Study on Need Assessment of Mechatronics Education in Norway and Poland

Hirpa Lemu, Jan Frick, Tadeusz Uhl, Wojciech Lisowski, Piotr Piwowarczyk

Study on Need Assessment of Mechatronics Education in Norway and Poland

Hirpa G. Lemu[1*], Jan Frick[1], Tadeusz Uhl[2], Wojciech Lisowski[2], Piotr Piwowarczyk[2]

[1]University of Stavanger, Stavanger, Norway
[2] AGH University of Science and Technology, Department of Robotics and Mechatronics, Kraków, Poland

Abstract. This article presents a summary result of the survey on the need for mechatronics education. The study was conducted as a cooperation project between two teams established at two universities: AGH-UST from Poland and University of Stavanger (UiS) from Norway. Both companies and High School Pupils are surveyed in this project, but only feedbacks from the former are analyzed in this article. As a result of the declining interest for engineering and science education in general and mechatronics education in particular, the project is intended to work out an International Curriculum for mechatronics education that can stimulate pupils for science and technology fields as well as to encourage students in engineering education. The field of mechantronics has been focused because this field, as a new and multidisciplinary area, has a high potential to integrate topics that are necessary for modern engineering industries and can provide graduates in a multi-skill and knowledge.

Keywords: Mechatronics, mechatronics curriculum, multidisciplinary field

1 Introduction

Complex mechanical systems of today like airplanes, cars, industrial process machines and spaceships have many embedded mechanical and electronic systems that monitor and control the behavior to avoid catastrophic failure and improve the performance. With its origin in Japan in late 1960s [1] the term mechatronics was in principle coined to define such control and operation systems. The concept has since spread all over the world and a significant international growth has been observed within the last three decades. According to technology review of MIT press [2], mechatronics is identified as one of the top 10 technologies that will change the future world. The field is in general viewed as the vehicle by which students are introduced to and made to comprehend the diverse disciplines (Fig. 1) such as computer science, electrical and mechanical engineering areas concurrently. By combining diverse fields, mechatronics curriculum provides sufficient background, knowledge, depth and breadth enabling the graduates to tackle complex engineering problems.

* Corresponding author: Hirpa.g.lemu@uis.no

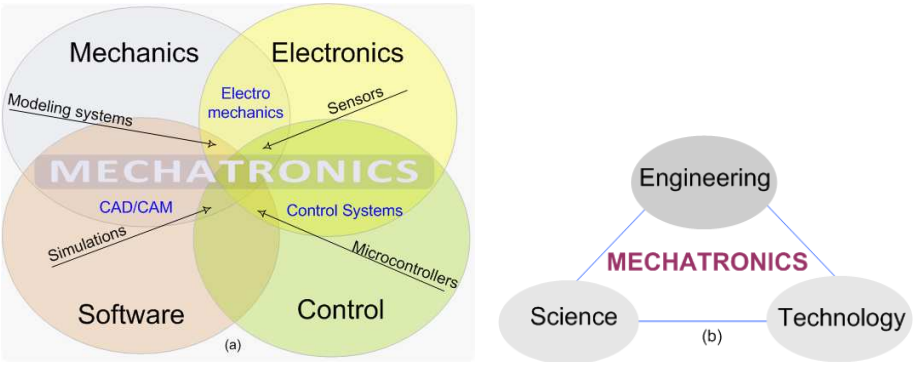

Fig. 1. Illustration of the diverse fields and concepts making up mechatronics

Understanding the fact that mechatronics is a newly emerging branch of study, that can interlink engineering, science and technology (Fig. 1(b)), many universities [3-5] have examined the curriculum in order to, among others, improve the structure and content of the program, increase the recruitment of students and improve effectiveness of teaching.

A number of these recent studies have attempted to investigate the organization of universities and how teaching of this discipline can be conducted. Some of the previous studies focused on the issue from the view of education philosophy of engineering [6] while others worked on the programs of curriculum [7] as well as the evolutionary development of the field as an engineering branch and the possible standardization of the education on nearly universal base [8]. The reported surveys, mainly in universities, have both national and regional characteristics[9].

Other studies [10] have attempted to define the identity and legitimacy of mechatronics as well as the implications on the selectivity and communication of the subject. This identity definition considers mechatronics as the "synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes" rather than the descriptions of the discipline solely as an interdisciplinary subject, as the union between mechanical and electrical engineering, control theory and computer science or other combinations of traditional disciplines within an engineering sphere. It is also important to recognize that mechatronics is not only a combination of engineering subjects, but it, as a multidisciplinary field of study, integrates science and technology with engineering (Fig. 1(b)).

The focus on formulation of mechatronics curriculum and defining its identity is, in a way, well motivated because comprehending a multidisciplinary field is challenging unless a suitable curriculum that motivates the students is outlined. At the same time it is essential that the formulated curriculum fulfils the expectations of the job market. A recent review by Alvarez Cabrera, et. al. [11] highlights the list of some of the existing challenges in design of mechatronics curriculum and systems for both the academia and industrial sector.

Based on the declining trend of interest for mechatronics study at well established universities like AGH-UST of Kraków, Poland, assessment of the need for this study has been initiated. The purpose of this study partially reported in this article is primarily to formulate a fundamentally new curriculum that enables a greater degree of self-direction in designing and developing mechatronics systems. To make the survey more comprehensive the expectations of students concerning the mechatronics study were also taken into account during the assessment. This article attempts to present a brief summary of the results of this cooperative research.

The rest of the article is organized as follows: Some highlight of the assessment approach used in the study and analysis of the company feedbacks are given Section 2 and 3 respectively. Section 4 discusses the practical implications of the feedbacks and Section 5 presents briefly students' expectations to mechatronics study. Finally, conclusion is given in Section 6.

2 Assessment Approach

This study is a result of a collaboration project between two teams: one team from AGH-UST of Kraków, Poland, and the second team from University of Stavanger (UiS), Norway. During formulation of the project objectives the team understood the mission of universities in formulating the curriculum as twofold:

1. Supporting professional success of their graduates on the labor market, and
2. Providing the candidates that suit the needs of the job market.

To achieve both objectives, questionnaires were prepared and concurrently distributed among companies and high schools in Norway and Poland. The study in this article presents the analysis results of company feedbacks in which 25 companies from Krakow area, and 12 companies from Stavanger area, are involved. In line with the stated project objectives, the questionnaires focus on two main parts.

1) *Collecting information on the companies:* this involves, among others, company size, profile, business life and the legal form of the company, and the role of mechantronics as a multidisciplinary area of knowledge as well as the extent of research oriented activity in the company and cooperation with universities.

2) *Assessing the companies' expectations:* this focuses on what the companies expect from a university graduate (possible recruit) related to the knowledge and predispositions. This includes what guides the company's recruitment policy and the basic knowledge, competence and skill the company expects from a graduate. In order to collect sufficient information for this part of the questionnaire, the survey has attempted to address the following three issues:

i. personal traits of the graduates,
ii. the theoretical knowledge base of the graduates and
iii. the necessary practical engineering skills.

3 Analysis of Company Feedbacks

3.1 Characteristics of the Surveyed Companies

Company Size, Profile and Legal Form: As depicted in Fig. 2(a), some specific features are observed regarding the results of the survey. The survey from Stavanger area covers mostly SME companies that were founded recently. This has a clear historical reason related with the recent development of oil industries in the region. Quite a large number of these companies have operated as individual business companies. The survey indicates also that about a half of them are involved in R&D activity and knowledge-based products and/or services do not constitute the critical part of their output.

The Polish partners, on the other hand, conducted the survey mainly at large companies, where a considerable amount of them have been operated quite long and currently most of them are international firms (with partial ownership). Majority of the companies conduct their own research at their R&D units. Most of the products and/or services offered by these companies are knowledge-based ones. The majority of the companies in both areas are involved in production and services (Fig. 2(b)). Further, the legal form of the companies involved in this study, in both areas, is limited liability ones that are usually the most innovative part of the technical service as well as manufacturing market.

A good communication between industries and the academia can be considered as a key to correlate the needs of the job market and the content and depth of teaching as well as the conducted research at universities. The diagrams in Fig. 3 show the results of two of the questions forwarded to the companies in order to get some indication on the level of R&D activities in the companies and the degree of cooperation with universities. The survey shows that many of the companies in both areas have their own R&D department and they do cooperate with universities. The usual forms of the cooperation are R&D projects and support of teaching by arranging visits and internships for students. The companies in Stavanger area do have high level of cooperation with universities, particularly in research consulting. On the contrary, the important area of cooperation between companies and universities in Kraków area is support of testing by universities.

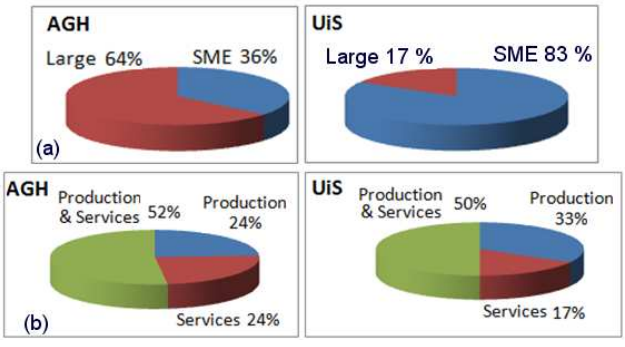

Fig. 2. (a) Size and (b) profile of surveyed companies

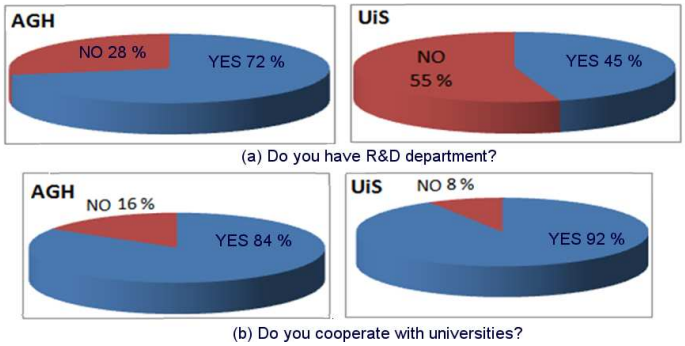

Fig. 3. (a) Availability of R&D department at the company and (b) degree of cooperation with universities

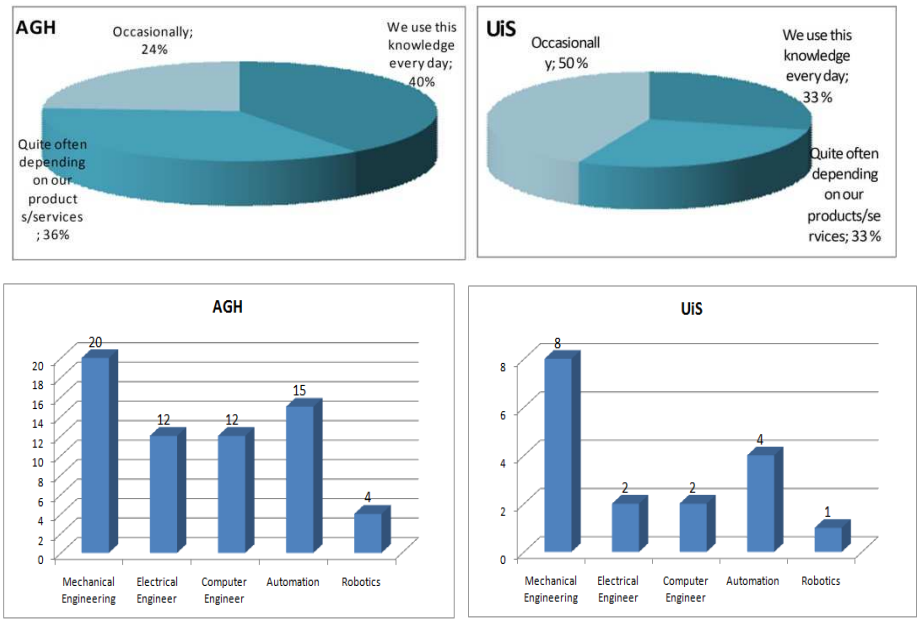

Fig. 4. Role of mechatronics in industry (top) and areas of mechatronics used in industry

Role of Mechatronics in the Companies: One possible reason for the declining interest in mechatronics can be the fact that this discipline is multidisciplinary. It demands, among others, to device or to develop new methods and engineering tools for the teaching process and the demonstration of mechatronics solutions in terms of modeling, simulation, evaluation and optimization. The developed methods and tools should have an advanced character targeting the non-homogeniety of the knowledge among the involved disciplines.

Further, the role of mechatronics field of study will depend on how the identity of the field is defined and recognized both at universities and on the job market. A

challenge to universities in stimulating interest in this discipline is to find the right identity in terms of coining courses from computer, electrical and mechanical engineering fields and clear professional definition of the graduates so that the job market understands the skill and knowledge gained by a graduate. Clear definition of the identity will have high implications on, for example, the design methodology, the modeling approach, the manufacturing processes and the material selection of mechanical products, components and systems.

Contrary to the suspicion of the project team, the feedbacks in general show that the companies use mechatronics as the methodology of solving problems in their everyday activity (Fig. 4 (top)). Among the areas listed in the questionnaire, the feedbacks indicate that mechanical engineering and automation are mostly used (Fig. 4 (bottom)). Quite strikingly, the distribution profile of the used technology in both surveyed regions is similar.

Most preferred plan of teaching for mechantronics:

3.2 Expectation of Companies from Mechatronics Education

Apart from few exceptions, the feedbacks from both regions have similar characteristics in terms of expectations and preference to mechatronics education and its curriculum. Most of the companies consider professional knowledge to be the most important skill of a candidate to be recruited. In order to contribute to this expectation, they stressed that practical application of knowledge through internships or trainings should be focused as part of education in engineering, compared with laboratory works and lectures (Fig. 5). Though the general preference tendency is similar in both regions, companies in Poland indicate a significant interest in lectures and laboratory work based teaching.

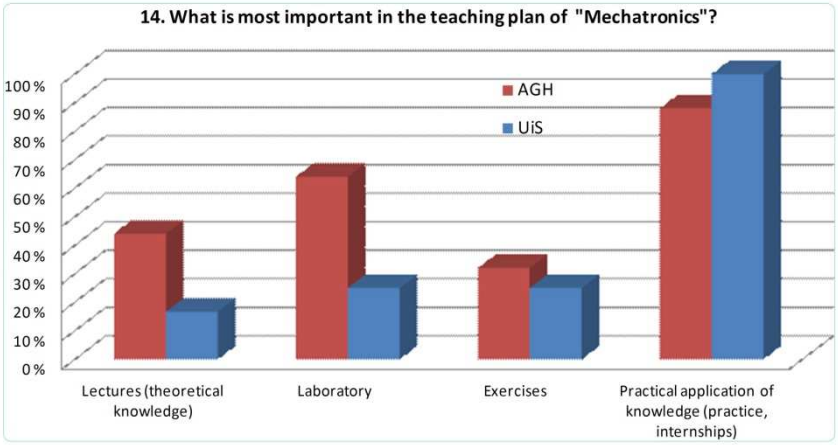

Fig. 5. Preferred teaching plan of study in mechatronics curriculum

With respect to preference of personalities of a graduate, the feedbacks (Fig. 6) indicate that the following are most appreciated by the employers: ability to work in team, creativity, independence, responsibility and loyalty with integrity.

In addition, companies in Poland stressed ability to seek self-knowledge through patents and standards, while Norwegian companies indicated importance of the communication skills and ability to cope with stress as their best preference. One main objective of the project is to formulate a new mechatronics curriculum that reflects the needs and expectations of the modern industry. The assessment (as depicted in Fig. 7) indicates that companies from both countries have high preference for

- ability to integrate knowledge from different fields,
- ability to analyze structural behavior and functionality of products in their environment,
- knowledge of computer-aided engineering systems,
- knowledge of mechanical systems and
- knowledge of construction and operation of machines.

The companies from Poland highly prefer practical knowledge of a foreign language as a language of professional communication, while the response of companies from Norway indicates very low preference for this skill.

The last question in the questionnaire focuses on assessment of expectations with respect to specific skills that are important for the company in the future. The preference of the companies in those specific skills (Fig. 8) is no exceptional. Most preferred skills include knowledge of use of computer-aided design (CAD) systems, knowledge of manufacturing technologies and selection of the engineering materials.

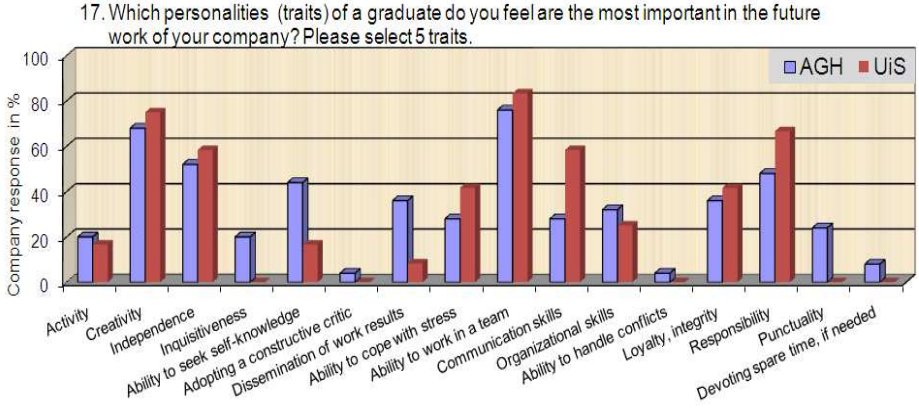

Fig. 6. Feedbacks on required personalities of a graduate in engineering

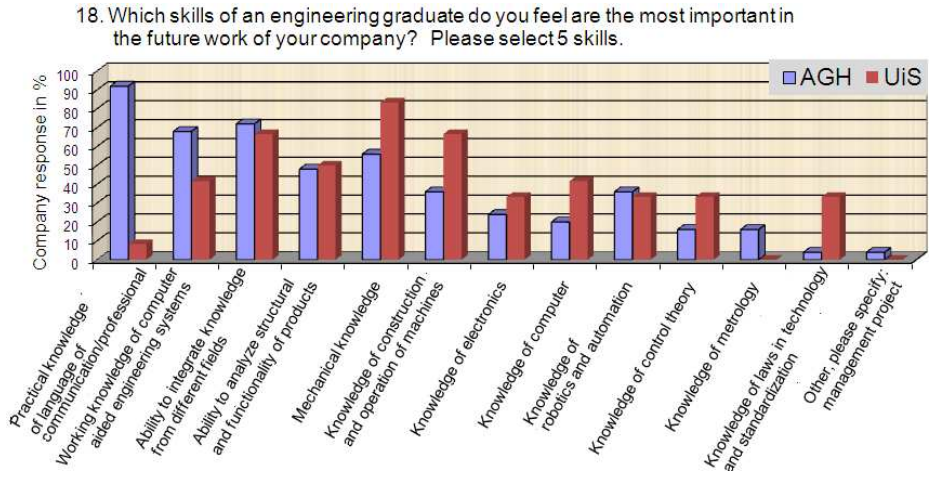

Fig. 7. Feedbacks on required skills of a graduate in engineering

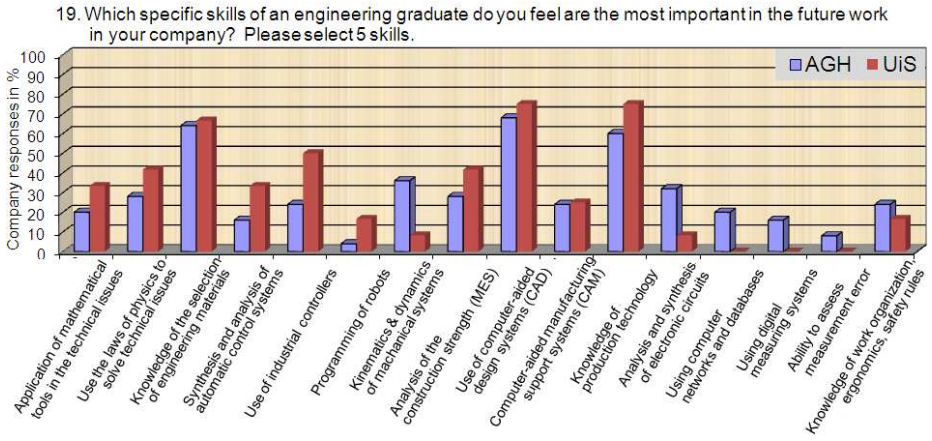

Fig. 8. Feedbacks on important specific skills required for a future graduate in engineering

4 Some Practical Implications of the Feedbacks

Though only few companies are assessed in this study, the feedback gives some indications to be taken care of in formulating a new curriculum for mechatronics education. The majority of the companies are willing to cooperate with universities in order to improve teaching methodology in the filed. Unless this is materialized, it is difficult to include practical trainings and internships in the study program. This study has also brought some obstacles to our attention. Introducing internships in both countries bears difficulties and risk of making the study program longer. Though a successful internship may require only 2 - 3 months, it is impractical to be completed parallel with the studies in accordance with the current academic plan.

The companies, in general, seem to underestimate theoretical knowledge and give less emphasis on skills in application of mathematical tools and laws of physics, while concurrently they demand the innovative approach and skills that need training. To train these skills a project based teaching and problem solving in a team with clear distribution of tasks and responsibility is suggested by the project team.

5 Students' expectations

The goal of any student to attend a given field of study is gaining knowledge and skills that provides him/her with well earned job. In addition, there are certain other factors that drive to enroll into a study program and strive to complete it. This involves primarily the correlation between interest and capability. One important challenge for mechatronics curriculum is thus its multidisciplinary character. The curriculum can be viewed as the means of introducing the subject matter in those diverse areas such as mathematics, electronics, mechanical and computer engineering fields. Lack of interest or fundamental understanding in one or several of these elements possibly leads to lack of interest in mechatronics study.

The other issue is making the teaching process interesting. This can be enhanced by introducing a practical oriented teaching process as discussed in the previous section. Experience shows that students, particularly engineering students, prefer hands-on learning than theory based ones. This demands resources in terms of cooperation with industries and qualified teaching staff.

The field of mechatronics is relatively new and not well known in the ordinary people's life. In a survey carried out as part of this project in Stavanger area, about 44% of the responded High School pupils do not know/understand what the word "mechatronics" means. Some work is needed to make the field well known to the potential candidates of the university enrollment.

6 Conclusions

The survey reported in this article was initiated due to an existing problem in recruiting students to mechatronics study program. As stated earlier in this article, few articles have appeared in the literature addressing this issue with a target of formulating an effective curriculum for mechatronics education. As it stands now, the solution to the problem has more of regional or local characteristic than universal. Among others, the knowledge and skill needed by the locally operating companies influence the content, depth and method of teaching. The feedbacks from this assessment have provided key indications in the extent to which mechatronics is known and implemented in companies and enabled us to identify their preferences. This will for sure help us to formulate an effective and attractive curriculum of the future. Further, it is highly expected that the obtained responses in the assessment will provide a good basis for discussions among members of the project team on the study curriculum, methodology of education, and contents of the didactic materials.

Acknowledgement: The authors gratefully acknowledge the financial support provided by Island, Liechtenstein and Norway by means of co-financing by European Economic Area and Norwegian Financial Mechanism under the Scholarship and Training Fund, project number FSS/2008/X/D5/W/0045.

References

1. Buur, J.: Mechatronics Design in Japan. Institute for Engineering Design, Technical University of Denmark, (1989).
2. Technology review, MIT Press (2003).
3. Lyshevski, S. E.: Mechatronic curriculum – restrospect and prospect. Mechatronics. 12, 195 – 205 (2002).
4. Meek, S., Field, S., Devasia, S.: Mechatronics education in the Department of Mechanical Engineering at University of Utah. Mechatronics**.** 13, 1 – 11 (2003).
5. Akpinar, B.: Mechatronics education in Turkey, Mechatronics. 16, 185 – 192 (2006).
6. Parasuraman, S., Ganapaty, V.: Philosophy and objectives of mechatronics education. Industrial Technology, 2002. IEEE ICIT '02. 2, 1199 - 1202 (11-14 Dec. 2002).
7. Kayis, B.: Trends in undergraduate mechanical, manufacturing, aerospace and mechatronics programs Wordwide: In-depth Study of 55 Universities' Programs. Engineering Management Conference. Proc. of IEEE Int., vol. 1, 178 – 182 (2004).
8. Grimheden, M., Hanson, M.: Mechatronics - the evolution of an academic discipline in engineering education. Mechatronics. 15, 179-192 (2005).
9. Acar, M.: Mechatronics Engineering Education in the UK, In: Mechatronics: the basis for new industrial development, Computational Mechanics Publications. pp. 763-770 (1994).
10. Grimheden, M. Hanson, M.: What is Mechatronics? Proposing a Didactical Approach to Mechatronics. Proc. of 1st Baltic Sea Workshop on Education in Mechatronics, Kiel, Germany (2001).
11. Alvarez Cabrera, A.A., Foeken, M.J., Tekin, O.A., Woestenenk, K., Erden, M.S., De Schutter, B., van Tooren, M.J.L., Babuška, R., van Houten, F.J.A.M., Tomiyama, T.: Towards automation of control software: A review of challenges in mechatronic design, Mechatronics. 20, 876–886 (2010).