Development of University-Industry Centre of Biomedical and Medical Informatics

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Abstract

Biomedical and Medical Informatics (BMI) belongs to the rapidly growing interdisciplinary field which aims at implementation of digital technologies in all aspects of healthcare. Due to rapid development and integration of information and communication technologies into all areas of human life, it is expected that demands for experts in this area will grow in the coming years. This fact should be reflected by higher education institutions to develop new interdisciplinary study programs that educate specialists that have knowledge of medical and biomedical terminology, understand the current issues of biomedical research and have a strong background in informatics and digital technologies. European universities have reflected this reality and have begun to offer study programs in the area of BMI. In Slovakia, this fact has been reflected by Faculty of Management Science and Informatics of University of Zilina, which opened a master study program on BMI in September 2019. To support this program and grasp the best practices of European universities offering BMI-related study programs, University of Zilina prepared and coordinate Erasmus+ project bringing together universities and industrial partners from nine countries of the European Union. The aim of the project is to create a university-industry centre in BMI with an online portal covering current challenges in BMI and containing teaching materials for courses related to BMI. The portal will be available for free to students of partner universities as well as other universities and practitioners interested in BMI and will support not only regular learning but also distance learning in BMI.

Keywords

Biomedical Informatics. Electronic Healthcare. Interdisciplinary Studies. Knowledge Alliances. Learning Systems. Medical Informatics.

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INTRODUCTION

During the last years, Information and Communication Technologies (ICTs) have become an integral part of human lives. They can be found in industry, offices, homes, and others. An important economic sector, where the relevance of ICTs increases very fast, is healthcare. This fact can also be recognized in several resolutions of World Health Assembly (WHA) approved in the last 20 years (WHO, 2020). For example, resolution WHA58.28 on eHealth approved in 2005 recognizes the potential of eHealth (the use of ICT for health) to strengthen health systems and improve quality, safety and access to healthcare (WHO, 2005; 2020). Resolution WHA66.24 from May 2013 expands the previous one by the need for health data standardization in order to achieve a secure, timely and accurate exchange of data for health decision-making (WHO, 2013). Another resolution WHA71.7 on Digital health, which was approved in 2018, emphasizes that digital technologies including ICT and mobile technologies play one of the major roles in health promotion and disease prevention by improving the accessibility, quality and affordability of health services (WHO, 2018). According to these documents of World Health Organization (WHO), digital technologies have become an integral part of medicine and will play a significant role in achieving universal health coverage. This fact has resulted in the promotion of Biomedical and Medical Informatics (BMI).

According to Bernstam, Smith and Johnson (2010), BMI is the interdisciplinary study of the design, development, adoption and application of ICT-based innovations in healthcare services delivery, management and planning. It deals with the resources, devices, and methods required to optimize the acquisition, storage, retrieval, and use of information in health and biomedicine. BMI tools include computers, clinical guidelines, formal medical terminologies, and information and communication systems, among others. It is an emerging field for decades due to the rapid advances in biomedical, medical, and ICT sectors (Mihalas et al., 2014). Successful BMI research has resulted in the development of innovative technology-supported techniques, diagnostic and therapeutic methods leading to radical changes and enhancement of healthcare delivery (Sligo et al., 2017). Further growth in this interdisciplinary area calls for a pool of high-quality experts. This requires the development of new study programs and modernization of curricula of existing programs, which enable to educate specialists that are able to communicate with physicians, nurses and employers of biomedical laboratories to develop software for processing and analysis of medical and biomedical data, to design, implement and manage complex healthcare information systems, to create systems for support of decision-making in medicine, and to understand data produced by various medical and biomedical devices. This fact is reflected by universities among the whole European Union (EU). In Slovakia, it is reflected by Faculty of Management Science and Informatics of University of Zilina, which has offered from September 2019 a new study program named as Biomedical Informatics (Macekova, Kvassay and Zaitseva, 2019). During preparing this program, members of the faculty established cooperation with other EU universities and companies dealing with BMI and prepared a joint Erasmus+ project which aims at creating a Centre of BMI (CeBMI), whose main part will be an online portal supporting free access to teaching materials intended for the main courses of BMI.

The delivery of BMI training programmes in universities have to be a joint cooperative effort of medical and technical universities, which will be facilitated through the CeBMI. Within the project, a shared online BMI repository will be created by all core project

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partners, i.e. technical and medical universities for the delivery of BMI courses. Companies involved in the project will be able to promote their own products, e.g. medical and biomedical applications or various hardware and software medical solutions, and provide in-house technology training for academic staff. Universities will be able to increase the quality of BMI related educational programs. The joint academic-industrial research collaboration will be conducted by academic and industrial partners. The CeBMI will provide ICT tools and open educational resources for ICT-enabled pedagogic approaches to increase effectiveness in education delivery and enhancing learning experience. The CeBMI will develop a research-informed curriculum with vital inputs from the industries. Even though developing such a curriculum is challenging, it could be realized through an international and interdisciplinary joint collaborative effort of medical and technical universities as well as industrial technology providers. So, the main goals of this paper are to summarize the current state in teaching biomedical informatics, present results of analysis of the study programs connecting medicine, engineering and informatics in Slovakia, justify the need for the CeBMI and present the key requirements on the portal developed within the CeBMI.

STATUS OF BIOMEDICAL AND MEDICAL INFORMATICS

According to Mihalas et al. (2014), medical informatics or biomedical informatics has been developed across western countries for more than fifty years. With respect to Bernstam, Smith and Johnson (2010) and American Medical Informatics Association (AMIA, 2020), it is an interdisciplinary field that deals with the effective use of biomedical data, information, and knowledge to support decision-making in biomedicine and medicine, whose main goal is to improve human health. Sometimes, it can be referred to as a part of a similar area known as biomedical engineering. However, it is important to note that the key difference between BMI and biomedical engineering is a fact that BMI focus on processing and analysis of various data produced in medicine and biomedicine using computer technology, while the main focus of biomedical engineering is the development of hardware solutions to understand, modify, or control biological (e.g. human) systems by applying electrical, chemical, optical, mechanical, and other engineering principles (Bronzino, 2012). Another term that is closely related to BMI is bioinformatics. According to Claverie and Notredame (2006), it can be defined as the computational branch of molecular biology since it deals with the development of algorithms, methods and software solutions for processing of biological data. In this context, it can also be viewed as a branch of BMI.

Although WHO recognized ICT and all digital technologies as an important tool for achieving universal health coverage (WHO, 2020) at the beginning of the 21-st century, some works of Mihalas et al. (2014) or Polašek and Kern (2012) imply that BMI has existed in western countries for more than half of a century. This has resulted in the development of various study programs dealing with BMI in many European countries that are also recognized by European Federation for Medical Informatics (EFMI, 2020a), which promotes research and development in medical informatics and encourage high standards in education in medical informatics across Europe (EFMI, 2020b). According to EFMI (2020a), most European countries, including Czechia, have several study programs on medical informatics, health informatics, biomedical informatics, bioinformatics or biomedical engineering. However, no information about Slovakia is currently provided at webpages of EFMI. Because of that, we analysed study programs provided by Slovak universities. The

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analysis was performed based on data provided by PortalVS.sk (https://www.portalvs.sk/) and by finding all programs that contains in their names key phrases, which are in Slovak "bio" (for biology), "med", "lek" (for medicine), "zdr" (for health), "klini" (for clinical), "ort", "prot" (for orthotics and prosthetics), "digi" (for "digital"), "dát", "big" (for data and big data). After that we identified the study programs whose names pointed to the correlation between informatics, electrical or mechanical engineering and medicine or biomedicine. Finally, we inspected webpages of each of the identified universities and checked whether the university offers the found program and whether its content really coincides with applications of engineering or informatics in medicine or biomedicine. Based on this analysis, we found that just three universities offer technically oriented biomedical programs (Table 1). Furthermore, before 2019, there was only one study program dealing with processing of biomedical data (Bioinformatics at Comenius University in Bratislava) and no program on education of specialists in the development of complex software solutions for needs of BMI. Because of that, Faculty of Management Science and Informatics of University of Zilina has tried to fill in the gap and open the study program on Biomedical Informatics in September 2019. Now, it tries to support it by development of the CeBMI.

Table 1: Study programs combining engineering with medicine and biomedicine in Slovakia.

University	Faculty	English and Slovak name of study program	Level	Source
Comenius University in Bratislava	Faculty of Mathematics, Physics and Informatics	Biomedical Physics (Biomedicínska fyzika)	Bc.	https://fmph.uniba.sk/studium/programy/biomedicinska-fyzika/
		Biomedical Physics (Biomedicínska fyzika)	MSc.	https://fmph.uniba.sk/studium/magisterske-studium/biomedicinska-fyzika/
		Bioinformatics (Bioinformatika)	Bc.	https://fmph.uniba.sk/studium/programy/bioinformatika/
Technical University of Košice	Faculty of Mechanical Engineering	Prosthetics and Orthotics (Protetika a ortotika)	Bc.	https://www.sjf.tuke.sk/uchadzac/studijne-programy/bakalarske-studium/71-protetika-a-ortotika
		Biomedical Engineering (Biomedicínske inžinierstvo)	MSc.	https://www.sjf.tuke.sk/uchadzac/studijne-programy/inzinierske-studium/80-biomedicinske-inzinierstvo
University of Zilina	Faculty of Electrical Engineering and Information Technology	Biomedical Engineering (Biomedicínske inžinierstvo)	Bc.	https://www.uniza.sk/index.php/studijne-programy-info-bc?oblast=1
		Biomedical Engineering (Biomedicínske inžinierstvo)	MSc.	https://www.uniza.sk/index.php/studijne-programy-info-ing?oblast=2
	Faculty of Management Science and Informatics	Biomedical Informatics (Biomedicínska informatika)	MSc.	https://www.uniza.sk/index.php/studijne-programy-info-ing?oblast=2

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Online Portals Related to Teaching Biomedical and Medical Informatics

As mentioned above, BMI is a complex and interdisciplinary area that needs diverse yet complementary knowledge, expertise and competences in medicine, biomedicine and informatics. BMI curricula for health professionals must include statistics, knowledge discovery, image processing, telecommunication networks, system reliability and safety, augmented reality, virtual reality, data science, etc. All these represent various domains of informatics. BMI curricula have to be developed based on innovative and multidisciplinary approaches to teaching and learning. According to Pinho, Franco and Mendes (2018), all these goals can be satisfied through an online portal that incorporates necessary tools to facilitate easy and quick creation of new or modernization of existing curricula and programs so that they will be adaptive to dynamic changing needs of the BMI domain and will reflect the real labour market demands. Such a portal should include a repository of lectures' texts and presentations, a list of practical tasks for labs, multimedia sources for home works, etc. Due to specifics of BMI, the portal should also incorporate tools for data analysis based on R, Python, Matlab, SaS, and others.

Several portals partially matching the requirements introduced above currently exist, but they are primarily aimed at academic staff and students of medical universities. For example, medical universities can use the following online resources:

- MedEdPortal (https://www.mededportal.org/) – open-access journal and online repository containing teaching and learning resources used in the health professions published by Association of American Medical Colleges (AAMC), which represents 171 accredited United States and Canadian medical schools (AAMC, 2020);
- OnlineMedEd (https://onlinemeded.org/) – online portal containing teaching materials for students of medicine;
- Health Education Assets Library (HEAL) (https://mwdl.org/collections/HealthEducationAssetsLibraryHEAL.php) – a digital library providing access to several thousands of videoclips, animations, presentations, and audio files supporting education in healthcare published by University of Utah – Spencer S. Eccles Health Sciences Library;
- PubMed (https://www.ncbi.nlm.nih.gov/pubmed/) – a free resource supporting the search of biomedical and life sciences literature managed by the United States National Institutes of Health's National Library of Medicine, which belongs to the leading repositories of medical information (DeBakey, 1991).

However, the analysis of these and other resources showed that they cannot be used for engineers since the knowledge of students in medical and technical universities in both ICT and medicine is significantly different (Kim, 2019). This calls for the development of new resources in BMI for the technical universities. These resources should be stored at an online portal that will be an addition to existing resources to improve the background in BMI education for all specialisations. Furthermore, as Klaassen (2018) and Kim (2019) state, the resources should be developed in a way that supports interdisciplinary education in BMI, which makes easier future communication between computer and software engineers and analytics, doctors and nurses. For these purposes, it is important to develop the portal for supporting BMI teaching as a common project of technical and medical universities as well as partners from the industry. Such a concept celebrates great success in the development

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of the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) (http://www.merlot.org/), which represents an online repository of learning resources managed by international consortium of higher education institutions, industrial partners and individuals (McMartin, 2009). Furthermore, according to Sheffield (2006), MERLOT belongs together with MedEdPortal and HEAL to the most effective online portals containing information about healthcare. During the development and creation of the portal, we can also build on the experiences and results of the Medical Faculties Network in Slovakia and Czechia (MEFANET) (http://www.mefanet.cz/). These and other portals can be used as a source of knowledge helpful in the development of the portal related to BMI issues developed as an integral part of the CeBMI.

CENTRE OF BIOMEDICAL AND MEDICAL INFORMATICS

The principal goal of the project led by University of Zilina is the creation of multidisciplinary teaching and research CeBMI. According to the current state in teaching BMI summarized above, the key part of the centre will be an online portal that provides (a) innovative embedded tools for easy and quick development of new curricula and update of existing curricula on BMI; (b) a rich virtual environment cross-fertilisation of ideas, knowledge exchange, transfer and co-creation. The portal will be developed in a cloud-based platform in order to cater for concurrent users and also for scalability purposes in order to accommodate for a foreseeable increase in student numbers in the near future. The project partners will fill in the portal with teaching materials and modules prepared by them. All these materials will be available to the users of the portal, who are teachers and students of the partner universities as well as other educational institutions interested in BMI. Based on the analysis of the existing portals mentioned above, we decided that the CeBMI portal will include the functionalities presented below.

- *The BMI-repository and educational resources* that will include teaching materials and current BMI-related scientific as well as research findings. The repository will have a thematic module structure. Access to the repository will be provided via free online registration. Registered members will be able to upload additional teaching resources approved by the administrators of the portal. These BMI materials will be additional reading resources or references for students and other users of the portal.
- *The dissemination section* will publish partners' relevant publications and also provide links to open-access BMI-related journals. This facility is to provide easy access to the latest BMI state-of-the-art, research findings, challenges and best practices in BMI teaching.
- *The news* will provide information on latest developments and trends in BMI curricula, technologies, techniques, and approaches, job vacancies, events, projects, and advertisements of new ICT products for medicine and biomedicine.
- *The discussion forum* will provide a virtual environment for knowledge exchange and transfer, best practice sharing, etc. It will be one of the main communicative means amongst the project partners and the public.

The CeBMI will involve representatives of medical, technical universities/faculties, companies and enterprises as registered users. The aims of the CeBMI are:

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- using new instruments and technologies in the form of a portal for easy creation of new as well as multidisciplinary BMI-related curricula and modification of existing curricula;
- collating synergised BMI-related theoretical and practical knowledge;
- support of national and international cooperation;
- support of cross-sectoral cooperation between the academic staff of universities and enterprises, which will help students develop entrepreneurship mind-set and entrepreneurial skills. Such cooperation will also stimulate the flow and exchange of knowledge between academia and the industries;
- involvement of industrial experts in students' educational process;
- exposing academic staff to real and actual BMI-related application problems. Academics will help bring the academic, research and theoretical dimension to these problems.

All these goals will support the new study program on Biomedical Informatics opened in September 2019 at the Faculty of Management Science and Informatics of University of Zilina and allow other universities to modify and further improve their own curricula dealing with BMI.

Partners

The interdisciplinary approach of BMI requires a unique combination of skills and experience that can only be provided by the best scientists of various European countries. The project gathers a group of high-profile experts from BMI, informatics and medical fields of various European countries such as Germany, Italy, Slovenia, and the United Kingdom in case of BMI, Bulgaria, Slovakia, and Spain in case of informatics and Czechia and Finland in case of medicine.

The project consortium includes partners that have different specialisations and expertise in BMI that is necessary for the development of a multidisciplinary portal resource and to provide a wide range of BMI-related consultancy services via the CeBMI. More precisely, the project consortium is composed of the next educational institutions:

- University of Zilina from Slovakia with specialization in data mining, medical decision support systems, system safety and reliability,
- Leeds Beckett University from the United Kingdom with a focus on knowledge discovery and telecommunication,
- Peter L. Reichertz Institute for Medical Informatics of the Technical University of Braunschweig from Germany, which is one of the leading medical informatics institutes in Germany and worldwide with specialization in image processing, healthcare information systems, and telecommunication,
- Università Campus Bio-Medico di Roma from Italy dealing with big data, machine learning, image and video processing and analysis,
- Universidad Rey Juan Carlos from Spain dealing with knowledge discovery, medical decision support systems, and medical simulation,
- University of Oulu from Finland which has very good knowledge in properties and characteristics of healthcare information systems and general medical background,

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- Universitat de Valencia from Spain focusing on medical statistics and ethical, legal, and social issues of eHealth,
- University of Ostrava from Czechia with the background in medicine, protection of healthcare data, and ethical, legal, and social issues of healthcare information systems,
- and the following industry partners:
- TELESIG Ltd. from Bulgaria dealing with the development of tools for biometrics analysis in mobile applications and security of information systems,
- STAPRO Slovensko from Slovakia, which is the Slovak leader in the development of hospital information systems,
- Dr. Guido Kaufmann e.K. from Germany dealing with quality control,
- Bioanim from Slovenia focusing on applications for virtual reality,
- Hospital of Zilina from Slovakia which belongs to the main hospital in the Northwest Slovakia.

It is worth noting that all university representatives who are involved in the project are also active BMI researchers and their research will be fed into research-informed teaching and also the development of high-quality teaching materials that are of excellent high-quality international standards. This is important for the provision and delivery of excellent quality education that will meet the demands of the labour market.

Courses

The previous description of the project partners indicates they cover a wide range of knowledge in BMI. Based on their experiences, research activities, and educational abilities they agreed on the development of the courses dealing with the following topics:

- image and signal processing,
- medical simulation,
- data mining,
- reliability, safety, and security,
- telemedicine and hospital information systems,
- artificial intelligence in decision making support,
- educational software in virtual reality,
- medical statistics and medicine for engineers.

All these courses will be developed within the project, and they will be accessible without any fee not only to the project partners but also to other partners interested in BMI. It is worth noting that the courses try to cover most of the topics related to BMI according to Shortliffe and Cimino (2014), which is inspired by a Stanford University (SU) training program focusing on various aspects of BMI (SU, 2020).

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CONCLUSION

As we presented in this paper, BMI is a well-recognized interdisciplinary field in western countries. According to our research, no study program on this problematic was offered by Slovak universities till the year 2019. Faculty of Management Science and Informatics of University of Zilina has tried to fill in this gap by its new study program entitled Biomedical Informatics. To support this program by grasping experiences and skills of some of the European well-recognized experts in BMI, we proposed to develop the CeBMI, which should cover medical and technical universities as well as companies dealing with BMI to provide a breeding ground for further development of BMI in Slovakia and other countries of EU. The main part of the CeBMI will be the online portal containing various teaching materials and learning resources to support BMI teaching. According to our analysis of some of the similar portals, the main benefit of the portal managed by the CeBMI will be its focus on students of technical universities since most of the existing portals are primarily aimed at students of medical universities. Furthermore, the participation of medical universities in the project will allow developing materials in such a way that they can be used not only by computer scientists but can also be used as a source of additional technical knowledge for graduates of medical universities, which can be a great support for interdisciplinary education in BMI. The current progress in the implementation of the project and development of the portal can be watched at the project homepage http://cebmi.fri.uniza.sk/.

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