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Discovering faint celestial objects by means of low aperture telescopes

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Monitoring and detecting the asteroids, comets and meteoroids, approaching the Earth's orbit, is a high priority problem in the field of asteroid-comet hazards for our civilization. Currently this problem is being solved mainly by means of the automatic telescopes, which scan the most part of the sky. Building and operating such expensive devices in Ukraine is not being planned in the near future.

However, the majority of circumterrestrial space monitoring problems can be solved using low aperture telescopes, equipped with modern receivers, computing program equipment and data processing technologies.

The method of discovering low contrast moving objects by means of signal accumulation along possible trajectories of their motion is suggested to be used as the technology for processing data of faint celestial objects' observations.

Signal accumulation along possible trajectories of motion is realized by means of multivalue transformation of objects' coordinates, which allows multistage realization. Multivalue transformation allows to accumulate signals along all possible trajectories of space objects' motion. Physically observed field of space, in accordance with the established model of motion is being split into intersecting space-time domains (space domains, moving from frame to frame) in a way, that the object wouldn't leave one of them during the detection period. An accumulator is assigned to each domain, and the signals of celestial objects are being accumulated in all the accumulators of the domains, to which they belong. During realization of the method the model of rectilinear and uniform motion of the object in plane is being used as a model of object's apparent motion.

At the first stage certain trajectories are united into classes (all the trajectories corresponding to one straight line belong to one class), and respective space domains are being researched. When making a decision as for possible presence of celestial object in one of the researched straight lines the second stage is being used — namely, research of time-space domains belonging to the particular straight line. Such or similar to such calculation scheme of data processing ensures practical realization of the method.

In the optical band the Method of Trajectory Signal Accumulation (MTSA) was realized as a software for processing of CCD observations, obtained with optical telescopes. Input data for the software are CCD frames containing images of stars and moving space objects; star catalogue; work parameters of the telescope and CCD camera. The processing software provides the following functions:

- Deduction of additive and multiplicative noise components of the image;
- Extracting images of celestial objects by means of the method of matched filtering and dividing them into classes "Stars" and "Possible objects";
- Detecting objects on the basis of "Possible objects" class by means of MTSA at the multi-frame processing stage;
- Identification of star pattern on the frame and the data from star catalog, calculating rectangular and angular coordinates of objects.

Results of the method's approbation when observing celestial objects (CO) at low orbits are presented. The observations were carried out with the use of the telescope "Highspeed automatic complex", which belongs to Mykolayiv Astronomical Observatory research institute and also with the telescope of Andrushevskaya Astronomical Observatory. Researching results proved high efficiency of applying MTSA in the process of discovering asteroids and CO in various observation conditions.

It is found out, that when using the method the reliability of faint objects' detection with nonzero apparent motion becomes almost identical to the reliability of motionless objects' detection.