Interdisciplinary Areas: Lessons Learned and New Challenges

Lenka Lhotska, Vladana Djordjevic
Dept. of Cybernetics
Faculty of Electrical Engineering,
Czech Technical University in Prague
Prague, Czech Republic
lhotska@fel.cvut.cz

Jan Havlik
Dept. of Circuit Theory
Faculty of Electrical Engineering,
Czech Technical University in Prague
Prague, Czech Republic

Milos Klima
Dept. of Radioelectronics
Faculty of Electrical Engineering,
Czech Technical University in Prague
Prague, Czech Republic

Abstract—**In the paper we will discuss our recent experience and lessons learned from education in interdisciplinary areas, such as biomedical engineering, cybernetics and robotics, and multimedia. Then we will describe our current effort in establishing integrated laboratory facility for interdiscplinary hands-on laboratory practice.**

Keywords-interdisciplinarity; cybernetics; biomedical engineering; assistive technologies

I. Introduction

Although engineering has always been interdisciplinary, recently this feature has become more and more obvious and important. Technological development influences and inspires many areas outside technology and engineering. Thanks to development of integrated solutions engineering disciplines are influencing each other as well. Let us mention, for example, robotics, biomedical engineering, and assistive technologies.

Robotics integrates and also influences “classical” disciplines, such as mechanical engineering, electrical engineering, control engineering, artificial intelligence, and computer vision. When applied to medicine (surgical robots), medicine is added to the list. Biomedical engineering (BME) covers even broader range of disciplines than robotics. Therefore the mutual influence is also more intensive. These areas are nowadays covered well both in research and education. Assistive technology also encompasses very broad range of disciplines, including information and communication technologies. We can also identify purely software areas such as eInclusion or eAccessibility, as well as mixed ones, as for example e-healthcare. Assistive technology exists in research however it is not yet covered in education in their complexity.

II. Biomedical Engieering

The study program Biomedical Engineering (BME) covers extensive area of advanced biomedical technologies, both of hardware and software. It concerns signal theory, methods of system modelling and simulation, image processing, complex medical data processing and interpretation, design and implementation of large health care information systems, design and realization of complex medical devices; complex view on the whole chain starting from a patient (measurement, examination methods) over data analysis to evaluation and interpretation and successive storage in health care records; engineering design and construction of medical devices, measurement, transmission and processing of electric and non-electric quantities. The students acquire very good theoretical fundamentals with strong interdisciplinary structure. Thanks to this they are flexible and have competitive advantage on the labor market.

Biomedical engineering applies engineering methods, science and technology to problems in medicine and biology, and is a growing field that will continue to have a significant impact on health care. It also involves learning about biology in new ways and developing new tools to diagnose disease and to repair or replace diseased organs.

Biomedical engineers work with other medical health care professionals as members of a team. Exciting advances in medicine, such as the artificial heart, pacemakers, medical imaging techniques, lasers, prosthetic implants, life support systems are the result of a team effort by biomedical engineers and other professionals.

The curricula were developed in close cooperation with clinical engineers working in hospitals and medical doctors. So they are based on long-term practical experience. The program also contains practical training in university hospitals and specialized clinics as a very important part of education. Before the students start this practical training they pass courses where they acquire information about all the devices and medical data and signal processing they will then experience in the hospitals. They have also courses on medical terminology, first aid, anatomy, physiology and pathophysiology taught by medical doctors from the First School of Medicine of the Charles University Prague. In that way they have the first contacts with medical doctors, their style of work and communication which is very important for the training in the hospitals.

The students come into direct contact with patients, advanced technology, medical doctors, nurses, and engineers working in the hospital. The students learn to be team members, team leaders, to provide information, educate and perform health care education of individuals and groups and take on responsibility for provided health care. The practical training is closely linked with the work in individual and team projects so that the students can experience more complex view on the problems to be solved. For example, a task in medical image processing starts with on-site visit at MR, CT or PET, recording the images, then processing and evaluating them.

At the end of their studies the students should have an idea about the complex chain starting from a patient over measurements, analysis to diagnosis and subsequent therapy based on the latest technological development in electronics and information technology, thus using all diagnostic, measuring and evaluating systems that may be used in medicine. They should be able to orientate themselves in both technical and non-technical problems linked with technology application in medicine as well.

III. Assistive Technologies

Nowadays thanks to results reached in technological development we can observe that the applications move closer to our everyday life. Houses, environments, household appliances and things of daily use are getting smarter and smarter. We can observe another phenomenon as well, namely shift of focus to quality of developed technologies with respect to users, including those with special needs. eInclusion has become main driving force for open information society. Inevitable part of this process is research and development in the area of information and communication technologies, electronics and automation, where in collaboration of engineers, medical doctors, and disabled people there are designed and developed various tools, aids, devices, computer programs, and educational aids whose purpose is to help and ease daily activities of disabled and elderly people.

Assistive technology (AT) is technology used by individuals with disabilities or age-related health conditions in order to perform functions that might otherwise be difficult or impossible. It allows them be more independent and live in the least restrictive environment. Assistive technology can include mobility devices such as walkers and wheelchairs, as well as hardware, software, and peripherals that assist people with disabilities in accessing computers or other information technologies. For example, people with limited hand function may use a keyboard with large keys or a special mouse to operate a computer, people who are blind may use software that reads text on the screen in computer-generated voice, people with low vision may use software that enlarges screen content, people who are deaf may use a TTY (text telephone), or people with speech impairment may use a device that speaks out loud as they enter text via a keyboard.

Smart environments, houses, and homes are very close to assistive technologies in the sense that they can support more independent living of disabled or elderly people.

IV. Lessons Learned

It is evident that the relationship between education and research in all above mentioned interdisciplinary areas must be very close. The relationship not only comprises of research results from electrical engineering but also from medicine and other relevant areas. It is necessary to include all these developments into courses for students so that they are informed about these trends and after graduation are able to work with the advanced technology in practice. It means that very good coordination is required between many different institutions, as technical universities, hospitals, and schools of medicine are.

When we have designed the curricula in BME, we have tried to take into account all the aspects of modern ways of education and the fact that BME is an interdisciplinary area. The students must have possibility to acquire team skills, including collaborative, active learning abilities, communication skills, leadership skills, and a multidisciplinary perspective during their study. Thanks to involvement in departmental and medical research, both basic and applied through the individual and team projects, they can experience research and engineering work.

Engineers use technology to solve practical problems. The technology that they use is underpinned by scientific knowledge and principles. Engineers must therefore have:

- Factual knowledge about the technology and scientific principles relevant to their branch of engineering;
- An ability to understand the context of a practical problem, and then define it in terms that can be understood and agreed by the client (usually a person from a different problem domain);
- An ability to use technology creatively to give the most effective solution to the client's problem;
- An obligation to do this ethically and in the best interests of the client; this is the basis for trust and a professional relationship.

In the old days the engineer's "client" was perhaps the company's production manager. Engineers tended to work for other engineers. Now, the engineer must deal with a much wider range of people inside and outside the company. He or she is more likely to be involved directly with the company's customer. This requires a wider viewpoint and the ability to work with a customer who often lacks technical knowledge. It is important to succeed because business success and even survival is determined by the customer.

In biomedical engineering and in assistive technologies all these requirements are even more appealing. The customers/users are almost exclusively non-engineers and they need simple and intuitive control of the applications (devices and software). Working in classical laboratories where the students usually do not see or realize the real-life context of the given problem is good for topics focused only on technical side of the problem. However when we want that the students really understand the practical problem and are able to see it from the user's perspective. This was our motivation when we decided to design a new project of the Centre for Assistive Technologies. It is closely linked with our research in assistive technologies and ambient assistive living (AAL).

V. Centre for Assistive Technologies Project

We have established a specialized facility – Centre of Assistive Technologies composed of several laboratories and working places: smart home, medical technology and biosignal laboratory, audio/video media laboratory, communication laboratory, and computer/seminar room. The first two are the core of the centre, the remaining three serve for education and research in connected areas and provide also support for the main part. The medical technology and biosignal laboratory has three sections, namely fully equipped intensive care unit (ICU), EEG laboratory (where also other biosignal measuring devices are placed) and medical technology section. This laboratory is focused on research and education that is closely linked with medicine. The intention is to introduce to students most of the technology they can meet in hospitals and in some cases in home environment. They have to understand the processes from the technical point of view. For example, at ICU there is also complete installation of electric power and data networks as in hospitals because the hospital installations have to satisfy more strict requirements concerning electric safety. Here we add new sensors that allow additional monitoring of the patient with respect to his/her safety, state of the bed, etc. The main idea is to design and develop approaches and successively devices that will be able to indicate certain medical problems, one of them indicated by medical doctors is hydration of the patient. Currently only indirect evaluation is done, namely volume of urine. In this area also research connected with electromagnetic compatibility, interference of wireless communication with medical devices will be performed.

The smart home is a test bed for design and development of different setups and functions that can be finally used in inhabited homes. The basic functions currently prepared are: security, control of home appliances, monitoring person´s activity, and monitoring person´s health state. Now we describe individual functions and technology behind. Security means protection against intruders and we add also safety in the environment. For the security function we can use cameras, PIR-based motion detectors, detectors of open/closed windows and doors. Safety function should control whether specified devices and home equipment are in required state, e.g. whether iron or cooker are switched off when leaving the home, or whether the water tap is closed. Monitoring person´s daily activity is important when the person lives alone and has certain disabilities. Then we have to check whether the person is doing well, has not fallen down and injured. Another case is prescribed physical activity or rehabilitation, e.g. after an injury, brain stroke or when multiple sclerosis is diagnosed. Here we can make use of sensors installed for security function and additionally accelerometers, tactile sensors, etc. Monitoring person´s health state can make use of the knowledge and skills acquired in the medical technology and biosignal laboratory. Only for personal monitoring we need miniaturized devices. Again according to the diagnosed health state we can propose corresponding setup of measuring equipment (e.g. ECG, blood sugar, blood pressure, body temperature, transpiration, breathing). Recent medical studies have shown that especially in elderly population there is problem with food and liquid intake. So one of the challenges is to monitor unobtrusively and relatively precisely how well the person is nourished. On the other hand at obese people it would be welcome to monitor amount of food and provide recommendation and warning against excessive food intake.

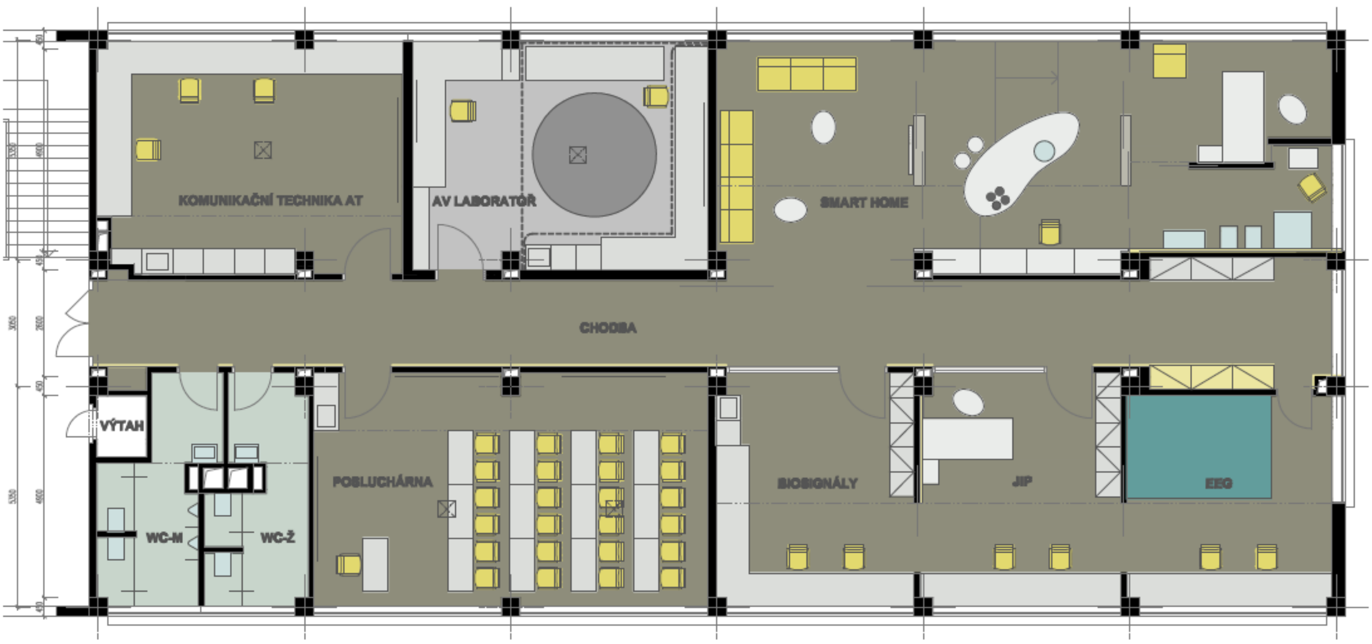

Figure 1. Ground plan of the Centre for Assistive Technologies

The facility will serve for practical project-based education of students in BME and especially AT. The situation in the given field may be characterized in following way: there are no graduates specialized in AT; there is no complex educational program in AT; there exist a number of information barriers between disciplines that may be solved exclusively by consistent interdisciplinary integration; there exists social and objective demand for employees in AT; in the Czech Republic there are relatively many SMEs and institutions focused on AT that need graduates and support for life long learning of current employees. The courses will become a core of an interdisciplinary study branch in Master study and at the same time they will be offered in life long learning. The core courses cover the following topics: data sensing and transmission; sensors, security and control in assistive environment; circuitry and system principles of electronic devices for AT; advanced methods of data mining and knowledge discovery and their applications in AT; telecommunication equipment and systems for AT; multimedia technology. The topics are systematically and logically interconnected. The content is designed in such a way that theory, applications and system integration are represented in suitable proportion.

The Centre will serve as a platform both for education and for applied research in the area of AAL. The main idea is to offer space for development of integrating solutions. Currently there are many partial solutions of smart homes, home security, health state monitoring, internet services. The problem is that these applications have been developed separately and usually they work as closed systems without possibility to interconnect them. The aim is to offer a standard user interface and communication for interconnection of various services and devices.

VI. CONCLUSIONS

Although it seems that all technologies described above are somehow covered by existing courses in electronics, informatics, telecommunications, etc., these courses are not properly interconnected. Nowadays we educate engineers specialised in electronics, or telecommunications, or informatics. But many of them are lacking the system view on an interdisciplinary problem.

In addition to purely technical courses there must be introduced courses that cover problems of handicapped people (for example their sensing limitations linked with necessity of having different computer or device interfaces, movement limitations – different design of equipment). The students must acquire knowledge about different types of handicaps and means how to compensate them. Further they must be educated in the design of tools and devices with respect to cognitive impairments, vision and hearing problems, supported communication, supported mobility; assessment and requirement analysis, and related topics. Another large area of interest is eAccessibility, namely improvement of access of handicapped people to electronic resources, including Internet. And last, but not least the legal, ethical and social issues must be considered since we are working with sensitive data similarly to medical domain.

Stress must be laid on project-oriented education. One of the aims of the prepared program is to educate engineers that will be able to design new technology, devices, and facilities with regard to people, considering their disabilities and not creating unnecessary barriers. We can find examples of tools and devices that were originally developed for disabled people and now are used by everybody.

In the area of AT it is desirable to include disabled students into project teams. For example, when solving a problem linked with mobility impairment, a student on a wheelchair could show and explain what the possibilities of movement are and what the restrictions we are not aware of are.

This last example shows that technology must be created with regard to people, considering their disabilities and not creating unnecessary barriers. From many tools and devices originally developed for disabled people, all users profit now. Traditional disciplines must leave their “trodden” paths and enter new dialogue and contribute to open and accessible society.