PROGRAMM OF AUTOMATIC ASTEROID SEARCH AND DETECTION ON SERIES OF CCD-IMAGES. V. E. Savanevich[1], A. M. Kozhukhov[2], A. B. Bryukhovetskiy[2], V. P. Vlasenko[2], E. N. Dikov[3], Yu. N. Ivashchenko[4], L. Elenin[5], [1]Kharkiv National University of Radioelectronics, 14 Lenin Av., 61166, Kharkiv, Ukraine (domsv1@rambler.ru), [2]National Centre of Space Devices Control and Test, 97419, Evpatoria – 19, AR Crimea, Ukraine, [3]Recearch and Design Institute of Micrography, 1/60 Parkhomenko Lane, 61046, Kharkiv, Ukraine, [4]Andrushivka Astronomical Observatory, 3-7 Observatorna Str., 13400, Andrushivka, Zhitomir reg., Ukraine, [5]Keldysh Institute of Applied Mathematics RAS, 4 Mius Sqr., 125047, Moscow, Russian Federation.

Introduction: Modern system of asteroids detection in one night take images of considerable sky area. The areas of such size can't be sufficiently processed using "blinking technique". Especially when we are talking about wide-field "fast" astrographs detecting simultaneously dozens of faint asteroids. One of the approaches dealing with this problem is implementation of automatic asteroids detection, visually controlling obtained information. The present report represents a program of asteroids detection and its first testing results.

Program description: The program input data is represented by series of CCD-images showing a part of celestial sphere and stellar catalog. The intraframe processing module checks defective pixels of CCD matrix; splitting frames for subseries with the basic frame detection; subseries frames combining with accumulation of signals coming from moving object, receiving superframes based on "areal approach" and digital smoothing filter application; preliminary selection of celestial objects' signals on superframes, based upon comparison with spatial convolution criteria of received flux (in the vicinity of image peak) with form of estimated signal. Then the module of intraframe processing evaluates coordinates and signals amplitudes on the superframes (marks formation) based on tabulated samplings using model of noise photons' decline coordinates like flat substrate [1]; combination of superframes from same subseries received for different hypothetic velocities of objects' visible movement; evaluation of equatorial coordinates of objects using astrometric reduction with even reference stars selection and carrying out of iteration evaluation by least-squares method (LSM), rejecting abnormal observation on each iteration. Plus under the formation of weighting generic LSM matrix of measurement's errors, we also consider dependence of errors' value in evaluation of equatorial coordinates on visible objects' brightness level and their coordinates in CCD-frames coordinate system (CS) [2]. Obtained results are represented as set of marks. These marks include evaluation of estimated celestial objects' amplitude and equatorial coordinates, as well as evaluation of present objects' coordinates in CS of basic frame's CCD-matrix.

The objects, still on series of frames are rejected in module of inside catalogue of still objects' formation (inside catalogue).

Still objects' marks are identified with objects from stellar catalog in identification module, by resolving a problem (using Hungarian method) of setting on bigraph, one part of which represents frame's marks while another one - objects from star catalog.

The module of objects' visible brightness evaluation performs LSM factors' evaluation of double-band, piecewise-linear module representing dependence of visible asteroid brightness' value on its signal's amplitude, based on objects from inside catalogue, identified with stars; objects' visible brightness evaluation; formation of rejection criteria based on visible brightness. The launch of the present model is stimulated by the fact, that the application of linear single-band model of photometric scaling for a wide range of amplitude values reduces precision of visible brightness evaluation for small amplitudes (appropriate to the asteroids' signal), while the application of quadratic single-band model of photometric scaling doesn't increase the precision rate as well [3]. The module of rejection based on visible brightness preserves only marks with visible brightness evaluation that doesn't exceed the set rejection criteria.

In the module of preliminary paths indication the paths are discovered on the statistics accumulation basis proportional to the signal energy along the possible paths of the object motion. The present signal accumulation is provided due to implementation of multiple-valued transformation of object coordinates allowing multistage implementation. Multiple-valued transformation also allows accumulating signals along all the possible motion paths of celestial bodies. Valuation of apparent magnitude of the object is used as flux statistics. The collection of marks which belong to one object with nonzero apparent motion is formed in the result of module operation. Only those marks which were not rejected according to the valuation of apparent magnitude are used for it.

In the module of amplitude and coordinate detection the OLS-evaluation of parameters of the discovered paths is provided and the decision about paths formed by asteroids is made. Decision rule (DR) of asteroid detection on each frame chooses "the best"

mark for extension of the path. “The best” mark should have little deviation (kinematic constituent) from asteroid path, while the amplitude value of “the best” mark (valuation of the apparent brightness of the object relevant to the mark) should not be very different from the amplitude of the other marks which belong to the given path (amplitude constituent). Application of this amplitude constituent in DR is connected with big amplitude variation of signals from asteroids by rapid change of observation conditions within the time of observation.

Paths formed by asteroids are identified with the paths of the known asteroids in the identification module. Data about the known asteroids are received from the base of parameters of asteroid orbits or from the server of Minor Planet Center (MPC) with the help of the checker module.

In the visual control module the observer has the opportunity to make the final decision whether the path belongs to the asteroid or false-detection by using the blinking method. Data about detected asteroids are used to make the MPC-report. Observer sends the generated report with measurements to the MPC sever via email.

Results of the program operation. The program has been tested on the basis of Andrushivka Astronomical Observatory (telescope Zeiss-600 with the 0.6-m aperture, equipped with CCD-camera FLI PL09000) and also on the basis of the Russian remotely-operated observatory ISON-NM [4], located in the State of new-Mexico (USA) (astrograph Astroworks Centurion-18 with the 0.45-m aperture , equipped with CCD-camera FLI ML09000-65). 25 new asteroids were discovered by Andrushivka Astronomical Observatory during the experiment from May till December 2010 [5]. Application of the program in the ISON-NM Observatory has greatly increased the quantity of discovered asteroids [6], within the period of December 1-26 74 new asteroids were discovered [5].

On December 10, 2010 with the help of the program the comet C/2010 X1 (Elenin) has been discovered [7 – 9]. It became the first comet discovered by the Russian astronomer since 1990 [10].

References: [1] Savanevich V. E. et. al. (2010) *Radiotekhnika* 162, 78 – 86. [2] Savanevich V. E. et. al. (2010) *Syst. Obr. Inf,* 87, 172 – 179. [3] Savanevich V. E. et. al. (2010) *Syst. Upr., Nav. Zv’yazku,* 15, 46 – 50. [4] http://spaceobs.org/ru. [5] MPC 70135 – 70574; MPC 71009 – 71492; MPC 71493–71888; MPC 71889 – 72344; MPC 72345 – 72992; MPS 358671-362682; MPS 362683-362940. [6] http://spaceobs.org/ru/2010/12/06/100-asteroid-observatorii-ison-nm/. [7] http://spaceobs.org/en/2010/12/13/c2010-x1-elenin-wj08b04/. [8] MPEC 2010-X101: COMET C/2010 X1 (ELENIN). [9] IAU Electronic Telegram №2584, CBAT, 2010. [10] http://www.gazeta.ru/news/science/2010/12/13/n_1614225.shtml.