Development Trends of Mechatronics

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Abstract: Mechatronics is an interdisciplinary field integrating Mechanical Engineering, Electronics, and Computer Science. In this paper are presented the "face" of was changing dramatically over recent years. The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework. This trend at system level is fuelled by growing investments in the fields of medical, life sciences and renewable energy as well as developments in industrial machinery. This approach greatly improves the design process by combining best practices and technology available to streamline design, prototyping, and implementation. By splitting the design process into parallel threads, the engineers may introduce a more efficient process of creation. Improving our way of life and the goods we use is not constrained by the common fields limits. In the nearest future, mechatronics will play a major role in enhancing the reliability, protection and affordability of products. In this paper are presented a development trends in Mechatronics and the future research will look into the negative effects of these technologies and necessary solutions to mitigate the threats.

Keywords: Mechatronic, Trends, Education, Cobots, Renewable sources.

1 Introduction

Mechatronics is an artificial word describing the integration of mechanical engineering with electronics, computer systems, and advanced controls to design, construct, and operate products and processes. Mechatronics is one of the newest branches of classic engineering with far-reaching applications. Generally, a mechatronic system can be seen as a mechanism, which is driven by actuators that are controlled via microelectronics and software using feedback from one or more sensors.

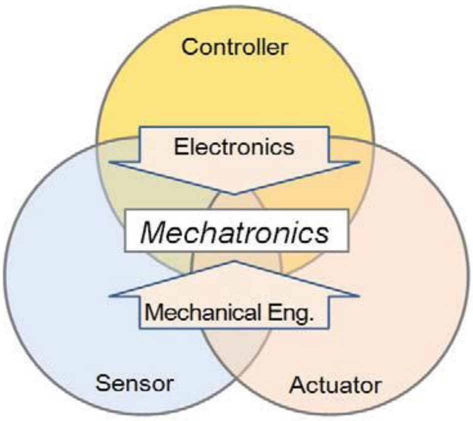

Fig.1 Basic components and disciplines of Mechatronics [1].

Mechatronics is therefore the title given to the sub-discipline of engineering which studies the integration of mechanical and electronic technologies to create 'intelligent' machines, systems and controllers. Mechatronics is an interdisciplinary field integrating Mechanical Engineering, Electronics, and Computer Science.

Failure of advanced technology projects has often been attributed to non-technical rather than technical problems. Research has postulated that the poor treatment of nontechnical issues within advanced engineering programmes has contributed to systems failure, as those charged with designing, developing and implementing the technologies have not been provided with the necessary set of skills and knowledge needed to manage these non-technical issues.

As a result, high profile professional bodies have called for a greater balance between technical and non-technical competences of technologists (for example review websites of Just IT Training & Recruitment (JP Morgan and Goldman Sachs International).
Mechatronics as an umbrella integrates areas of technology like measurement systems and sensors, actuation systems and drives, systems behavior, control, and microprocessor systems.
Currently we have the following Mechatronic systems requires the following theoretical basic knowledge:

- Conventional: Classical Mechanics, Electronics, Control Engineering.
- Micromechatronic Systems – MEMS: Classical Mechanics, Electronics, Control Engineering
- Nanomechatronic Systems – NEMS: Quantum Theory, Advanced Control Engineering
- Femtomechatronic Systems – FEMS: Quantum Theory, Advanced Control Engineering
- Atomechatronic Systems - ATEMS
- Conventional, and Micromechatronics Systems are realized since 2000
- Nanomechatronic systems are in realization.
- FEMS will be realized in 2-3 years and
- Atomechatronic Systems – ATEMS are currently a dream.

The definitions "What is Mechatronics" are quite different like: "Integrated optimal design of a mechanical system and its embedded control system. Not every controlled mechanical system is a mechatronic system. In many cases the control is just an add-on in a sequential design procedure. The most important term is Embedded". Mechatronic design is a teamwork of specialists from Mech.Eng., Electrical. Eng., Control. Eng.) supervised by a Mechatronic Manager [1].

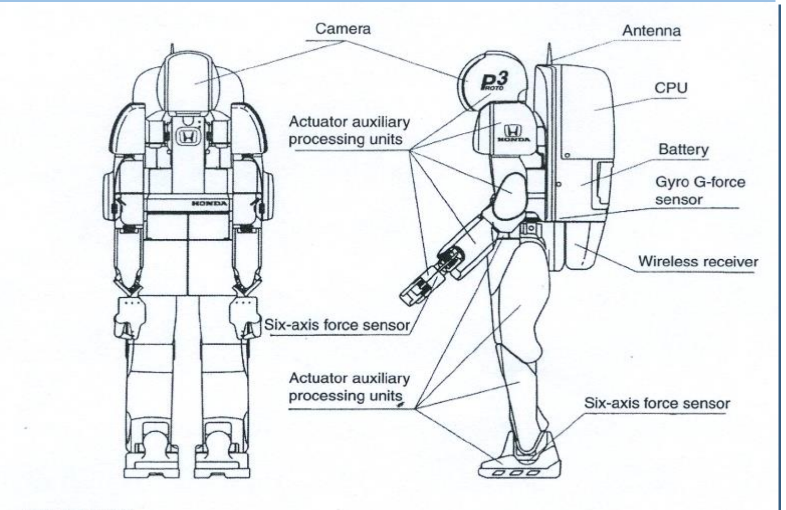

FIGURE 1.2(b)
Components of a humanoid robot. (American Honda Motor Co. With permission).

Fig.2. A humanoid robot as a frequently used example of a Mechatronic System [1]

Classical examples for mechatronic systems are mass-produced products like washing machines, dish washers, microwave ovens, cameras, watches, hi-fi and video recorder systems, central heating controls, sewing machines, smart homes or for (self-driving) cars active suspension, antiskid brakes, engine control, speedometer display, transmission, assistance systems. In Production Automation Production 4.(5,6).0, networked robots, collaborative robots, cooperative robots.

2. Education in Mechatronics

A mechatronics technician use engineering and mathematical principals to implement and maintain electronic systems lie those used for computers. It is a new career that is considered multi-craft that focuses on the skills needed to work on robotic and intelligent equipment. Currently a mechatronics technician have to have knowledge able to work on anything from banking machines to multi-million dollar, highly complex mechanical equipment. Often mechatronics technicians assist in the design/development and engineering staff to develop, repair and maintain electronic/robotic systems and individual components. The may be involved with the development of a product from the conception through testing and production. Therefore he or she must to be educated in:

- Applied mechanics
- Advanced control
- Pneumatics and hydraulics
- Computer software/hardware
- Materials science
- Analog and digital communications
- Advanced programming methods.

For example in Austria we have currently a lot of new education programs [1]

3. Trends in Mechatronics

The “face” of was changing dramatically over recent years. The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework.
This trend at system level is fuelled by growing investments in the fields of medical, life sciences and renewable energy as well as developments in industrial machinery. This approach greatly improves the design process by combining best practices and technology available to streamline design, prototyping, and implementation. By splitting the design process into parallel threads, the engineers may introduce a more efficient process of creation. In the past a team has had to wait for a practical prototype to create a control algorithm for a mechanical device. Now engineers can use a virtual prototype based on concept models and simulation data to get started faster.
Ghost of Computing entails a decline in electronics capacity/size (miniaturization). When the size of the technology required for a computer is getting closer and closer to zero, the problem is no longer how much smaller and more powerful the technology can be produced, but what the technology can be used in now. Society is reaching a peak and turning point where there seem to be no end to limitations and mechatronic minds are able to realize every existence. Mechatronics supports broad areas of interdisciplinary expertise. Improving our way of life and the goods we use is not constrained by the common fields limits. With the ever-changing demands and requirements of a dynamic and complex world, to keep in tandem, technologies and inventions have to progress at a very fast pace. In the nearest future, mechatronics will play a major role in enhancing the reliability, protection and affordability of products. Future research will look into the negative effects of these technologies and necessary solutions to mitigate the threats [2].

4. Mechatronics Management

It was clear that mechatronic managers must possess the core skills of mechanical engineers and electrical engineers as well as management and business. Their knowledge enables them to supervise or solve a wide range of mechanical, electrical and software problems, allowing them to participate in and lead multidisciplinary design teams.
Furthermore, they have to have the usual competencies from Engineering Management
Technical Competence: the individual has sufficient subject knowledge and can plan and organise so as to achieve maximum results.
Administrative Competence: the individual has a range of business knowledge, can follow rules, procedures and guidelines set out by the organisation and can perform to the expected standards set out by the organisation.
Ethical Competence: The individual has moral standards which guide them in their decision making activities in the work environment.
Productive Competence: The individual is efficient and capable of producing desirable results. Productive competence particularly focuses upon the capability of the professional to continuously develop their knowledge and skills.
Personal competence: The individual can manage time, possesses necessary ‘people skills’, time management, communications and conflict management skills to operate effectively in the working environment. [1]

5. Examples

5.1.Robotics

Automation and robotics excel in the manufacture of standardised products using standard manufacturing processes in high volumes to an excellent quality standard. When creativity or customisation is expected, the human being is key. The solution is the collaboration of robots and the humans. Traditional robots cannot work side by side with humans but Cobots are designed to work in synchronisation with human employees and were first developed in 2012 in Denmark.

A Cobot is not a replacement robot; it assists workers rather than replaces them. These robots are safe around humans by using force limiting sensors and rounder geometries than traditional robots. They are lightweight and thus are easily moved from task to task. In addition they are easy to implement and use without a specialised automation Engineer or Technician. In fact, an Operator with Cobot programming skills can deploy it. Another advantage mentioned previously is that Cobots are so affordable that it is a worthwhile investment for any company, regardless of the size of the company.

Cobots are extremely versatile and can be used for a wide variety of applications, examples of which include: Packaging and Palletizing, Machine Tending, Industrial Assembly, Pick and Place, Quality Inspection, Injection Molding, CNC Tending, Assembly, Polishing, Screw driving, Gluing, Dispensing and Welding. They can be easily changed over from one operation to another is a very short time. At the moment they are being used in the larger manufacturing companies but there is an opportunity to introduce this technology into small to medium size companies [3]

As detailed by the ISO10218 standard, robots can have four types of safety features. They are:

- Safety Monitored Stop
- Hand Guiding
- Speed and Separation Monitoring
- Power and Force Limiting

The safety monitored stop is implemented in environments where the robots operate mostly alone, with occasional human interference. The feature will cause the robot to pause (though not shutdown) when the safety zone is violated (i.e. a human enters its workspace). The speed and separation monitoring feature are an extension of safety monitored stop. Instead of adopting a single behaviour throughout the robot's entire workspace, the latter is gradated into several safety zones.

The research is called "The Industrial Collaborative Robots Competitive Assessment" concluded that Universal Robots (UR) were leading, particularly when focusing on the implementation volumes. The companies ranked in the assessment were: ABB, Aubo Robotics, Automata, Doosan Robotics, FANUC, Franka Emika. Kuka AG, Precise Automation, Productive Robotics, Techman Robot, Universal Robots. Yaskawa Motoman

Fig.3: Cobots [3]

5.2 Renewable Energies

Mechatronic and renewable energy systems are all over our world, with electrical energy as their basis. Renewable energy systems such as: Photovoltaic (PV) systems, concentrated solar power (CSP) systems, Wind turbines, geothermal power plants, Wave converters, and Bio gas power plants, "produce" electrical energy [4]. Mechatronic energy systems consume and/or (partially) store electrical energy. The importance of Mechatronic Engineering will further increase due to consumer demands for "smart" tools, devices and systems. Hence, mechatronics is described as mechanical engineering for the 21st century [5].

The importance is a reliable and efficient operation of these systems and their interconnection with the future power grid to ensure global welfare and sustainability.

5.3 Production Automation

Kopacek in 2019 stated that industry 4.0 combines production methods with state-of-the-art information and communication technology. The driving force behind this development is the rapidly increasing digitization of the economy and society, and the result, manufacturing and the work environment are irreversibly changing exponentially. In the tradition of the steam engine, the production line, electronics and information technology, smart factories are now determining the fourth industrial revolution. The technological foundation is provided by intelligent, digitally networked systems that will make largely self-managing production processes possible [6]

The focus of Europe is now on the implementation of strategic concepts. With a strong technical foundation, the challenge in Europe is to balance the opportunities of digitalisation in industrial value creation with the needs of a human-centric world of employment. Europe sees Industry 4.0 and 5.0 as a socio-technological challenge. Reclaiming industrial competitiveness is critical in manufacturing as well as the preservation of sustainable careers. Breque et al state that "there a consensus on the need to better integrate social and environmental European priorities into technological innovation and to shift the focus from individual technologies to a systemic approach." [7]

A framework of the emerging Industry 5.0 can be seen in figure 1 as proposed by Doyle-Kent in 2021 [8]. The importance of education leading this field cannot be underestimated, and an interdisciplinary approach combining the technological, social ethical, industrial, environmental and management aspects is required going forward to enable graduates not just to survive but to flourish in their future careers.

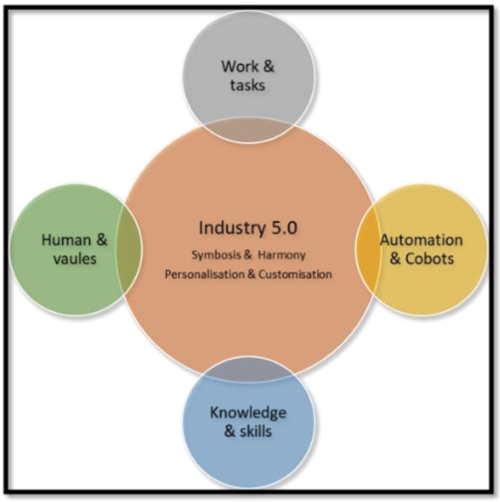

Fig. 4. Conceptual framework illustrating Industry 5.0 [8]

Additionally an Industry 5.0 definition has been put forward by Doyle-Kent so that researchers can easily conceptualisation this paradigm shift that is fast approaching. "Industry 5.0 is the human-centered industrial revolution which consolidates the agile, data driven digital tools of Industry 4.0 and synchronises them with highly trained humans working with collaborative technology resulting in innovative, personalised, customised, high value, environmentally optimized, high quality products with a lot size one." [8].

6. Summary and Outlook

In this paper are described a newest trend in Mechatronic, such as: Education, Management, Robotics, Cobot, Renewable energies, Industry 5.0 etc., in field and framework of Mechatronic The complexity of devices and systems has increased dramatically, requiring a system-level approach to mechatronics design. This approach helps engineers to combine mechanical and control design, execute a test easily, and reuse algorithms within the final embedded delivery framework. Newest trends in Mechatronic energy systems consume and partially store electrical energy. The importance of Mechatronic Engineering will further increase due to consumer demands for "smart" tools, devices and systems. In this paper Mechatronics is described as mechanical engineering for the 21st century, where the importance is a reliable and efficient operation of these systems and their interconnection with the future power grid to ensure global welfare and sustainability. Focus in future regarding development trends in Mechatronics is to look into the negative effects of these technologies and necessary solutions to mitigate the threats.

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