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Large telescopes & Virtual Observatory: vision for the future

Virtual consolidation of observatories and universities resources by means of world virtual observatory organization

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Introduction

Today the successes in development of computers, telecommunication and virtual world architecture permit to unite the distribution resource and to give the distant access to astronomical telescopes and data bases for scientific research and education. We ivestigate the seven blocks model of virtual organization for consolidation resources. This model consists of the next blocks:

1. Population- scientists, students, robots and agents. 2. Aspiration of population groups. 3. Territory. 4. Production. 5. Ecology and safety. 6. Finance.
7. External relations - input and output flows of population, information, resources.

The world virtual observatory is the virtual world, which structure consists of the three groups variables - appearances, essences and structured uncertainty, which defines the number and destribution of arbitrary coefficients in equivalent equations (see Table 1). The consolidation of resources permits to create the large telescopes with distributed structure on our planet and cosmos. Virtual instruments can have the best characteristics by means of collective effects [8].

However very important in this process is the role of ground-based and space of new generation of observational techniques with wider possibilities; use of standards in recording, processing and storing of observational data; use of mobile telescopes, differential methods of measurements. The latest technical achievements are used to equip modern ground-based telescopes with CCD sensors of high sensitivity; computer control of observations; reduction and storage of observational data with high-effective computing means; access to information networks etc.

The CCD imagers and digital CCD cameras designed and manufactured for the equipping of the modern astronomical telescopes and scientific instruments are described.

1. We use the seven block structure of virtual world /R.1,2/, which consists from next blocks:

1) Population - astronomers, professors, students and its agents in virtual world,
2) Passionarity - the intentions of astronomers, professors, students and its agents,

3) Territory - the virtual space, which consist on distribution astronomical and astrophysical instruments and data bases,
4) Production - the process of observations and investigations,
5) Ecology and safety,
6) Finance,
7) External relations of our virtual world with go in and go out flows of peoples, agents, finance, information and another resource; communication between different virtual worlds and real worlds.

According to the linguistical combinatorial method of simulation /R 3,4,5/ we can create the general equation for description of our virtual world

A1*E1+A2*E2+A3*E3+A4*E4+A5*E5+A6*E6+A7*E7 = 0 (1)

where:
A1 - characteristic of population of virtual world, E1 - change of this characteristic,
A2 - characteristic of passionarity of virtual world, E2 - change of this characteristic,
A3 - characteristic of territory of virtual world, E3 - change of this characteristic,
A4 characteristic of production of virtual world, E4 - change of this characteristic,
A5 - characteristic of ecology of virtual world, E5 - change of this characteristic,
A6 - characteristic of finance of virtual world, E6 - change of this characteristic,
A7 - characteristic of external relation of virtual worlds, E7 - change of this.

The next step of our analysis is the resolution relatively E variablies, which can be the derivatives from A,

E1= U1*A2+ U2*A3+ U3*A4+ U4*A5+ U5*A6+ U6*A7
E2= -U1*A1+ U7*A3+ U8*A4+ U9*A5+ U10*A6+ U11*A7
E3= -U2*A1-U7*A2+ U12*A4+ U13*A5+ U14*A6+ U15*A7
E4= -U3*A1-U8*A2-U12*A3+ U16*A5+ U17*A6+ U18*A7 (2)
E5= -U4*A1-U9*A2-U13*A3-U16*A4+ U19*A6+ U20*A7
E6= -U5*A1-U10*A2-U14*A3-U17*A4-U19*A6+ U21*A7
E7= -U6*A1-U11*A2-U15*A3-U18*A4-U20*A5-U21*A6

where U1,U2,...,U21 - arbitrary coefficients, which can use for organization of different movements on manifold (1) for decision of different task in virtual world.

Equations (2) describe the full combinations of interaction in our virtual world. Each principal (investigator, professor, student) of virtual world can have the agent, which must help its principal. The creation of agents increase the effectiveness of using astronomical and astrophysical instruments and data bases. On fig.1 we show the interaction between the scientific organizations (university, observatory 1,…, university, observatory N) and Virtual world of Astronomy – Global computer model for decision making support.

2. Both telescope parameters and registration methods play an important role for the expansion of the range of artificial and natural observed objects in the near-Earth and deep space, in particular for those with low intensity in the optical spectral band.

At present the majority of astrophysical and astronomical telescopes are equipped with the CCD image sensors. Array photosensitive CCD (Charge Coupled Device) offer significant advantages: the observation of faint celestial objects in a varied registration modes, large dynamic range, the capability to digitize the output signal – all these CCD features provide the possibility to use different data processing techniques and, as a result, improve the effectiveness and accuracy.

2.1. St-Petersburg "Electron-Optronic" Research & Production Company currently designs and manufactures more than 10 CCD models (Fig.1) of different types for UV-VIS-near IR spectral bands (0,2 μm…5,5 μm) /6,7/.
The class of the virtual phase CCDs, traditional for the company production line, includes 7 CCD models with the formats from 386×298 to 1225×1300 pixels. They have full-frame or frame transfer organization and are made with the help of two-phase polysilicon technology in the image section. These devices feature high UV (up to 25 %@250 nm) and overall (up to 65% at maximum) quantum efficiency (QE), low PRNU (Photo-Response Non-Uniformity (1,5%...3 %), and low readout noise figures (8-10 electrons rms at 1 MHz readout rate). For the ISD-017AP CCD the readout rate of less than 4 electrons at 50 KHz has been achieved.
Three-phase polysilicon CCDs are presented by two devices with 512×512 and 1024×1024 formats. These devices have the fiber-optic input window and are intended for the direct coupling with the output screen of the image intensifier tube. The 512×512 has frame-transfer architecture, 22×22 μm^2 pixel, QE up to 45% at 600 nm, 500× antiblooming, full well of 350000÷400000 electrons.
All CCD are available both in noncooled version and in Peltier-cooled one in gas-filled vacuum-tight housings.
The company carries on the R&D works on thinned CCD for the operation in electron-bombarded mode (EBCCD). EBCCDs of 520×580 and of 1024×1024 formats are available.
For the mid-IR imaging in 3-5,5 μm spectral band the interline Schottky-barrier CCDs with 256×290 and 480×320 pixels are available.

2.2. In the field of the slow-scan digital CCD cameras the camera of new generation – 14-bit compact CCD camera of monoblock design S1C – has been developed and is manufactured in small lots. This model features dual-mode (draft and fine) readout, varied CCD exposure time (within 1ms…3000s range) and wide variety of image pre-processing built-in functions.
The specific of the S1C series is all-digital video signal processing (CDS, black-level restoration, etc.). Camera operation and signal display are controlled with the help of PC. The camera design comprises the monoblock (100×80×90 mm) with remote power supply unit. The basic interface to PC is serial, the distance to PC is up to 15 m in a standard version and up to 200 m with the fiber-optic interface cable. The specialized PCI adapter used to connect the camera with PC allows real-time image displaying.
Main performance characteristics of the S1C camera series you can on Fig.1.
All cameras of the S1C series can be easily configured for the different applications – the choice of the image formats and CCD operation regimes (clock diagrams, operating voltages levels, exposure time), as well as built-in functions of the image pre-processing can be controlled from the PC on-the-fly. Besides the basic set-up parameters can be written into the camera by default.
The cameras are implemented on the base of the 14-bit ADC of "Analog Devices" and reprogrammable logic of "Altera". The built-in microcontroller of "Atmel" serves to control all camera modes of operation. The image processing is all-digital.

Software is running under Windows® 9x/200/XP and provides:

Control of the camera operation parameters
Displaying of the image on the PC monitor (with adjustable zoom, brightness, contrast and gamma)
Saving of the images on the PC HDD
Image pre-processing functions: -dark field correction; -flat-field correction; -smear correction; - defects correction; - digital AGC; - digital frame integration; - construction of sections and hystograms; - low level DLL is available.
The new version of this CCD camera, 16-bit with CCD cooling down to-70^{o}C is under development at the moment.

3.3. There has been developed a low-cost digital CCD camera on the base of the Peltier-cooled ICX249AL (Sony, Japan) for the amateur astronomy (Fig.2). The CCD chip cooling down to -20^{o}C reduces the dark current drastically and together with the CCD antiblooming capability, allows the camera to have wide range of exposure times (256 µs…20 min). Original design of the housing allows to use two-stage Peltier-cooler which results in the temperature drop up to 60^{o}C between the CCD chip and the ambient (at Peltier-cooler consumption power of 5 to 7 W). CCD camera is especially effective when used to observe inactive and fixed objects under low-lighting levels. Main camera specifications is shoun on (Fig.2).

4.4. For the imaging in 2-5,5µm spectral band TVC200ML and TVC480ML thermovision CCD camera are manufactured. These cameras are based on the 256×290 or 480×320 Schottky-barrier IR CCD. The detector cooling is provided by refilled liquid nitrogen cryostat with the hold time from 6 to 32 hours. At present the IR CCD camera with the Stirling-type CCD cooler is under development (see(Fig.3).

Conclusion

Virtual worlds conception permit to unite the different astronomical and astrophisical resourses of different institutions and increase the educational and investigational potential of world community.
The performance level of the CCD devices and CCD cameras of "Electron-Optronic" evaluated according to the totality of the performance characteristics (accuracy, sensitivity, reliability, price, etc.), is competitive with the world analogues, which makes possible for the Russian and Ukrainian astronomers to participate in the advanced research projects in astrophysics, positional and near-Earth astronomy.
The scientific and technical cooperation between the manufacturer and astronomical observatories has proved its efficiency on a sample of different telescopes equipped with the advance CCD cameras.

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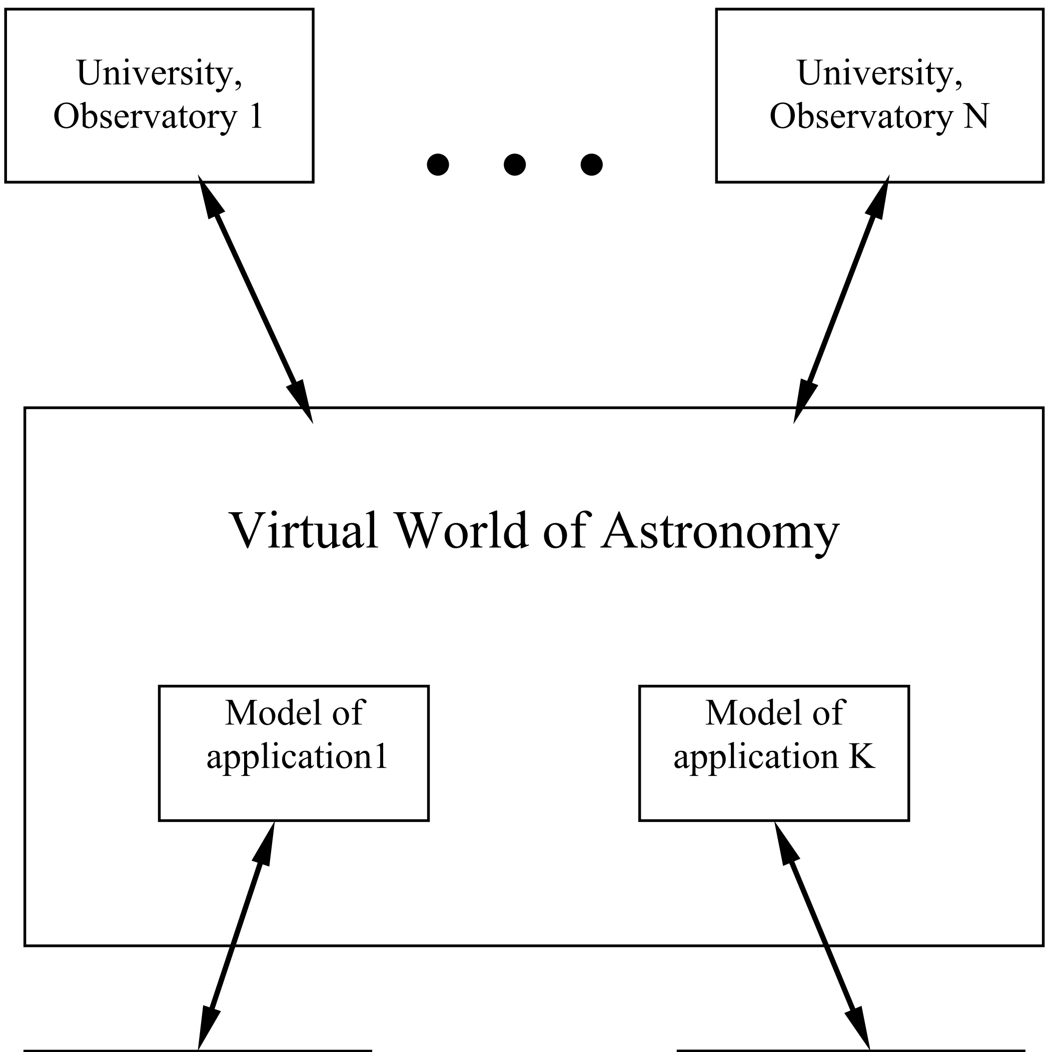

Fig.1. Interaction between scientific organization (university, observatory 1,... university, observatory N) and Virtual Word of Astronomy
Interaction between particular models of application 1,…K and users M,…L

	1	2	3	4	5	6	7	8
2	1							
3	3	1						
4	6	4	1					
5	10	10	5	1				
6	15	20	15	6	1			
7	21	35	35	21	7	1		
8	28	56	70	56	28	8	1	
9	36	84	126	126	84	36	9	1

Table 1. The number of Arbitrary Coefficients, on horizontal - the number of restrictions, on vertical - the number of variables in our system.