The Fast and Inconspicuous: New Near Earth Asteroids Discovered Using Deep Learning and Synthetic Data Are Fainter and Move Faster than Those Previously Discovered

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Asteroid collisions pose a significant danger to Earth. For instance, the Chelyabinsk meteor of 2013 led to ~1500 injuries. NASA's goal was to find 90% of city-annihilating asteroids larger than 140 m by 2020, but we've only detected ~30% so far. For smaller asteroids (19 - 44 m diameter, Chelyabinsk was 19 m) the detection completeness is only 0.1%. The reason we have dismal detection rates is because observatories have difficulty detecting fast moving asteroids (FMAs) that move faster than 5°/day. Small asteroids are only visible when they are near Earth, and when they are close they move very quickly relative to Earth, becoming FMAs and leading to many missed detections. Leveraging data from the Zwicky Transient Facility (ZTF), I trained a neural network to detect "streaks" created by FMAs. It attains an accuracy of 99.8% and a false positive rate of 0.02%. Using just four nights of public ZTF data, I have found six previously undiscovered asteroids and many new detections of previously discovered asteroids. With visual magnitudes from 19.0-20.3 and motion rates from 6.8-24°/day, these undiscovered asteroid detections have higher motion rates than most asteroid detections and are fainter than most FMA detections. My discoveries are also very small (~1-51 m diameter) and close to Earth (~5-60 lunar distances away). I am able to detect extremely faint FMAs because my method uses a synthetic dataset targeting faint streaks. Faint asteroid streaks correspond to small asteroids that are closer to Earth, which are the ones that are the most elusive, and by targeting them with a synthetic dataset I can more effectively detect them. Because I only use synthetic data, my approach can be applied to any observatory to substantially improve the detection of asteroid streaks.

Awards Won:
First Award of $5,000
Peggy Scripps Award for Science Communication
Office of Naval Research on behalf of the United States Navy and Marine Corps: The Chief of Naval Research Scholarship Award of $15,000