Concept of Interdisciplinary Research in Biomedical Informatics and its Transformation into a New Study Program

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***Abstract*—** A concept of teaching for students with specialization in informatics is considered in this paper. The concept takes into account the processing of biomedical data but also interdisciplinary subjects in the field of biology, chemistry and biomedicine. The implementation of this concept has resulted in a new study program opened at the Faculty of Management and Informatics of the University of Žilina in Slovakia. The main focus of this paper is on the presentation of the core courses of this study program.

***Keywords*—** Bioinformatics, Biomedical informatics, Biomedicine, Informatics, Education

I. Introduction

Informatics and information technology are becoming an integral part of healthcare of the 21-st century. For example, augmented reality allows creating computer systems simulating complex medical procedures, which make it possible to significantly simplify and speed up their training by physicians, nurses, and other medical staff. An example of such a procedure is local anaesthesia, the simulator of which was developed within the European project RASimAs [1], [2]. Similarly, artificial intelligence approaches, such as data mining, allow developing expert diagnostic systems that can facilitate and accelerate patient diagnosis and predict future health status. An example of such a system can be software for automatic analysis of EEG signals that can determine whether a patient is suffering from epilepsy [3]. These and other facts stimulate the need for specialists in informatics who can work with physicians and other healthcare professionals to create sophisticated medical applications. As a result, various interdisciplinary fields focusing on the use of informatics, information technology and computer modelling in the medical field emerge in the world as well as in Slovakia.

According to information presented at PortalVS.sk, Slovak universities offer several interdisciplinary study programs in which students acquire knowledge of medicine, biology, physics, informatics and information technology. First of all, there are bachelor's and master's degree study programs on biomedical physics and biomedical engineering, which are offered by Comenius University in Bratislava, Technical University of Košice, and the University of Žilina. Graduates of these study programs can work in medical facilities and laboratories as specialists on the hardware used in these institutions and as creative engineers in companies engaged in the development and production of medical devices and equipment. Another program focusing on the application of informatics in biomedicine is bioinformatics offered by the Comenius University as a part of a bachelor's degree study program, whose graduates can be employed mainly in biomedical laboratories as system administrators and experts who understand characteristics of biological and biomedical data and are able to analyze this data using existing software tools.

Graduates of the aforementioned study programs are important for improving the technical background necessary for the development and improvement of healthcare. However, these study programs provided by Slovak universities do not sufficiently reflect the need to educate

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computer scientists and software engineers who are able to communicate with physicians, biochemists and biomedical engineers and to create comprehensive information tools for healthcare facilities, specialized software tools for analysis of biomedical data and decision support systems in diagnosis and treatment. Such specialists are required and in high demand by various software companies dealing with the development of software for medical purposes. This fact has been reflected in the Faculty of Management Science and Informatics of the University of Žilina, which has been developing a new 2-year master's degree study program. This study program has been named as biomedical informatics and new courses proposed within this program include dynamically developing interdisciplinary areas that provide engineers and scientists with additional opportunities and challenges, but also impose new requirements on basic teaching and learning skills. In this paper, we present the key courses of this study program.

II. Biomedical Informatics at Faculty of Management Science and Informatics

In biological, but especially in biomedical data, there is a large number of unexplored and undiscovered facts and contexts that can contribute not only to understanding the patterns of life but also to the treatment of serious diseases [4]. One of the disciplines that make it possible to solve biomedical problems in the field of a secure collection, management, use and sharing of information is biomedical informatics (BMI) linking the field of information and computer science with healthcare.

Biomedical informatics is an interdisciplinary field that uses information technology to improve healthcare in any aspects. Unlike classical biomedical engineering, which mainly deals with development of healthcare devices, surgical robots, prosthetics and other medical hardware [5], medical informatics applies results of biomedical engineering, bioinformatics, image processing, and data mining in development of complex software solutions for various problems related to healthcare, such as processing of radiology data [6, 7], EEG [3, 8], or ECG [9, 10], cancer research [11], decision making in medicine [12], analysis of biomedical data, such as macromolecular structures, genomics, and protein sequences [4, 13]. These scientific fields imply that experts on biomedical informatics have to have strong knowledge and skills in informatics, software engineering and data processing and have to be educated in basics of human anatomy, physiology, and biomolecular chemistry. Based on these requirements, study program biomedical informatics at Faculty of Management Science and Informatics has courses divided into three essential groups.

Courses of the first group deal with the development and management of large-scale medical information and healthcare systems. The main courses of this core are medical informatics, advanced algorithms and data structures, advanced database systems, and course on software for biomedical informatics. Medical informatics focuses on information systems of electronic healthcare and allows students to understand the problems of medical informatics, its interaction with related fields, and its use in the electronic health system. After passing the final exam, students will understand the importance of electronic health documentation as well as the principles of evidence-based medicine and critical thinking in clinical practice. The course on advanced algorithms and data structures allow listeners to grasp the knowledge of advanced data structures, such as various modifications of binary search trees, advanced priority queues, data structures for fast multi-dimensional search, or data structures for storing data in external memories. After passing the exam, students will know efficient techniques for the implementation of sophisticated data structures. The last course, which is advanced database systems, deals with advanced features of SQL, optimization principles of the query processing,

principles of object-oriented database systems and distributed database systems. As one can recognize, topics covered in these four courses represent key informatics knowledge of students and are basics for other courses dealing with the application of informatics in biomedicine and healthcare.

The courses in the second core group allow listeners to gain an overview of typical problems in the field of software development for medical practice, to learn to create three-dimensional models of anatomical structures and to model selected physiological processes in the human body. This group also includes three courses. The first of them is the course on software for biomedical informatics that allows students to obtain skills in selected software tools for biomedical informatics. Currently, the course makes students familiar primarily with work in Matlab environment [14], learns them to analyze data and create their own applications and extensions for Matlab. Another course deals with the basics of theoretical medicine. Students passing the final exam will know basic medical terminology and will have basic information about the creation of terms and phrases used in medical terminology. The students will have also basic knowledge about the structure and functions of the human organism with emphasis on the morphology and function of tissues and systems of organs and will be able to create three-dimensional computer models of selected anatomical structures and use them in medical practice. Finally, in the course named as modelling of biomedical systems and processes, the students learn the basic modelling principles including the theoretical background in several biomedical areas. The topics covered by the course include random generators, discrete-event simulation, mesh generation, time sampling, and approximation of time variation of various processes. During laboratory classes, the students work with data that can be either the input for modelling or output of the modelled biological processes that need to be analyzed.

The third core group includes courses on data mining, biomolecular informatics and chemistry, and applied informatics in preclinical medicine. These courses mainly focus on understanding characteristics of biomedical data and algorithms for their processing and make students familiar with the application of data mining, machine learning and other approaches of artificial intelligence in the development of semi-automatic diagnostic systems to support decision making in medicine.

Project education is an integral part of the study program. It focuses on the practical use of the knowledge that students acquired in the aforementioned courses in real projects. These projects are devoted to the development of information systems for medical facilities, software tools for medical image data processing and subsequent semi-automatic diagnostics, new algorithms for processing uncertain data, as well as simulation tools facilitating the development of devices for the detection of tumour cells in the blood.

III. Conclusion

Biomedical informatics is an interdisciplinary field focused on the use of informatics and software engineering in the development of algorithms and software for processing medical and biomedical data to increase the quality of healthcare. It is assumed that the demand for specialists on informatics with the ability to use it in processing various biomedical data will increase in the coming years. This fact can be viewed by an increasing number of software companies dealing with the development of software for biomedical and medical purposes. This and other facts motivate Faculty of Management Science and Informatics to develop the new study program aimed at education of such specialists. This program was approved by the Slovak Accreditation Commission at the beginning of the year 2019 and now the first year of its teaching is running.

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REFERENCES

[1] V. Voski, A. Herrler, E. Zaitseva, M. Kvassay, Y. Law, R. B. Duparc, A. Sujar, M. G. Lorenzo, E. Smistad, and T. Deserno, "A virtual physiological Human Model for Regional Anaesthesia," in Proceedings of Virtual Physiological Human (VPH) Conference, 2016, pp. 1–4.

[2] E. Zaitseva, M. Kvassay, V. Levashenko, T. M. Deserno, V. Voski, and A. Herrler, "Qualitative evaluation of faults (mathematical incorrectness) in the anatomical model for Regional Anaesthesia Simulator," in 2016 International Conference on Information and Digital Technologies (IDT), 2016, pp. 311–318.

[3] J. Rabcan and M. Kvassay, "Identification of persons with epilepsy from electroencephalogram signals using fuzzy decision tree," in Information and Communication Technologies in Education, Research, and Industrial Applications. ICTERI 2017, vol. 826, N. Bassiliades, V. Ermolayev, H.-G. Fill, V. Yakovyna, H. C. Mayr, M. Nikitchenko, G. Zholtkevych, and A. Spivakovsky, Eds. Cham, CH: Springer, 2018, pp. 209–229.

[4] J.-M. Claverie and C. Notredame, Bioinformatics For Dummies. Hoboken, NJ, USA: Wiley Publishing, 2006.

[5] J. D. Bronzino and D. R. Peterson, The Biomedical Engineering Handbook: Four Volume Set. Fourth Edition, Fourth. Boca Raton, FL, USA: CRC Press, 2015.

[6] B. F. Branstetter, "Basics of imaging informatics: Part 1," Radiology, vol. 243, no. 3, pp. 656–667, Jun. 2007.

[7] B. F. Branstetter, "Basics of imaging informatics: Part 2," Radiology, vol. 244, no. 1, pp. 78–84, Jul. 2007.

[8] U. Orhan, M. Hekim, and M. Ozer, "EEG signals classification using the K-means clustering and a multilayer perceptron neural network model," Expert Systems with Applications, vol. 38, no. 10, pp. 13475–13481, Sep. 2011.

[9] A. S. Al-Fahoum and I. Howitt, "Combined wavelet transformation and radial basis neural networks for classifying life-threatening cardiac arrhythmias," Medical & Biological Engineering & Computing, vol. 37, no. 5, pp. 566–573, Sep. 1999.

[10] F. A. Afsar and M. Arif, "Robust electrocardiogram beat classification using discrete wavelet transform," in 2008 2nd International Conference on Bioinformatics and Biomedical Engineering, 2008, pp. 1867–1870.

[11] M. F. Ochs, J. T. Casagrande, and R. V. Davuluri, Eds., Biomedical Informatics for Cancer Research. Boston, MA: Springer, 2010.

[12] L. A. Lynn, "Artificial intelligence systems for complex decision-making in acute care medicine: a review," Patient Safety in Surgery, vol. 13, no. 1, p. 6, Dec. 2019.

[13] P. Compeau and P. Pevzner, Bioinformatics Algorithms: An Active Learning Approach. 3rd Edition. San Diego, CA, USA: Active Learning Publishers, 2018.

[14] Matlab. Available online: https://www.mathworks.com/products/matlab.html.