



Reconstruction of the satellites' trajectories using the "Pi of the Sky" data

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The "Pi of the Sky" project focuses on searching for short optical transients of astronomical origin, fixed on detecting flashes accompanying Gamma Ray Burst (GRB). The experiment uses fully automated telescopes, based in Chile and Spain (objects are visible almost the whole time), with wide field of view (80×80 degrees) and fast aligning system (able to discover phenomena and acquiring data from the very beginning).

Our main goal is to analyze the "Pi of the Sky" data, focusing on satellites tracks around the Earth. There are hundreds of them, which are identified and erased on a daily basis in order to distinguish GRB occurrence. However, those short-time phenomena are excellent to study. It is possible to reconstruct satellite's orbits, and to anticipate their movement in the future. The telescopes program is closely related to the Space Debris problem (i.e. space-floating artificial debris) therefore crucial for monitoring and forecasting their positions.

An algorithm is proposed for calculating satellites' trajectories using photographs (FITS format) with 10 s exposure time. The theoretical model, describing satellite trajectory is applied. It uses two-dimensional normal distribution, expanded in satellite movement direction, which is fitted to the data with Levenberg-Marquardt (L-M) method. Satellites' coordinates in the sky were calculated using a series of images (distinction from GRB), then their orbital elements were reconstructed. Estimation of uncertainty is crucial for such problem - for a given position, the uncertainty fell below 0.1 pixel (above expectations). It was calculated with statistical uncertainty of L-M method and compared to the outcomes of generated image with hundreds artificial satellites. The calculated orbital elements uncertainties were below 0.1%.

Our method can track satellites up to approximately 33,000 km radius (sufficient track length on photo) and can be used for any FITS data. The whole project can be improved in the future (satellite identification, monitoring Space Debris). The method can also be used in meteor track research (the same shape on photo).