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WILGA Photonics and Web Engineering January 2012

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ABSTRACT

The paper presents a digest of chosen technical work results shown by young researchers from technical universities during the SPIE-IEEE Wilga January 2012 Symposium on Photonics and Web Engineering. Topical tracks of the symposium embraced, among others, new technologies for photonics, sensory and nonlinear optical fibers, object oriented design of hardware, photonic metrology, optoelectronics and photonics applications, photonics-electronics co-design, optoelectronic and electronic systems for astronomy and high energy physics experiments, JET and pi-of-the sky experiments development. The symposium held two times a year is a summary in the development of numerable Ph.D. theses carried out in this country in the area of advanced electronic and photonic systems. It is also a great occasion for SPIE, IEEE, OSA and PSP students to meet together in a large group spanning the whole country with guests from this part of Europe. A digest of chosen Wilga references is presented [1-268]. Wilga Sessions on HEP experiments were organized under the umbrella of the EU FP7 Project EuCARD – European Coordination for Accelerator Research and Development.

Keywords: advanced electronic systems, optical fibers, optoelectronics, photonics, measurement systems, astronomy, high energy physics experiments

1. INTRODUCTION

The 29th Symposium of young scientists WILGA 2011 Photonics and Web Engineering has gathered around 100 participants. There were presented around 60 papers – mainly concerning the realized Ph.D. theses and participation in research projects relevant to the topical area of the meeting. There were also presented a few plenary papers introducing the audience into new research areas of photonics and electronics. The symposium is organized under the auspices of the SPIE – The International Society for Optical Engineering, IEEE (Poland Section and Region 8), Photonics Society of Poland, KEiT PAN, PKOpto SEP and WEiTI PW. The symposium is organized annually by young researchers from the PERG/ELHEP Laboratory of ISE PW with cooperation of SPIE and IEEE Student Branches. There are two edition of the Symposium: January and May. Media patronage over the symposium is extended by Elektronika monthly technical magazine, Symposium proceedings are published by Elektronika, JET - Journal of Electronics and Telecommunications KEiT PAN and Proceedings SPIE. Wilga Symposium is topically associated with the cyclic research meetings on optical fibers and their applications organized in Bialowieza (prof.J.Dorosz, Bialystok Uni. Technology) and Krasnobrod (UMCS Univ., and Lublin Univ.Technology, prof.W.Wojcik) every 18 months. Below, there are presented some presentations from the main of the most interesting sessions or topical tracks of WILGA 2012 Symposium – January Edition.

Participants of Wilga 2012 January Symposium, Session of FPGA/DSP/CPU/MultiGbE Photonic Systems

2. TOPICAL TRACKS OF WILGA 2012 – JANUARY EDITION

The topical session and tracks of WILGA 2012 January Edition were as follows: technologies for optoelectronics and photonics, optical fibers for sensors and all-photonic devices for sensors, active optical fibers, sensors and sensory networks, object oriented design of optoelectronic and photonic hardware, photonics applications, advanced bioelectronics and bioinformatics, co-design of hybrid photonic – electronic systems, computational intelligence in optoelectronics and robotics, development in the wide-angle astronomic observations of the whole sky – pi-of-the-sky project, processing and imaging of multimedia data streams, machine vision, vehicles – quadrocopter and Mars rover, analog transmission systems in noisy conditions with digital reverse transmission channel, optoelectronic and photonic metrology, reconfigurable measurement systems, high performance – low-jitter low-latency transmission systems – White Rabbit, thermonuclear fusion experiments – JET and ITER, research results update from HEP experiments – TOTEM and CMS/LHC in CERN. A number of Wilga sessions concerned applications aspects of photonic and electronic circuits and systems, including in this advanced applications which combine hardware and software. A separate session track was organized by SPIE, IEEE, OSA and PSP - Photonics Society of Poland students for the new students beginning their adventure with the science of photonics and electronics.

3. ASTRONOMY

Development of the next generation of pi-of-the-sky ultra-sensitive cameras require building a photonic and electronic test stand for precise qualitative camera sub-system evaluation. One of the tasks here is to build temperature stabilization device in calibrated source using spectral method. Calibrated light sources tend to change their parameters during work. The reasons are: temperature changes during the work of the source and wearing out of the source. The source radiation spectrum shifts towards shorter wavelengths and the radiation intensity increases with higher temperatures An additional feedback control circuit was added with the aim to correct the light source work conditions. The device consists of an integrating sphere for intensity measurement and spectrum acquisition, two photodiodes and a spectrometer; two shutters (coarse and fine), driven by stepper motors, for intensity regulation; halogen lamp current control circuit, and DDC112 integrated circuit for photodiode current measurement. The driver, which uses SPI interface and bases on ATmega64@16MHz, several DACs and ADC, UART, digital I/Os, several sensors, LCD 4x20 matrix for characters display, handles the setting of correct work conditions for the light source. It is done by current control, shutter control, voltage monitoring and light intensity monitoring. The driver has duplex communication bus with the spectrometer LPC1764@100MHz. The spectrometer handles spectrum measurement, calculates optimal work conditions for the light source. The system prototype worked on a PC and then was transferred to ARM with MatLab algorithm.

Astronomical databases get larger and larger with fast data accumulation form massive all sky observations. Satellite and ground based projects include deep space and wide angle sky monitoring. Specialized databases include measurement results for changing stars, results of GRB observations, quasars, standard candles monitoring, etc. A team from ISE applied CUDA (compute unified device architecture by Nvidia) for aiding the search in massive databases for weak spectral lines quasars (WLQ). Quasars, very distant objects, are fast rotating black holes surrounded by accretion disk, obscuring torus, emitting a strong jet along the rotation axis, with narrow and broad line emission and absorption regions – close to the accretion disk and jet area. Astrophysical objects change slowly, which enables unification theories based on statistical approach. Different features in quasar spectra, including the continuum and narrow spectral lines, are combined with various physical effects of large scale going on in the vicinity of the central black hole. Shape of the continuum reflects the processes in the accretion disk around the black hole. It is possible, from the spectra measurements, to determine black hole mass, spinning rate, singleness or binary set, matter inflowing rate, and observation angle against the spinning axis. The spectral emission and absorption lines are combined with the optical atomic and particle processes in the gas surrounding black hole. The spectra reveal the evolution of the objects as we observe them at different stages of their age. One of the questions to be answered here, by researching the WLQ spectra, is how faint non-active distant galaxy turns on its activity and becomes a bright quasar. The measurements determine gas density, constituents, emitters and absorbers, type of collisions, abundance, speed and direction of gas winds. The quasar spectral function has: continuum base CB, narrow and broad emitting lines NEL, BEL, and narrow and broad absorption lines – NAL, BAL. All these shapes, lines and their characteristics are databased. WLQ are objects of typical continuum emission but with very weak or no features on the CB. They are considered as young objects without the jet. Typical databases for quasars have hundreds GB of data and are difficult for direct and efficient analysis. There is a need to process and compare millions of quasar like spectra of astronomical objects. For this purpose an Hbase was applied with unlimited column number. The data were adapted from changed PostreSQL. The numerable column tables, numbered in thousands, are backups of the dataframes in the R environment. The data are processed using their own matrix and multicore rules, good packages and with double precision accuracy. This procedure reduces the databases by a factor from 10 to 100. Now a well known paradigm of using GPGPU technology was applied. Instead of using a CPU a GPU (graphical processing unit) was used for performing parallel computations on the spectral characteristics. In this approach, a one thousand column matrix containing one thousand spectra becomes a one-dimensional vector stream. This stream is loaded to the GPU. Kernel functions are applied to each element in the stream in parallel. The streams cab be concatenated together, which results in shorter computation time. There are obtained linear indexes of column – major matrix with spectral data. The applied CUDA and Thrust library operates on high level streams and kernels. In the result 100 thousand space objects spectra were calculated 100 times faster, than using traditional in-series computational methods.

Astronomical equipment must fulfill the most stringent and highly normalized reliability standards. This increases dramatically the cost. On the other hand there is a tendency to use off-the-shelf high quality equipment. The currents trends are: high demand for computing power, utilization of COTS components especially for LEO (low Earth orbit) satellites, reconfigurability of the systems where the functionality depends on mission phase; usage of SRAM FPGAs for versatility and ASICs for reliability, usage of standard interfaces like 28V bus, SpaceWire, CAN etc. The cost can be further decreased by applying universal systems. The requirements for such systems are: high availability and dependability versus unlimited reliability understood by large fault tolerance, switchable functionality, own housekeeping and state monitoring, usage of SpaceWire interface, availability of an integrated processor for running user software. The features of universal system for low price space applications are: reconfiguration of SRAM FPGA by antifuse (FLASH) FPGA using JTAG; verification of processing results and detecting syndromes; communication with other S/C modules. Communication tasks include: malfunction reports, acquiring new configuration, reporting of performance and functional state and executing superior module commands. The developed space oriented universal system provides basic functionality of all service modules at the spacecraft and is its central unit for telemetry. It runs constant verification procedures of SRAM FPGAs configuration memory and on-board RAM memory. A pre-flight prototype of an universal system for space applications was manufactured at CBK PAN laboratory in Warsaw. There was verified re-programmability of memories in ProASIC FLASH FPGA. Re-programmability was checked to be less than 0,5s. There were verified several functions of the system: performance for on-board SEL effects protection, storage of FPGA configuration, clock source switching circuit and internal watchdog. The system undergoes radiation tests and integration in heat dissipating and radiation shielding package.

4. SENSORY NETWORKS

One of the tendencies to build reliable sensory networks using GSM is to combine RF wireless and optical technologies (open optical links and optical fiber cables). The network may work as a distributed, multifunction and mobile measurement system. It was used for tests measurements of the intensity of pedestrian traffic in a few key points of the city. A module of sensory network, called SensorBox, was build. The node of the network is known as it is registered in the GPS. The communication with the base station is via GSM, using GPRS. The communication of the node with the sensors is via RJ-50 connector. Modularity of the system assures usage of different sensors. The following technologies and components were used. The system was outlined in the Altium Designer. There were used GSM modules: QUECTEL M72, SAGEM HiLo, ZTE MG 3006. There was used GPS module: SKM53. Other used components were: microcontroller, exchangeable SIM memory card, STM32F, JTAG, SWD multiplexers, USB, multiple connectors RJ-50, power supply 3,3V, LCD display. The mother PCB contains: connection with the sensors, multiplexing of the µC peripheries, communication with the base station, display and a keyboard, several RJ-50 ten pin connector – with full access to µC peripheries and power supply. There was used a cellular phone grade Li-ion battery of 1Ah, charged via the USB. The module may be supplied via the USB with simultaneous battery charging. The activity time of the module, when supplied only from the battery depends strongly on the data transfer intensity and GPS usage, but exceeds 12 hours in the worst case. Peripheries multiplexing uses SPI, I2C, UART, ADC channels and I/O ports. Exploitation costs of the sensory network module is similar to that of a standard cellular phone. The module turned out to be very cheap, practical, rugged and quite innovative. It actively adds to the development of fast growing field of mobile sensory networks. The module documentation including hardware and micro-controller software is available in OpenHardware repositories. The module is build in a package resembling a cellular phone.

5. WHITE RABBIT

White Rabbit is expected to be an enabler of a number of innovative technologies and applications in photonics and electronics. WR uses two protocols for synchronization: synchronous Ethernet and enhanced PTP. The clock is encoded in the Ethernet carrier and recovered by the PLL of the PHY, which means no extra traffic cost. There are offsets between the clocks to be managed. PTP synchronizes the local clocks with the master clock by measuring and compensating the delays introduced by the network links. One of innovative WR based solutions is a precise local positioning system based on White Rabbit. WR is a deterministic Ethernet-based network, which synchronizes up to 1000 nodes with sub-ns accuracy over fiber or/and copper, to a distance up to 10 km. The application consists of a WR switch, a network of distributed receivers, a transmitter and an embedded computer. Low power transmitter generates a pseudo-random signal. The receiver detects the signal and transmits the information to the computer. WR switch synchronizes the receivers and performs further data transfer. The embedded computer receives the data from the SPEC cards and estimates the position of the transmitter. The receiver uses an FPGA processor. The FPGA controls SDR module, correlates the received signal with the pattern, does the time-stamping of the signal and transmits the packets. The following components and software pieces were used for construction of the receiver: simple PCIexpress FMC carrier with PPC (power PC CPU)– SPEC, FMC slot, XS6 FPGA, SFP transceiver with WR support, FMC card with SDR (software defined radio), SDR implementation and SPEC firmware. SPEC board is an endpoint of WR network. SPEC PCB contains: FPGA, SFP connector for WR network, FMC connector for external interfaces and modules, PCIe connector. SPEC is a PCIe device and needs a PC platform to work. Our SPEC design was extended by putting there a PPC CPU to make it a standalone system. Thus, the FMC carrier with PPC CPU is an independent embedded system that can work as an endpoint of the WR network. It may be also used as a measuring system and can be extended through the FMC connector. The system was tested in real life working conditions. The system supports also non-WR devices, i.e. is compatible with the Best Effort non-synchronous Internet as well as synchronous Internet (high quality and low latency for high performance computing).

6. INDUSTRIAL STANDARDS

A marriage between FPGA and ARM processors (alternatively PowerPC CPU or software based CPU MicroBlaze) on a single, universally equipped PCB with relevant I/Os (including fiber and/or wireless) and ADC/DAC, results in a very powerful application system. Such a system was used for building an extended network of sensors, for control of hybrid power station (wind turbines and photovoltaic), environmental monitoring, and many other. AD9980 circuit on such a board provides all HDTV modes. CH7301B circuit makes the board compatible with the CVI and other video and control standards (RS, VGA, DVI). The software is readily manufactured in the fpga vendor environments, like the vga2dvi converter module, and many others. The basic assumption is to make the system multichannel and flexible for different kinds of sensors, including RF and optical. Such a universal mother PCB may be done experimentally, with test architectures containing Fpga, CPU, memory, internal multi-gigabit bus, GbE optical links and other I/O ports. However, a number of Fpga and CPU vendors offer Evaluation Platforms of quite universal architecture and all the necessary key components onboard. One of the frequently used examples is V-5FXT fpga ML507 by Xilinx. The system is conveniently compatible with the ISE Design Suite software environment. Such solutions speed up considerably the design of practical functional blocks of various photonic and electronic systems like, in our case, multi sensory networks, video systems and others.

The µTCA standard, a miniaturized derivative of ATCA (advanced technology communication architecture), has recently been used not only for telecom but also for the development of measurement and control systems in high energy physics experiments, astronomy, biomedical engineering, free electron lasers, accelerators and large research infrastructure. µTCA format was officially chosen by some large scale photonics infrastructure like European X-FEL laser, FLASH laser etc. One of the subsystems made in this technology is the upgrade of the Bunch Arrival Time Monitor for the large E-XFEL machine. µTCA may also be a platform for a direct sampling sub-system. The basic features are: support of high accuracy (up to 16 bit) and high speed (up to 1Gsps) ADCs. An application specific analog part of the sub-system is positioned on FPC mezzanines (Fpga mezzanine card standard ANSI/VITA 57.1). Common components like Fpga, power supplies, logics, management, etc., are placed on the base board. A lot of commercial ready FMC modules, featuring high performance Fpga circuits, are available with a variety of signal processing functions. FMC minimizes the signal latency while maximizing the data throughput. Dedicated FMC modules are designed for specific purposes and then are reused in other of future projects. µTCA carrier boards support double width or two single width FMC. They display AMC.4 compatibility with IPMI support. AMC.4 and FMC I/Os include: PPC CPU, GEth, PCIe, P2P links, M-LVDS, CLKA and CLKB routed to Fpga, JTAG, many TP links, USB. FMC boards serve customary tasks including analog signal processing (analog mezzanines). The ATCA and /or µTCA crates with versatile RTM (Rear Transaction Modules) serve the general purposes of making the whole system work. The system was build inside the EuCARD project.

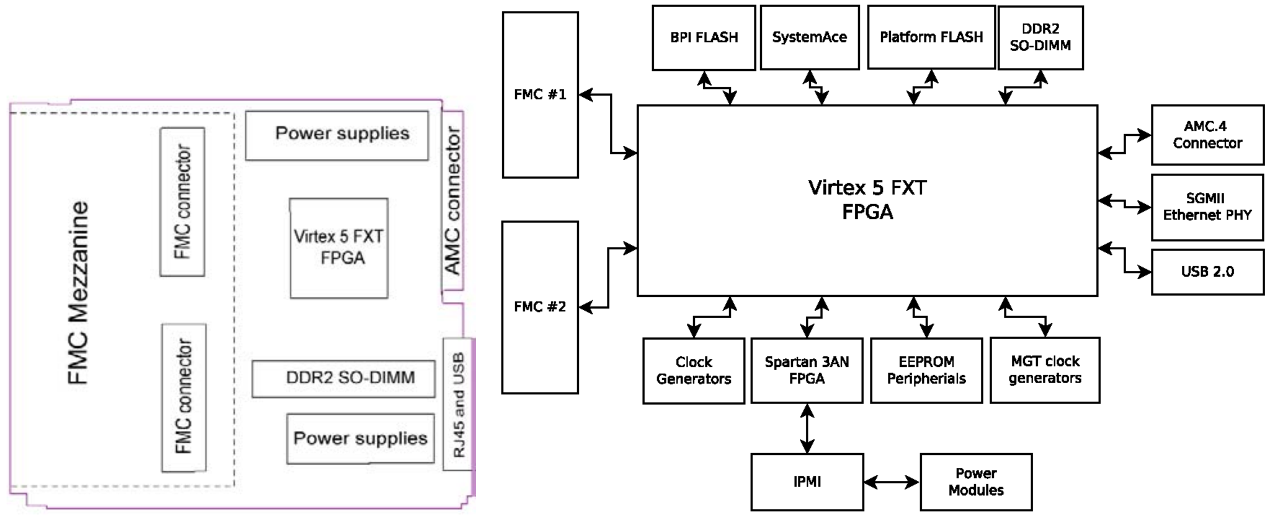

Fig. A µTCA carrier board and FMC Mezzanine (ADC daughter) for fast EVM

7. ARTFICIAL INTELLIGENCE

Epistemic logic and its relations to the modern ICT was a subject of Wilga topical session prepared in cooperation by prof.J.Mulawka (WUT) with the research team of prof E.Nieznański (UKSW). Ontological and epistemic approach to future photonic and electronic systems, in hardware and in software spaces, turns out now to be an essential development basis of the intelligent virtual worlds. Hardware and software/firmware is a sort of a basic foundation of such systems. Future development of photonic/electronic systems building fully intelligent virtual worlds is expected to base on more sophisticated ontological base than it is today. The basic features of such worlds in the future will be very probably full conscience of subjects and objects, and full submergence. Today, strictly speaking, the used ontology is simplified, if not primitive. The search for new extended bases for artificial intelligence systems go into various directions. Some of them are: new logic systems, epistemic logic, research in knowledge representation, formal description of ontological systems, and others. A logic is a formal language which supports reasoning – natural and artificial. The logic has precisely defined syntax and semantics. The logic is fully independent of the domain of application. As a consequence, representation of some things in logic may not be very natural. Epistemic logic is a subfield of modal logic concerned with reasoning about the knowledge. It was rediscovered in modern form by Kripke in 1963. There are four basic modal operators in epistemic logic, which may be digitized and applied in a digital world: W – one knows that; S – one is certain that, P – one supposes that, D – one admits that. The logic defines/induces relations between the operators, and bases on coherent axioms and rules, for example analogous to CPL – classical propositional logic: A1. $S(p\to q) \to (Sp \to Sq)$; A2. $Sp \to SSp$; Df.W:$Wp \leftrightarrow Sp \wedge p$; A3. $Wp \to SWp$; A4. $Sp \to Pp$; Df.D: $Dp \leftrightarrow {\sim}S{\sim}p$; A5. $Pp \to Dp$. Using such operators and relations between them it is possible to prove theses. The used axiomatic method involves replacing a coherent body of propositions (like a mathematical theory) by a simpler collection of propositions (like axioms). The axioms are designed in such a way that the original theory can be deduced from the axioms, using among others modus ponens rule, semantic tables of Beth, literals, clauses, clause sets, resolution rule. The general goal is to adapt and test the above methods into epistemic logic, what may require research on new theorems, and to incorporate epistemic logic into the ITC engineering knowledge.

Virtual intelligent worlds are dynamic entities. Dynamic epistemic logic embraces such fields as: epistemic logic, public announcement logic, action models, expressivity and probability. Dynamic epistemic logic is the logic of knowledge change. DEL embraces by no means a single logical system. It is an overhead for the whole family of logical systems. DEL is expected to allow the artificial intelligence to specify static and dynamic aspects of multi-agent systems. The language of DEL bases on dynamic semantics, which is a subarea of semantics. It distinguishes between de dicto and de re understanding of sentences. It is concerned with the change of information and the change in general. The main idea of dynamic semantics, in information theory and artificial intelligence sense, is that the meaning of a syntactic unit, irrespectively if it is a sentence of a natural language or preferably a computer program, is best described as the change it brings about in the state of a human being or a computer. The meaningful information in such an ontology is regarded as an entity (existence) that is in functional relation to a particular subject. The subject has a certain perspective in the real or/and virtual world. Such a subject is defined as an agent. Epistemic logic trying to describe the general relations of an agent may be written formally: I know that p [$K_a p$]. He does not know that p [$\neg K_b p$]. He knows whether p [$K_b p$ □ $K_b \neg p$]. He knows that I know that she does not know that p [$K_b K_a \neg K_c p$]. Epistemic models use A.Kripke structures M=(S; R; V), where S is a nonempty set of states, R gives an accessibility relation $R_a \leq SxS$ for every a belonging to A; V:P→ρ(S). If all relations R_a in M are equivalence relation, we call M an epistemic model. Public announcement logic, important in virtual reality, bases on the following statements. After announced that *p*, everyone knows that *p* [(p)Ep]. After it I announced that *p*, it is common knowledge that *p* [(p)Cp]. Example: After it is announced that none of the programmers know the newest programming language, all the programmers who do not know this language know that they do not know this language [$(\Lambda_{a \in A} \ \neg K_a m_a)\Lambda_{a \in b} \ K_a m_a$]. The epistemic modeling of a real and/or virtual situation contains the following components. Given is a description of a situation (for example in the Internet based virtual reality). The designer/modeler tries to determine: a set of relevant prepositions, a set of relevant agents, a set of states, a nondistinguishability relation over these worlds for each agent action models. Further step in creation of an intelligent virtual world is a dynamic modeling. There is given a description of a situation and an event that takes place in this situation. The designer/modeler first models the epistemic situation, and then tries to determine: a set of possible events, preconditions for these events (for example space and time coordinates, but not only, also more complicated ones), a nondistinguishability relation over these events for each agent. An action model M, in such intelligent virtual reality, is a structure over a finite domain of action points or events S, maintaining an equivalence relation on S, denoted by operator $\sim_a$, and fulfilling precondition function pre: S→L that assigns a precondition to each s ∈ S.

Building of practical intelligent virtual environments (very complex intelligent software systems basing on rich ontology, we say ontology driven) requires the ability to represent the knowledge. Knowledge is defined here simply as all what I know, and is a symbolic description of the real world. It is a set of messages from a specific area. The task of knowledge representation is split to categorial objects representation. The applications of categorial object representation are: categorial LISP, PROLOG, semantic networks, implementation of machine engines in extended logics, and logics of categorial objects, concepts and systems. The most objective (and popular in relevant research) Knowledge Representation Methods (KRM) are independent of implementation. They base on procedural representation (called production rules) and may contain simple unification processes and could be used as tensors of knowledge. KRM is a root of Semantic Networks (now the Semantic Web) in the original linguistic M.Ross Quillian and Allan M.Collins sense (semantic knowledge representation). Semantic network connects all possible notions combined with an object or subject of the knowledge. This may include: description, varieties, features, actions, relations, applications, linkages, answers to such questions like: it has, it is, made of, used for, where, why, what, etc. Modified Quillian approach to KRM includes: simple and perceptive ways to represent information, object oriented approach to knowledge representation, natural representation, etc. However, yet the meaning of semantic networks is not always well defined. Categorial Semantic Networks include the following categories: T – things, F – features, S – situations, and C – classes. The categories are related by the following operators: Relatives Y/X = Y of X, relation T/T; Concatenations X^Y =XY, relation F^T; Categories X, X_1, …, Y,Y_1, … categories {T, F, S, C}; Hypostasis Y//X=Y arising from X, F//S being X, T//C aggregate unit from the class; Operators of relation and quantity: of, from, ^, ~, =, a, the, very, some, all. Using these formal tools any expression and then clause in Categorial Networks is analyzed as a succession of operators QTFSCA. Formal tools include categorial Lisp and Prolog. Lisp consists of objects – entities. An object is composed on n cells. Numerable cells represent categories. Classical Prolog variables represent everything. During unification category everything is substituted by formal variables. To infer a method of resolution is used, which creates a very big solution space. In extended Prolog, oriented for semantic networks, objects are represented by cells with categories. During the unification only the adequate categories are matched, and again a method of resolution is used to infer. As a result a huge space of possible solutions is significantly reduced. To find a solution, much smaller space is searched, what is much faster.

Relatively simple (yet more and more complicated) examples of ontology driven virtual worlds are existing in some advanced PC games. Ontological drivers may concern separately particular layers of the virtual reality like communication, bots behavior, avatar's personality, properties of the space/nature and/or all the layers together. Ontological background concerns also the relations between the mentioned layers of the virtual reality. A lot of different techniques is applied for practical solution. One is interfacing Clojure with Pogamut platform, an AI software exercise tried at Artificial Intelligence Lab. of ISE PW. Clojure is a contemporary dialect of LISP language. It supports functional and multithreaded programming and runs in JVM and CLR. Clojure: is succinct and factorial functional language, integrates with and is embedded in Java, can be integrated with pogamut, uses Java libraries, runs as Java threads, allows for inline Java code, Clojure functions are called by Java code, and is available as a clojure.jar Java library. Pogamut, under constant upgrade, simplifies creation of bots/agents, controls squads of bots and agents in virtual environments, enables flexible bot navigation, integrates several Virtual Environments (like UT, UDK-UE, Defcon), enables simple reinforcement learning and has ontology driven communication. Squad control includes: coordination, communication, organizational structuring, maneuvers, formations, planned and emergent behavior by influence vectors and team controller. Learning enables gathering of experience. Ontology driven communication bases on FIPA-ACL agent communication language. Integration of Clojure-Pogamut bases on modular horizontal layered architecture (MHL) which consists of layers and mediators. The mediators can execute multiple layers. Each layer represents a simple or complex behavior and has access to agent components like memory, communication, body, behavior. Abstraction allows for simple Mediator change according to strategy design pattern. MHL architecture enables programming of each layer in a different language – Clojure, Scala, Groovy and others. Clojure code can be called from Java in three ways: a compiled jar file with class generated by gen-class; a clj script file clojure.lang.RT or inline by string object.

8. DNA COMPUTING

The work on DNA computing is done in WUT and WULS (Warsaw University of Life Sciences) cooperation. One of the intermediate aims is to master the genome browser algorithm. The Genome Sequencing Project is the world's largest action of producing the full dataset to create maps of genomes. The recognized number of genomics sequences ATCG is continuously increasing. The aim of the GBA system is to display genomic features fast and in an easy way. The research procedures go from acquisition of the genomic data to the genome draft, which is partial assembled genome, and include the following steps: short reads – sequencer output; contigs (physical map of the genome that is used to guide sequencing and assembly) – sequencer output assembly; BES – back end sequences; scaffolds – contigs and BES assembly; markers map – known sequences and position on chromosomes; chromosomes – with assigned all elements; genome draft. Genome annotation, which is a process of attaching the information to the structures, concerns two processes – structural and functional. Structural annotation consists of the identification of genomic elements: gene-like structures, coding regions, location of regulatory motifs. Functional annotation consists of attaching biological information to genomic elements: biochemical function, biological function, involved regulation and expression of interactions. The genomic data are stored in a standardized very large tabular format, imposed by classical biological tradition, and very difficult for further digital processing by ICT systems. New approach is required for "DNA computing" which employs high throughput assays, automatic operator-less processing, advanced statistics and smart bioinformatics. All these features have to be combined in a single smart display of the genome overview – a genome user-friendly browser. The information display goes from a single nucleotide to a chromosome with annotated data, from multiple and diverse sources, including gene prediction and structure, proteins, expressions, regulation, variations, etc. The example is the MSU Rice Genome Annotation Project (GBrowse). The advantages of GBrowse are: simple and clear view of the genome structure and detailed information of genes, easy accessible data, improvement of the usage of knowledge stored in genome. The disadvantages of GBrowse are: installing, configuring and updating is difficult, input of new genome data takes very long time, there are used scripting languages. The GenWeb – a new genome browser. Which is a joint effort of WUT and WULS introduces new facilities in algorithms, data structure and in software architecture. The Intervals contain: reads, contigs, scaffolds, structural and functional annotations data. The Intervals tree node contains a point in sequences (index) and intervals with common index. Software bases on client-server solution. The client uses web browser. There are used the following programming languages and libraries: C++ (calculation library), Python, Adobe Flex, DJango, BioPython (access to external databases), Boost and others. The system has access to NCBI and EBI databases. The value of genome sequences lies in their assembly and annotation, but its practical usefulness depends on the way of management and presentation.

There are researched different methods of decoding gene sequences. The aim is to lower the costs, shorten the sequencing time, increase the accuracy and generally make the method accessible for wide medical procedures. Proteins are linear sequences of amino acids. There are at least 20 amino acids including Alanine, Leucine, Serine (A,L.S,…). DNA is a double helix of nucleotides – nucleic acids (C T A G) plus U, instead of T mainly in RNA. Single strand RNA contains DNA information out of the nucleus. Peptide biosynthesis goes through DNA – mRNA, Rybosome plus tRNA plus rRNA, which results in polypeptide. Codon is a triplet of DNA, eg. GCA, ACT, CGT,…There are 64 codons, and each peptide is coded by at least one codon in 1 to N relation. Codons have specific frequencies in different proteins. The decoding algorithms base on codon frequencies. The approach is: choose a codon randomly, select the most frequent codon in a given organism, randomize codon with respect to its frequency in the organism, optimize locally in sliding window. The properties of such methods are: require the codon frequency table, low expression for the resulting synthetic gene, tertiary structure (folding), biosynthesis is stopped with too low level of corresponding tRNA, do not reflect any grammar. Hidden Markov Model (HMM) is used successfully for decoding of gene sequence. Markov model is a stochastic model that assumes Markov property of the researched system defined as: Q finite set of states A, C, T, G; probability S of start states equal to 1 ; transition matrix A of unitary properties. At these assumptions the probability of getting sequence s is described analytically as a product of elementary conditional probabilities. Hidden Markov Model is somewhat more complicated, because the entire state is not visible, or there is an additional hidden level. The HMM has in this case the following arguments: V – observations (20 amino acids); Q – hidden states (64 codons); A – transition probability matrix, E – emission probability matrix; S – start probability vector. Probability of getting an assumed sequence is also a product individual probabilities from emission and transition matrices. HMM tends to reflect frequency table and can model grammar. The task is, thus, to get hidden sequence knowing the output sequence. Viterbi learning/training algorithm is applied for back reflection. Out of the sequence Q,V,E,A,S, there are two parameters one can change – start probability vector S and transition probability matrix A. Assuming that in the current algorithm S is constant and equal to $S(q_i)=1/64$, and the probability matrix is constant. The key factors in the algorithm success are: fast Viterbi implementation, efficient optimization algorithm, more complicated mode – higher level HMM with additional loops in Viterbi, adding folding and other effects, application of neural networks.

9. PHOTONICS AND ELECTRONICS APPLICATIONS

A number of session concerning the applications of photonic and electronic circuits and systems included work on particular engineering and technical solutions for various fields like: car industry, airborne industry, robotics, management of the road traffic, remote control methods for utility systems via the Internet, audio and video techniques, biomedicine, safety techniques, home appliances. A group of work concerned the development of a mobile platform for a universal robot equipped with advanced devices like cameras, grippers, Other group concerned the development of distributed measurement networks for minimum energy service of the network of self configuring environmental sensors. These sensors are expected to use a lot of energy harvesting.

10. CONCLUSIONS AND WILGA 2013

The WILGA January 2012 meeting was a fruitful event gathering young researchers from the fields of photonics and electronics systems. The 2013 Symposia on Photonics and Internet Engineering will be held on 24-27 January 2013 at WEiTI PW building in Warsaw and on 27.05 – 02.06 2013 in Wilga Resort by PW. The organizers warmly invite young researchers to present their work. The WILGA Symposium web page is under the address: http://wilga.ise.pw.edu.pl .

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WILGA Symposium has produced more than 2500 articles, out of which over 1000 were published in Proc.SPIE. Several hundred of them are associated with the research activities of the PERG/ELHEP Research Group at ISE WUT. The Group is an initiator and major organizer of the WILGA Symposia. The paper was prepared using the invited and contributed presentations debated during Wilga 2012 January Edition. Some fragments of the text were quoted from these presentations and from session discussions.

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