THE DATABASE OF THE NIKOLAEV ASTRONOMICAL OBSERVATORY AS A UNIT OF AN INTERNATIONAL VIRTUAL OBSERVATORY

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Results of the development and organization of the digital database of the Nikolaev Astronomical Observatory (NAO) are presented. At present, three telescopes are connected to the local area network of NAO. All the data obtained, and results of data processing are entered into the common database of NAO. The daily average volume of new astronomical information obtained from the CCD instruments ranges from 300 MB up to 2 GB, depending on the purposes and conditions of observations. The overwhelming majority of the data are stored in the FITS format. Development and further improvement of storage standards, procedures of data handling and data processing are being carried out. It is planned to create an astronomical web portal with the possibility to have interactive access to databases and telescopes. In the future, this resource may become a part of an international virtual observatory. There are the prototypes of search tools with the use of PHP and MySQL. Efforts for getting more links to the Internet are being made.

INTRODUCTION

Development of the digital database of NAO was begun after the appearance of a local area network (LAN) in the beginning of the 1990s. The LAN consisted of several computers and was located in one building; the Axial Meridian Circle (AMC) was connected in 1995. The top speed of information exchange in 1995 was about 0.5 Mbit/s. Length of the network was not more than 200 m. The database included the astrometric catalogues existing at that moment and CCD observations obtained with the AMC [1, 2].

The LAN has considerably grown up and today unites more than 30 computers installed in four separate buildings including two dedicated servers and three telescopes. The top speed of information exchange is equal to 100 Mbit/s. The total volume of information obtained during CCD observations in NAO together with the results of data processing is near 90 GB. The total volume of information obtained from other sources such as astronomical catalogues is near 25 GB.

DEVELOPMENT OF THE NAO NETWORK AND OBTAINING OF THE OBSERVANT INFORMATION

As it was already mentioned, the development of the LAN in NAO started at the beginning of the 1990s to support an upgrading of the AMC [1, 2] and to start regular observations (Tables 1, 2). In the beginning of 2001, the first dedicated server which played a role of the file and proxy-server was installed to provide access to the Internet for users in NAO.

The extension of the LAN is shown in Table 1. The quantity of operations executed by using a common data access to documents and programs has grown up considerably. Volume of this exchange information is approx. 18 GB and increases with a rate of about 100–200 MB per week. Growth of data volumes containing CCD observations is shown in Fig. 1 and in more details in Fig. 2.

The AMC has observed in 1995–1998 using a drift scan method with a frame size of 275×1300 pixel ($8' \div 60'$). Since 2002 observations were performed with frame sizes of 1040×7000, 1040×13000 and since 2004 – with a frame size of 1040×20000 ($0.45° \times 2.8°$, $\times 5°$, $\times 8°$).

The Multi Channel Telescope (MCT) (called till 2002 the Zonal Astrograph) has observed since 1999 in a stare mode with a frame size of 1040×1160 pixel ($0.5° \times 0.5°$), and since 2002 also in a drift scan mode with the frame sizes of 1040×2000 and 1040×4000.

The CCD observations in zones around extragalactic radio sources within the program on the determination of angles between optical and radio coordinate systems [3–5] were obtained at observatories in Turkey and China in the cooperation with NAO. The majority of frames has a frame size of 1K×1K, 1.5K×1K, and 2K×2K.

Table 1. Development of the NAO network

Year	Parameters of network			Number of on-line devices		
	Type	Cable	Speed, Mbit/s	Server	PC	Telescope
1993	Peer-to-peer/Bus	Coaxial	1	0	3	0
1995	Peer-to-peer/Bus	Coaxial	1	0	4	1
1997	Bus	Coaxial	10	1	8	1
1999	Bus	Coaxial	10	1	12	2
2001	Bus	Coaxial	10	2	19	2
2002	Bus	Coaxial	10	2	24	2
2003	Star/Bus	Twisted Pair/ Coaxial	10/100	3	25	2
2004	Star/Bus	Twisted Pair/Coaxial	10/100	4	28	3

Table 2. Telescopes in the NAO network

Name	Connection to LAN	Limited Mag	CCD Size	Stare Mode	Drift Scan	*FOV*
AMC	1995	$\tau = 60^s$, 15.5^m	1040×1160	–	1040 × 20000	$24' \times 450'$
MCT	1999	$\tau = 120^s$, 15.0^m	1040×1160	+	1040 × 8000	$28' \times 30'$
FRT	2004	$\tau = 120^s$, 18.0^m	1040×1160	+	1040 × 8000	$40' \times 40'$

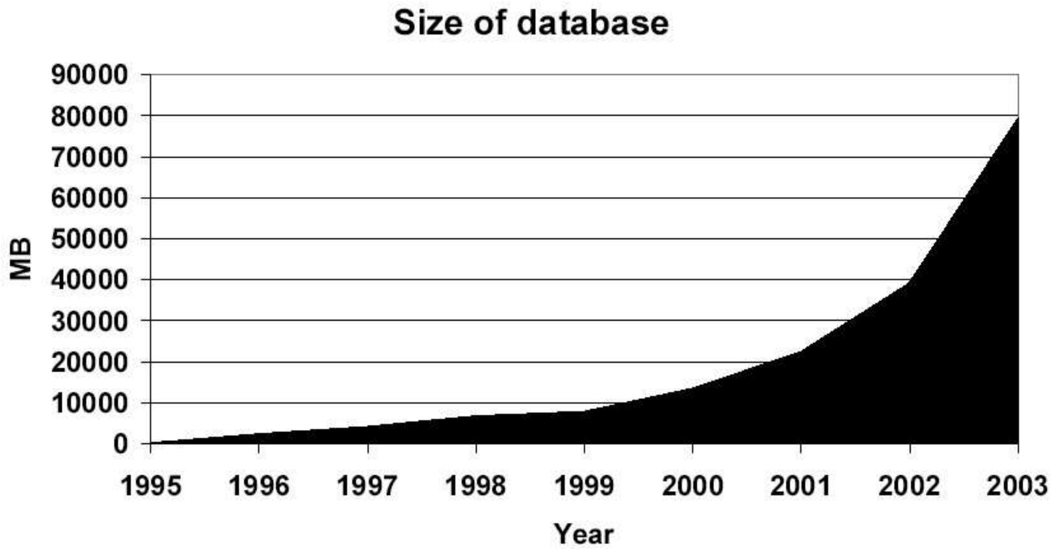

Figure 1. The growth of volumes of the observation information in the database of NAO

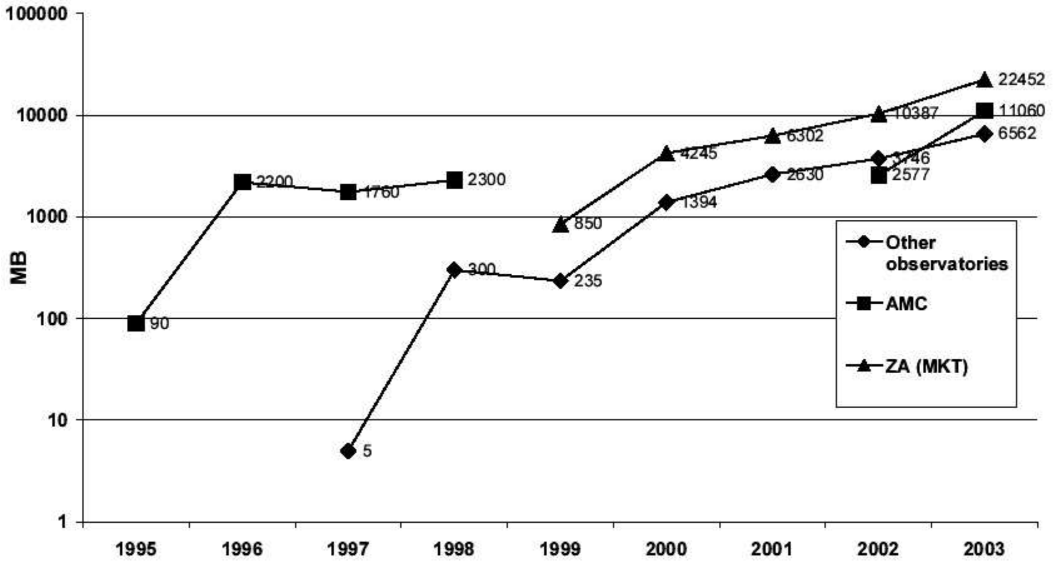

Figure 2. Receiving of the observation information in the database of NAO in 1995–2003

ON-LINE PROCESSING OF THE DATA

The CCD observations obtained at the telescopes of NAO and other cooperating observatories have been processed in an automatic and semi-automatic mode to determine coordinates of observed stars, minor planets, and other objects starting from 1996.

Initial data processing includes [6, 7]:

- automatic account of features of telescope such as dark signal, non-uniformity of sensitivity of pixels, bad pixels for a stare mode, bad columns for a drift scan mode;
- automatic digital filtering of CCD frames by an individual filter set for each telescope;
- semi-automatic identification of objects using initial binding of a frame to the catalogue;
- automatic detection of coordinates of objects in a CCD matrix coordinate system.

Time duration of the initial data processing of one night of observations, in dependence on a data volume and sizes of the CCD frames, ranges from 1 to 6 hours. From 50% up to 70% of time takes the process of the identification. Time of other stages of data processing can be reduced due to the growth of computational capabilities of modern computers. Determination of angular coordinates of observed objects are made by using various methods and programs.

To decrease a period from observations to final results, the program for a completely automatic identification of observed objects was developed and tested. It permits to eliminate humans from the process of initial data processing and by that to boost a speed rate of data handling.

STRUCTURE OF THE DATABASE

All data obtained during last two years are stored in servers in two copies, namely, a working and a backup one. We save twice observational data on compact discs as archives. One copy is available for users. The second one is stored in the central storage of NAO. The overwhelming majority of the data obtained after 1998 is stored in FITS format, before that the data were written in RAW format.

CCD observations from other observatories recorded on compact discs we receive by post or handing. The Internet resource of NAO (near 33.6 Kbit/s) existing before September 2004 did not allow us to carry out a fast transmission of large volumes of data of observations.

Also, the database (DB) of NAO includes results of observational data processing as the extended information on all star-shaped objects captured on CCD frames. For the identification of objects we use various catalogues. The most popular catalogues are UCAC2, USNO-B1, USNO-A2.0, and Tycho-2.

Special databases for navigation and finding the necessary objects or areas on the sky are created. These databases contain the CCD observations and structure of the glass library of NAO, which contains more than 9 000 photographic plates. There are the search tools which use PHP and MySQL. Access via the Internet for other users will be created in this year.

The database includes the observational data obtained by the permanent GPS station "MIKL" and the data of ionosphere soundings since 2002. The database is updated every five minutes (Fig. 3) [8] [http://www.mao.nikolaev.ua/rus/ion_r.html] or [http://www.mao.nikolaev.ua/eng/iono.html].

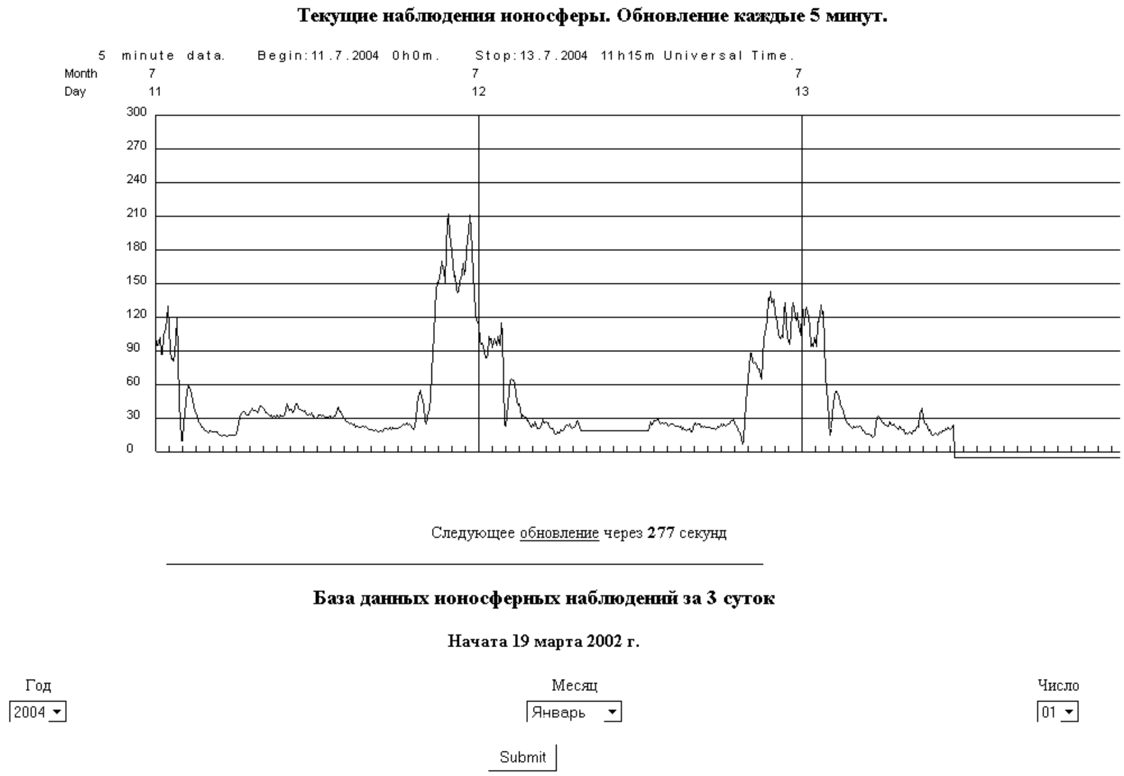

Figure 3. The ionosphere sounding database

In 2004, we began to develop an on-line database of coordinates and orbits of artificial satellites using our own observations.

Also in 2004, work on digitization of the glass library of NAO with aid of the scanner EPSON Perfection 3200 was started. Plates with geometrical size of up to 24 cm $\times$ 24 cm and FOV $5^\circ \times 5^\circ$ are used. The size of an scanned image file with 1200DPI resolution is about 50 MB. An instrumental accuracy in this mode is about $0.15''$ in direction of the CCD ruler and about $0.30''$ in direction of the carriage. Accuracy of single determination of $(O-C)_{\alpha,\delta}$ is $0.21'' \times (m-7)^{0.23}$.

PERSPECTIVES OF DEVELOPMENT OF THE DATABASE OF NAO

Taking into account the tendency on a worldwide scale and resolution of the XXV IAU GA on extension of cooperation by developing the International Virtual Observatory Alliance (IVOA), it is planned to create on the basis of the general astronomical database an information resource of astronomical character with the possibility of interactive access to databases and telescopes of NAO. This resource may become a part of the IVOA and provide the extended possibilities of work with cooperating observatories. NAO like many observatories in the former USSR takes part in the DB of the regional Russian virtual observatory.

However, a modern server is to be installed to make sure the operation of the NAO database. The volume of the database is increasing exponentially (Fig. 1). Efforts on the extension of the Internet access up to 2 Mbit/s are carried out. At present, the rate of 33.6 Kbit/s is enough only for work of up to 5–6 persons simultaneously without any transfer of significant information. In this year, we are going to open a new wide channel with access to the Internet. We hope to raise our productivity by developing of astronomical databases and to integrate our databases in IVOA.

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