for astronomical research, effectively increasing the productivity of astronomical equipment and reducing research costs.

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