Shape Estimation Through Lightcurve Analysis and Exploration Orbit Design by Reinforcement Learning for 1777 Gehrels

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This study proposes a methodology to characterize asteroid 1777 Gehrels through its light curve and to derive an exploration orbit using reinforcement learning. A total of 120 images were collected using the one-meter telescope at the Deokheung Optical Astronomy Observatory of the Korean National Youth Space Center. After preprocessing, a light curve for asteroid 1777 Gehrels was generated, revealing a rotation period of approximately 170 minutes. An asteroid model predicted from the light curve was created using a 3D printer. By measuring illuminance while rotating the printed models, light curves were obtained, and the asteroid's shape was estimated by comparing these curves with Gehrels' light curve. Among the models evaluated using the Pearson correlation coefficient, the Gehrels 3 model exhibited the highest agreement when rotated at an axis of 0°. Furthermore, reinforcement learning was applied to derive the probe's orbit, utilizing the PPO and SAC algorithms from the ML Agent package within the Unity environment. By simulating the revolution and gravity of solar system objects, the learning graph analysis revealed that the SAC algorithm performed better than the PPO algorithm for orbit derivation. This study demonstrates a novel approach for determining the optimal orbit of an asteroid probe using reinforcement learning.

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