Key information technologies for digital economy

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Abstract

The paper is dedicated to the key information technologies, which are important for the economic progress of various countries. Common properties of the IT sphere are discussed. Examples of research work at Ufa State Aviation Technical University are given for the topics of Big Data, Artificial Intelligence, Robotics and Sensorics.

1 Introduction

The role of information technologies (IT) in different areas become increasingly significant. They have become important factor of progress for developed and developing countries, which ensures a stable high rate of development and the effectiveness of integration into the global space. In European Union the list of main implementation steps towards the creation of a single digital market was published in May 2016 [EU16]. In Russia, the program for the development of digital economy [PDE17] was approved in May 2017. Updating cycle of the IT has a direct impact on all other industries. Not only scientists, but also practitioners, managers, etc., are engaged in the research, development, application and implementation of IT in various types of activity. This article focuses on issues related to key information technologies. The second section discusses the characteristics of the IT industry and key IT, which provide the development of the digital economy. In the third section, some relevant scientific results by authors from the Ufa scientific school are given.

2 The field of information technology

The activity in the sphere of IT include IT services, software development, and equipment supply and maintenance[APC18]. IT services include systems integration and implementation, customized application development, outsourcing and offshoring, support, maintenance, consulting, training and education. Software development include infrastructure applications, solutions for decision support, user applications, business software, consumer software, embedded software. Equipment supply sphere is related to the supply of PCs, servers, peripherals, external devices, equipment for data storage. The IT industry also includes such sectors as sales of telecommunications equipment, e-commerce enterprises for the mass market and for corporate clients, and Internet-based media resources [APC18]. Globally IT services occupy a larger market share than the software sector, but their growth is already stabilized. In the field of software development, emerging markets start to play more important role due to rapid economic development and decreasing level of piracy. Equipment supplies has a small share of costs in developed countries, and a large part in developing ones. The global IT industry retains great long-term growth potential. The most demanded IT-specializations in Russia are 1C programmers and developers,

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system administrators, maintenance specialists, java programmers and developers, web-programmers, testers, PhP-programmers, deployment specialists, web-designers, technical writers.

Regional issues of IT-development mostly coincide with issues at the federal level. In particular, these are insufficient financing, personnel shortage, inconsistency of actions between different levels of government. However, there are some peculiarities in the regions, e.g., a weak development of the information and telecommunication infrastructure. Another problem is that in Russia in recent years no significant bank of solutions or services has been established at the federal level, which regions can use together and at no additional charge; in fact, every region is seeking funds for the same solutions.

Nine key IT for the development of digital economy are stated in [PDE17]. They are listed in table 1.

Table 1: Key IT for the development of digital economy

Technology	Description	Applications
Big Data	Processing large amounts of data (large in comparison with standard scenarios); work with fast stream of these data; parallelized work with unstructured and weak-structured data.	medical and socio-economical data analysis, GIS, etc.
Neurotechnology and Artificial Intelligence	Artificial intelligence (including artificial neural networks) is a technology for creating intelligent machines or programs, which are capable to model human intelligence for implementing complicated task, such as natural language text processors, expert systems, virtual agents, recommendation systems, etc.	medicine; unmanned vehicles; management of human resources, industry; finance; household robots, smart buildings, etc.
Distributed Ledger Systems	Distributed ledger is a database that is stored and updated independently by each node of the network. The most well-known type of distributed ledger is blockchain. Security of the stored data is provided by specific use of cryptographic hash functions and digital signatures.	banking, finances, energy systems, etc.
Quantum Technologies	Manipulation of complex quantum systems at the level of their individual components in order to create powerful and secure quantum computing system.	cryptography, artificial intelligence, molecular modeling, etc.
New Industrial Technologies	Automation and robotization, integration of IT systems, simulation and modeling, additive manufacturing, alternative energy, industrial big data and analytics, development of cyber-physical systems and "Industry 4.0" concept.	Industrial production
Industrial Internet	Subcategory of the Internet of Things; a concept for building information and communication infrastructures: connecting any non-residential devices, equipment, sensors, control systems to the Internet and integrating the elements among themselves.	System integration, IT services; transport systems, telemetry, geolocation, etc.
Components of Robotics and Sensorics	Robotic components intensify industrial production. sensors in robotics act as receptors through which robots receive information from the outside world and their internal organs.	Robotized production
Wireless Communication Technologies	Transferring information between points without wired communication	Industrial Internet, Internet of Things, communication systems
Virtual and Augmented Reality	Virtual reality is a concept of expanding the physical space of human life with objects created with digital devices and programs and having the character of an image. Augmented reality allows placing visualized information around the objects of the real world.	informational and educational products; games; product development; presentation and demonstration

3 Research in Ufa: current results and next steps

The scientists from the Faculty of Computer Science and Robotics at Ufa State Aviation Technical University made significant work in the field of fundamental research and in the field of practical research (in collaboration with customers from the real sector of the economy). Several tens of examples of research projects connected to key IT may be given. However, due to the limited scope of this article, we will focus only on some results in the field of big data, artificial intelligence, robotics, and sensorics.

Big data analysis in Geo-technologies are now at thbeing developed at the Department of Geo-Information Systems (Prof. O. Christodoulo). Geo-information systems (GIS) are becoming one of the main technologies for analyzing big data for many applications, such as production management, transport, energy, security, etc. Geo-data are complex, and with the transition to big geo-data complexity increases almost exponentially. It means processing billions of geographic objects, (lines and polygons). In addition, the calculation of spatial relationships is often required. Applying technologies like Hadoop to them could help to solve problems that cannot be solved by traditional methods, or, at least, to get a significant gain in efficiency and speed of computations. The following research works in processing big geo-data were conducted: development of GIS of trunk oil pipelines and 3D models of potentially hazardous objects for OJSC "Uralsibnefteprovod", development of an automated system for the formation and maintenance of a regional waste cadastre in the Republic of Bashkortostan, development and implementation of the GIS for OJSC "Gaz-Service", development of the GIS for governing organizations in the Republic of Bashkortostan, modeling the flood zones during the period of spring floods in the Republic of Bashkortostan [Chr13].

Research work on BigData at the Department of Computing Technology and Information Security is made together with Frodex LLC on the research topic: Intelligent analysis of banking transaction data as part of a antifraud system [Sap17] (Prof. V. Vasilyev). Within the framework of the project, the system for collecting and processing user data was developed as part of the antifraud system. The key element of this system is the data mining module. Analysis algorithms are applicable in the conditions of big data. Hadoop hardware and software cluster is deployed. It consist of 16 server machines that implements the capabilities of a distributed transaction banking data processing system based on modern distributed file system technologies, non-relational DBMS (Cassandra), big data processing technologies (Apache Spark,TensorFlow, Spark-sklearn).

Research on medical applications of Big Data are mainly conducted at the Department of Computational Mathematics and Cybernetics (Prof. N. Yusupova, Prof. G. Shakhmametova). The most relevant direction of work is data processing for diagnosis, treatment and prevention of diseases. Taking into account high volume of input information or implementing a complex data processing algorithm may be really difficult for a decision maker. Relevance of this task increases with the accumulation of information, which is happening avalanche-like due to the improvement of information collection and storage technologies. Tasks of medical analytics solved via BigData technology may be divided into descriptive analytics (What happened?), diagnostic analytics (Why did it happen?), predictive analytics (What will happen?), and preventive analytics (What should be done in order NOT to happen?). Medical data are obtained from various sources:results of research and testing; medical records and diagnoses; medical meters; analytical information from medical authorities and pharmacies.

In collaboration with the Department of Internal Medicine Propsy at the Bashkir State Medical University (Prof. R. Zulkarneev) a technique for complex analysis of toxicologic data was developed and implemented [Sha18]. This technique includes three main stages: exploratory data analysis using visual analysits, non-parametric analysis, data mining. The developed technique is applied to the analysis of data on acute poisoning in the Republic of Bashkortostan in 2015-2016. The results obtained during the analysis can assist the managers of medical institutions and chief specialists of the governing bodies in analyzing the indicators characterizing the dynamics of trends in public health, planning the allocation of health care resources in the region, and managing specialized medical services. Additionally software complex for non-parametric medical data analysis methods was developed. Future plans include descriptive and diagnostic analytics of medical data; study of the effectiveness o f treatment based on analysis of medical records and diagnoses; expense forecasting based on the analysis of data such as the number of repeated visits, the prevalence of pathologies, the number of patients with chronic diseases, etc.

Intelligent analysis of big social and economic data is also performed at the Department of Computational Mathematics and Cybernetics (Prof. N. Yusupova, Prof. O. Smetanina). Solutions are based on text analysis, pattern recognition, machine learning [Guz14, Yus18]. Main instruments are data quality assessment, factor analysis, dimensionality reduction, cluster analysis. One example task is odentification of similar educational programs in different countries with preliminary processing of semi-structured and structured data. Another

one is identification of hidden patterns in personal data, including the data from Internet-resources. Results are used for the selection of job-applicants, for assessing the loyalty of customers (including students as customers of educational services), for assessing the correct choice of a professional path, etc. Analysis of natural language text was applied for review-based decision making. Pattern recognition as a mix of classification and identifica tion methods was applied for person recognition based on voice and images.

Research in the sphere of intelligent robotics and sensorics is conducted at the Department of Computer Technology and Information Security (Dr. Konstantin Mironov). This work is dedicated to the task of object transportation by robotic throwing and catching [Gay17]. This is a novel possible way of material transportation, which may replace traditional conveyor belts for transporting small objects in the industrial environment. Catching is based on tracking and forecasting the trajectory of the thrown object. Proposed tracking system is based on stereo vision. Novel approach to forecasting the trajectory of the thrown body was proposed. Traditional approach to this task consist in mathematical modeling of the ballistic trajectory. Learning-based approach is less popular. Proposed predictor was applied based on nearest neighbor regression, which does not require exact physical model of the motion. These two approaches were then mixed in the new one, which is based on genetic programmi ng. The forecast is made using an equation, which is learned by the procedure of genetic programming. Results of numerical and throwing experiments showed that accuracy of trajectory forecasting is enough for successful robotic catching.

4 Conclusion

Global IT industry has great growth potential in the long term with a tendency to increase the share of IT services in comparison with software and hardware. The key information technologies of the digital economy include: big data, neurotechnologies and artificial intelligence, distributed ledger systems, quantum technologies, new production technologies, industrial Internet, components of robotics and sensorics, wireless communication technologies, virtual and augmented reality. Research experience at the Faculty of Computer Science and Robotics (USATU) has a direct relationship to the key areas of information technology, named in official documents. Further research is related to both fundamental problems and the application of results for real-world problems.

References

[AEC18] Association of Enterprises on Computer and Information Technologies *Web Resource.* www.apkit.ru (vizited on 31.05.2018, in Russian)

[Chr13] S. V. Pavlov, O. I. Christodulo *Theorethical Methods for the Developing Geo-Information Systems based on Integration of Multidimensional Data Models and Geo-information Technologies.* Geo-information technologies in development of corporate information systems, Ufa, 2013, pp. 40 to 46 (in Russian).

[EU16] *European Commission sets out path to digitize European Industry.* Press Release, Brussels, 2016.

[Gay17] R. C. Gayanov, K. V. Mironov, D. V. Kurennov *Estimating the Trajectory of a Thrown Object from Video Signal with use of Genetic Programming.* 2017 IEEE Symposium on Signal Processing and Information Technology, Bilbao, Spain, pp. 134 to 138.

[Guz14] M. B. Guzairov, N. I. Yusupova, O. N. Smetanina et. al *Methodological Aspects of Artificial Intelligence.* Machinery Science, Moscow, 2014, 267 pp.

[PDE17] Program *Digital Economy of Russian Federation.* Order of the Russian Government #1632-p from 28.07.2017 (in Russian)

[Sap17] M. U. Sapozhnikova, A. V. Nikonov, A. M. Vulfin, M. M. Gayanova, K. V. Mironov, D. V. Kurennov *Anti-fraud system on the basis of data mining technologies.* 2017 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT), Bilbao, Spain, pp. 243 248

[Sha18] G.R. Shakhmametova, N.I. Yusupova, V.V. Mironov, R.Kh. Zulkarneev *Statistical and Intelligent Methods of Medical Data Processing.* IT in Industry, vol. 6, no.2, 2018, pp. 13 to 18.

[Yus16] N.I. Yusupova, D.R. Bogdanova, M.V. Boyko *Processing Weak-Structured Data Based on Methods of Artificial Intelligence.* Innovative Machinery, Moscow, 2016, 267 pp.