WILGA Symposium on Photonics Applications

Ryszard S. Romaniuk*

ISE, Faculty of Electronics and IT, Warsaw University of Technology

Received June 24, 2009; accepted June 24, 2009; published June 30, 2009

Abstract— WILGA09 work is presented. The symposium is co-organized by the Photonics Society of Poland, SPIE-Europe, WUT, IEEE, and KEiT PAS. There are presented Ph.D., M.Sc. theses and achievements of young researchers. The papers are a good digest of the condition of academic research in photonics. The subjects for theses in photonics are determined by the interest and capacity (financial, laboratory, intellectual) of the young researchers and their tutors. The following topical sessions were organized during WILGA: merging of photonics and electronics, photonic Internet engineering, distributed measurement systems, security in photonics based IT, astronomy and space technology, HEP experiments, image processing and biometry.

SPIE Polish Chapter and its continuator, the Photonics Society of Poland, have organized in cooperation with WUT, for more than a decade, an interdisciplinary Ph.D. student symposium, known as WILGA [1]. It is organized twice a year in January and May. The symposium has gathered together more than 3500 students. There were published more than 1500 research papers in more than 10 volumes of Proc. SPIE and several volumes of Electronics [2], ETQ PAS [3], MST IOP. WILGA is attended by Ph.D. students of technical universities in this country and from abroad (faculties of EE, IT, mechatronics, technical physics). WILGA features a student paper contest sponsored by SPIE.

WILGA Symposium on Photonics Applications has established a meaningful position on the domestic market of academic meetings. It is a pretext for young scientists to compare research work conditions in different parts of the country and abroad. In WILGA, there are conditions to undertake a more general discussion on the condition of particular disciplines of technical research and prospects of their development. The prospects are determined by financial conditions, application requirements, and a focused interest to develop a new technology. WILGA is a sensitive mirror showing the status of a certain segment of the 'young science' against the international background. This WILGA barometer shows precisely a lot of positive and negative processes in this domain. A period of strong reconstruction can be observed in the area of technical sciences in this country and internationally. The most gifted young people do not choose technical sciences as the subject and aim for their professional career.

*E-mail: rrom@ise.pw.edu.pl

A number of technical research branches are developing in an interdisciplinary way. This path concerns the realized Ph.D. theses from photonics and their applications, as well as from related disciplines. The neighboring disciplines start to overlap, giving rise and/or opening new research areas. One of such research areas, combining a number of subjects such as solid state physics, optics, mechanics and mechatronics, electronics, material engineering and chemistry is 'microsystems'. The 'research products' of this branch are such devices as MOEMS, SOC and LOC. Photonics plays a crucial role in microsystems, which finds its immediate reflection in WILGA papers. Nearly all of these devices cannot work without a multi-level software. The programming is combined with hardware, determining the functionality. The hardware is connected to the Internet. This justifies another name for WILGA, which is Photonics and Web Engineering.

An important branch of technology is the integration of mechanical, optical and electronic hardware and software. The basic theoretical and practical question is which functionalities to place in the photonic and electronic hardware and which in the software. The tendency in this domain is to position in the hardware, apart from the OS, only the resources needed for the hardware to operate: calculation power, memory and logics. The whole parameterized, configurable, flexible and scalable functionality is placed in the software of μPs: photonic (parallel image processing), general purpose (procedures), digital signal processing (floating points calculations), behavioral modeling (objects), and basic logics. Such an photonic/electronic node of a system, of a relevant processing power, adjusted to the application needs, is connected to a network by means of broadband wireless and/or optical fiber links. The node has TCP/IP and industrial I/O ports, optical analog and digital.

Several directions of the design development of advanced functional systems, serviced by photonics and electronics can be observed. Two of these were addressed in WILGA works. These concerned two separated poles of these application processes in photonics and electronics. On the one hand, a big number of very narrowly specialized, and economically tailored devices are designed, optimized for the usage of confined resources. This is clearly observed in cheap gadgets

which do not need any versatility but optimally fulfill the imposed tasks. On the other hand, the research interest concerns big systems of extended calculation potential. During the developmental stage of a large system, due to a fast decrease of unit costs of resources, the design of big photonic systems are frequently quite redundant. The nontrivial task of optimizing the usage of large calculation power pays for itself in the case of serial applications, which is rarely the case in academic research.

Photonics and IT

The increase in calculation resources of a complex photonic/electronic network system node and the increase in reliability is achieved without any excess costs. The rule for hardware cost reduction, with the introduction of a new generation of μPs, is valid not only for GPP, DSP, FPGA, μC chips but also for photonic ones. It includes also the unit costs of broadband communications between chips, PCBs and crates. This makes way for using in academic projects the components of much greater resources at nearly the same overall costs. The availability of increased resources allows to develop more ambitious projects at universities. WILGA covered subjects from this area including photonic IT systems.

Fiber and Laser Photonics

Optical fiber technology is the foundation of standardized, broadband, transport networks. This area is available for academic laboratories. R&D work is carried out in technical niches around optical fiber communications. An optical fiber network, with links stabilized thermally and mechanically, is a good medium for time, reference phase and frequency distribution systems. Such systems are a step towards building a technical infrastructure for optical clocks, or optical reference 'rules'. The aim is to build an optical clock system with the accuracy surpassing the atom clocks. An optical, ultra stable link for connection between two or more atom clocks is build by a team from AGH.

Active and sensory optical fibers and photonic materials are under development in several academic research centers in this country: BUT, UMCS, ITME, AGH, WUT. The interest in research in this area is caused by several factors: availability of instrumentation, non-telecom optical fibers, low price of fibers, mastering of optical circuits made of instrumentation fibers, and a large variety of specialty fibers. A broad range of fiber constructions has not yet been exhausted.

WILGA presentations in this area concerned capillaries. An integrated, photonic, chemical laboratory on optical capillary was constructed. Among the measurements made by this device, the following were presented: quality factors of milk, veterinary measurements in cows, food industry – quality of edible oils and alcohols, petrochemical industry – differentiation between motor oils and quality of petrol.

Laser technology is developed on the academic level in MUT, WUT and WrUT. The research teams from MUT and from IFPiLM participate in the European programs HIPER and ELI on laser infrastructures. Laboratories are building demonstrators of relevant laser technologies. The role of these costly projects is to train experts on the doctoral level and application research.

Communication and LAN

Research is carried out on passive, transparent optical networks PON and in the area of cost effective solutions with multimode optical fibers. A multimode optical fiber transmission with modal groups multiplexing was the subject of a recent lab experiment in WUT. The effective multiplexing factor was two or three on a distance of several hundred m.

Optical fiber CATV systems are very cost effective. They provide proper bandwidth with multimode fibers, transmission quality, and relevant transmission distance between numerous video signal sources and the video head station. R&D work is carried out on different analog and digital modulation methods and optimization of application solutions for various technical work conditions. Research results were presented on multichannel system using a multimode fiber working in the first window of 850nm. A video FM signal was transmitted outside the baseband of the fiber.

Internet Engineering

WILGA Symposium featured the topical session on different aspects of photonic Internet engineering. The Internet is a platform for the development of photonic access networks, including: networking, local and distributed measurement, telemetric, safety, multimedia, public, GPS localization, GIS data, urban traffic monitoring, and more. Internet engineering embraces a hardware layer and software layers. The latter consists of OSI model sub-layers.

Self-configuring, distributed measurement networks, integrated with the Internet and using GPS, GIS and sensors are predicted for natural environment monitoring. Miniature sensors, including photonic, communicate with the network backbone via wireless communications using SDR and RFID standards. There are imposed very rigid requirements concerning the power supply and power usage confinements. There are used low voltage electrets batteries with zero current supply or low-voltage micro nuclear ones with high current supply.

Astronomy and Space

The students at WUT interested in space technologies are organized in research clubs. One of these is Students Club of Space Engineering. There is cooperation of these groups with CBK PAS. The groups participate in

realization of international programs to build mini students satellites. A few of such satellites were launched to the Earth's orbit. Practical experiments were performed concerning the flight trajectory, dropping of parcels from the orbit, optical observations and measurements. The experiments required photonic -electronic measurement and control systems. They had to fulfill strict technical requirements to survive the space conditions of work.

The Mars Society announces each year the University Rover Challenge. This year's competition of Mars robots took place in a Utah desert. One of the rovers, called the Scarab, was from WUT and prepared by students in cooperation with PIAP. The rover consists of a versatile car with machine vision and a gripper. The obstacle race consists of a terrain path, taking probes of soil for analysis and helping a 'wounded astronaut'. Apart from mechanics, the key role in robot operation is played by photonic/electronic control and automation system. The development work on this rover was presented.

Students from WUT, WU and PAS take part in the realization of a project of wide angle optical observations of the whole sky - 'Pi-of-the-Sky' [5]. The aim is to detect optical flashes accompanying the GRB effects. During the research, it has turned out that the optical and electronic apparatus is suitable for other measurements like cataloguing of changing stars, observations of satellite paths, discovering meteorites and cataloguing space debris. The experiment has telescopes localized in a few places around the globe, among them in ESO in Chile. In March 2008, the Pi-of-the-Sky experiment observed one of the largest GRBs originating from the distance around 7 bln light years. The observation results were published in Nature. The students from WUT are participating in the design and construction of ultra-low-noise and cooled CCD cameras. WILGA had two 'space-tec' sessions.

Ph.D.Students from WUT cooperate with the MPS Institute. They participated in design, construction, testing and fabrication of an on-board, cosmic-grade version of a near infrared spectroscope SIR. This instrument was launched in an Indian space mission Chandrayaan-1. The satellite now circles around the Moon on a polar orbit. It makes precise spectral and geodesic measurements and mapping of the lunar surface. Another region of cooperation concerns matrix detectors for IR designed for cosmic conditions. These detectors, working in 0,8 – 2,5μm, are designed for the LEO space project.

Environment protection

There are realized research projects in WUT concerning measurements of the quality factors of surface water. The EU FP 6 and 7 research projects SEWING and WARMER gave practical results. A working technology demonstrator for water measurements is under final tests. The system is an advanced measurement network, including photonic technology, with data fusion and processing. The system measures typical polluted water parameters, like opacity, alkaline salts and heavy metal ions. The priority of these projects is to build cost effective automatic networking systems for warning against water pollution.

Image processing

One of the topical sessions in WILGA was devoted to image processing in theoretical, practical and computational aspects. Some aspects concerned the biometry –recognition and/or detection of a face, a palm of hand, an eye, etc. Ph.D. students from WUT presented a series of papers on the subject, creating a homogeneous picture of the development of this discipline of science and technology.

The research on automatic determination of pollen level is carried out in WUT. A three-year grant was realized in this subject. A measurement system was designed and constructed, consisting of the following parts: a device gathering pollen grains in a standardized way, a device for pollen microscopic image acquisition, multilevel software for image processing and pollen classification. The software classified pollen and calculated the number of pollen grains in each category. A decision was calculated for pollen levels. The system was shown to be also practical for measurements and classification of other defined air pollutants.

Radar Imaging

WILGA Symposium is a multi-conference event. Every two years Wilga has a partner conference on Radar Technology and Digital Signal Processing. The major subjects were: radar imaging, object identification and tracking, security.

FEL and Accelerator

Young researchers from WUT take part in large international experiments in the area of synchrotron radiation, high intensity and high power lasers, photon physics, elementary particle physics, accelerator science and technology, nuclear technology and space technology. The students of WUT spend fellowships in DESY at FLASH and E-XFEL lasers, in CERN at LHC accelerator and CMS detectors, in Fermilab at ILC accelerator, at ALBA synchrotron and in PSI. WILGA featured several sessions on the current results from these experiments. The construction of an E-XFEL clone is planned in Poland, on a smaller scale, under the name of POLFEL. Young experts from WUT are potentially the natural crew of a future POLFEL team.

References

[1] WILGA Symp. on Photonics Applications [wilga.ise.pw.edu.pl]
[2] Elektronika [elektronika.orf.pl]
[3] ETQ PAN [etq.tele.pw.edu.pl/index.php]
[4] Pi-of-the-Sky [grb.fuw.edu.pl/]

