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EDUCATIONAL MODELS FOR MECHATRONIC COURSES

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Abstract: The paper deals educational model based on embedded system via using the microcontroller. The quality of education is supported through the using of these educational models. Students learn on practical exercises and experiences. That is the best way how to tech mechatronics.

1 Introduction

Mechatronics is defined as synergic combination of mechanics, electronics and computer controlling for improving of properties of existing products and developing of new products.

Mechatronics grows up last years as research and business approach to product design and developing. It is possible to say that almost every sophisticated product has mechatronic background. The product involves new functions as monitoring of its state parameters – self-diagnostic, self-repairing, guider to easy use with interactive user-friendly interface, self-calibration, remote wireless communication with user, events history saving, protection before damaging etc. The product has improved previous functions but also mechatronics approach enables to involve set of the new functions, which cannot be realized before (airbags system, automatic parallel and perpendicular parking system, drive efficiency assistant etc.) These functions help to customers to safely use of the product and some functions is automatically executed with product. Product becomes to intelligent system which removes amount of liability from customer upon the product. Products with these properties are very attractive and preferred by customers. These products also ensure the business successful and profitable position on unstable market. All these mentioned facts are as the motivation for teaching of the mechatronics approach to product design and development. This paper tries to show didactic aids and methods which are currently used at mechatronics courses at our university. Students work with similar building parts as in real practice and obtain experiences with design of such products. It is possible to say that mechatronics also going directly through the student hands and that is the perfect way how students can learn mechatronic thinking [1-6].

2 From the system structure to building parts

Design of new products starts with design of system structure on the level of function subsystem and organs. System structure shows which main subsystems are needed and how the relations between them are. Students can generate various alternatives of subsystems after multi-level decomposition of designed system. The last step is selection of base building parts after evaluation of subsystem decomposition.

This process cannot be successful without perfect knowledge of base building parts properties. Consequently, our student have a lot of function model of base building parts which can be used for quickly composing of function model of designed subsystem or overall product. Students under supervision of teacher can use heuristic methods for system design. They can verify of their design ideas and they obtain experiences about base building parts behaviours. Students obtain basic ability for experimentally work and prototyping. Another main advantage is that students become to skilled user of laboratory equipments and machines devoted for measurement, testing, signal processing etc.

Set of functional models of basic building parts and subsystems are consist of microcontroller modules, switches modules, variable resistive modules, relay modules, transistor switch modules, LED diodes modules, AD and DA converters, signal amplifiers, signal filter modules, various sensor modules, LCD modules, speaker modules, actuator modules (DC motor, stepping motors, rotational RC servos, linear servos, SMA actuators, piezo actuators, electromagnetic actuators), water pumps, air fans, XY stage for testing etc (fig. 1).

Microcontrollers are belonging to group of embedded systems, which are applicable for control of processes and product functions. This purpose needs to capture information about the product and also about surround. These information's have to be processed inside the microcontroller and after processing the microcontroller makes decision about next steps if it is necessary. Right decision depends on suitable selected sensors and processing of captured information. Data capturing and processing is the main role of microcontroller. Microcontrollers have a miniature dimensions and it enables to integrate inside to products. It belongs to group of embedded systems, which have main role – controlling of product activity and man-machine interface between product and user. These products are user friendly and microcontroller helps to user with successful using of products.

Figure 1 Several parts of building items for prototyping of mechatronic systems

Students can build very quickly any construction and they can experimentally verify function and behaviours of it without a lot of hours of soldering (fig. 2). They learn that everything has to be examined and verified, because of mistakes which are very often mentioned in datasheets.

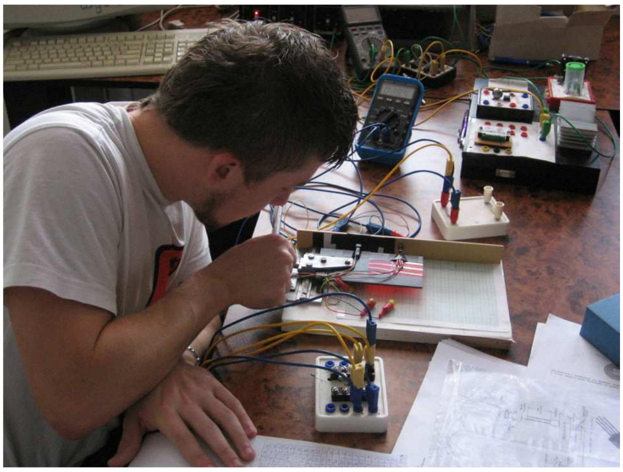

Figure 2 Student experimental working with mechatronic subsystems

Students also use the microcontrollers on solderless breadboard (fig. 3). This is another way how to support student skills and experiences. Students can build by himself electronic circuits and make testing before the making of printed circuit board.

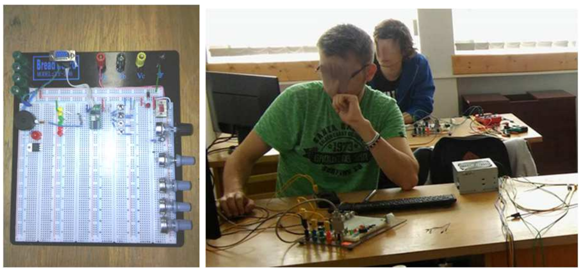

Figure 3 Exercises with embedded systems on solderless breadboard

The didactic process lies on using of heuristic method for solving of case studies. Teacher as supervisor defines problems, which are necessary to solve and students generate working as team of designers and developers. They generate possible solution of defined problems via using of brainstorming and collaborative work. Students invent new effects and behaviours of base parts and subsystems.

They exercise to build basic conventional and unconventional structures used in mechatronic products. They obtain basic knowledge, skills and experience from area of sensors, signal processing, electromechanical systems, actuators, embedded systems (microcontroller, programmable logic controller), design of various control algorithms, logical systems, power electronic and driving of AC and DC motors and stepping motors etc.

More complex subsystems (fig. 4) enable to directly build various types of mechatronic systems. For these reason students can work with linear positional units, drive systems with DC motors, water tank with regulated level. These didactic aids enable to try PID control and two-stage regulation and also combination and sequential logic systems.

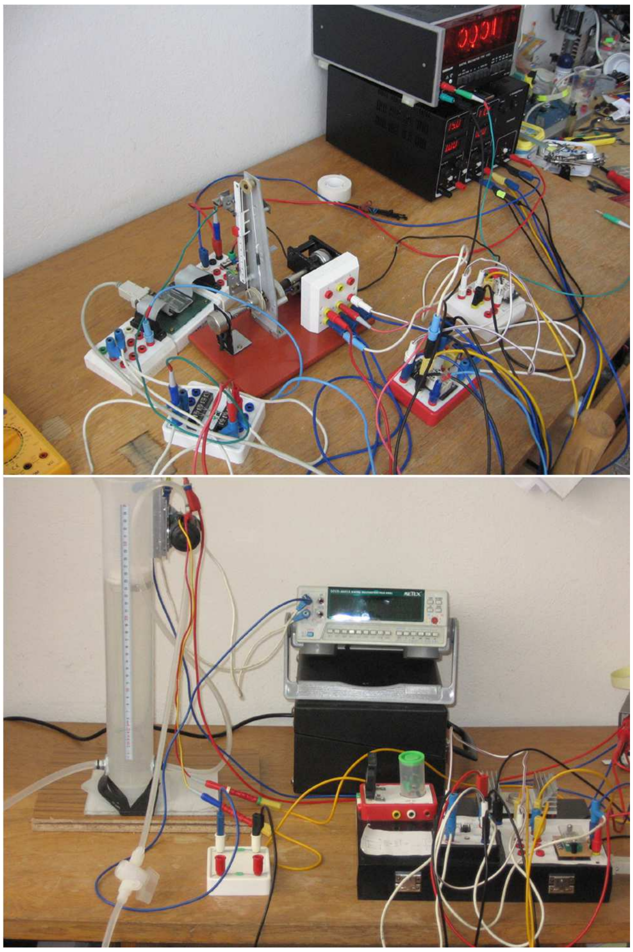

Figure 4 Linear position regulated system and water tank with level regulation

3 Didactic mechatronic models with variables wiring and structures

More sophisticated didactic models are also used in educational process. Students design flowcharts for realization of specified functions and after that can write source code for programming of microcontroller.

Lift model as complex model (fig. 5) has been developed. Several master thesis and bachelor thesis have been defended on partial problems of this topic.

The concept of lift model is structured as modular system for embedded system training, measurement and data processing training, control algorithm training etc. Lift model has modular structure and it allows varying structure. Consequently, students have possibilities to do experiments and verification of own designs.

Line follower LINA 2010 (fig. 6) didactic model is developed for competition between students. Every student works on own algorithm and trains on this robot. After optimalization and completing of program students can compete. The main goal of competition is to follow line but also obstacle avoiding of brick is necessary. Line follower LINA 2010 also has to pass through the bridge and through the tunnel with door. Door is opened only when robot moves switching cube at minimum of 2 cm in any direction. The winner is who is the most quickly.

Solution of this robot seems to be easy but several key issues raised up on prototype of the robot. That is a typical example, that also design of simple product can has also many problems. Practical experiences are very important for students, because students are better prepared for practice. That is something what is not possible to learn from books. Consequently, practical exercises bring skills and experiences to students.

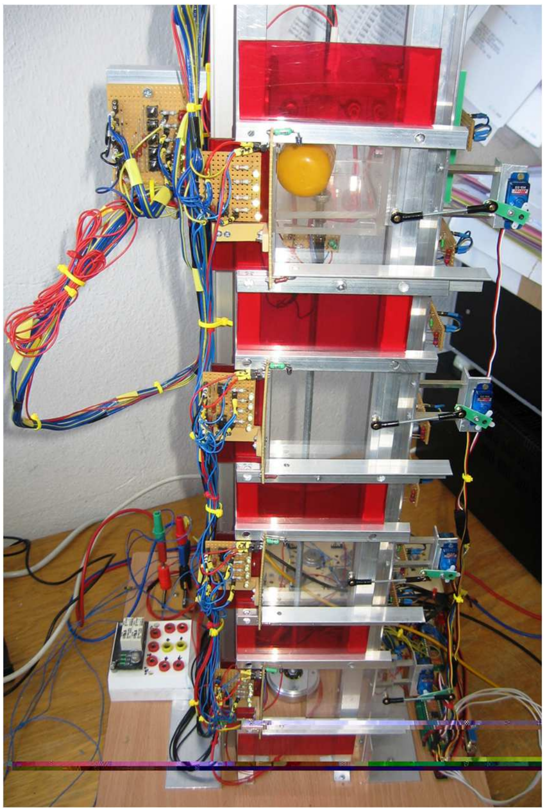

Figure 5 Didactic model of the lift

Problem of obstacle avoiding is as main task of the two wheeled robot VDU2004 with differential controlling (fig. 7 left). It includes collision infrared reflective sensor which uses frequency modulated light for obstacle sensing. This didactic model is also reconfigurable. Students can modify the wiring of it. One of the exercises involves the maze competition for students.

GTR2010 is a four wheel didactic model of inspection robot for inspection of hardly accessible places (fig. 7 right). Every wheel is driven via independent DC motor.

Students work on problem of generating of the trajectory and controlling of the wheels with electronic synchronization of rotation velocity and torque.

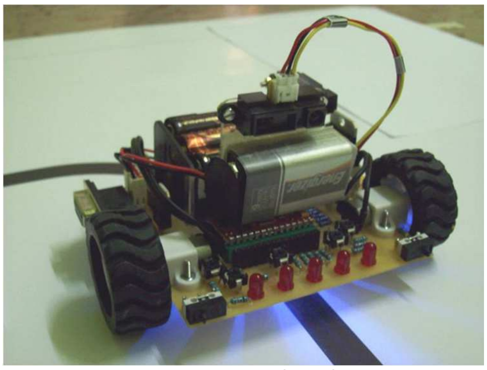

Figure 6 Didactic model of linefollower robot

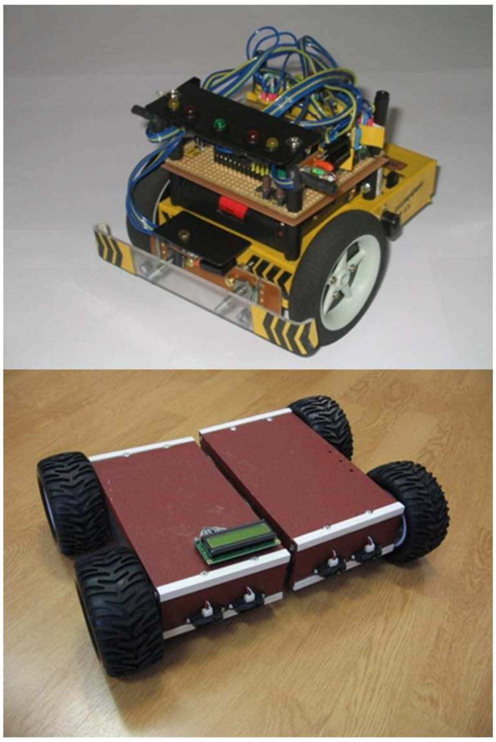

Figure 7 Wheeled didactic models

Linear manipulator XYZ and articulated manipulator with 5 DOF (degree of freedom) are also available. Students have possibility to practically practice the solving of the inverse kinematics problems and algorithms of feedback controlling. Also legged robots have been developed as didactic model for training on mechatronic courses. Several of them are shown on figure 8. Students can propose the algorithms of locomotion and they can also make optimization of locomotion with experimental verification. Practice of feedback position controlling under variable loading is allowed on these models. More complex tasks are as locomotion through the rough terrain with obstacle avoiding with respecting of their stability.

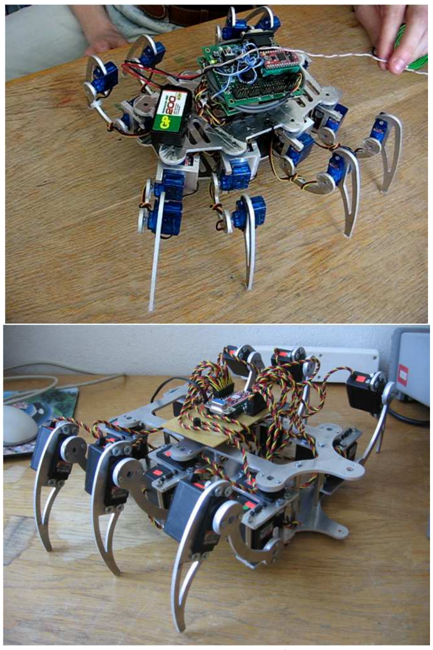

Figure 8 Didactic models of legged robots

Figure 9 Puck collecting robot

Puck collecting is a competition category at RobotChallenge. The aim of this competition is to find and collect pucks with defined colour (blue or red) and

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place them to home position with same colour. The robot has two wheeled undercarriage with differentially driven wheels. Robot (fig. 9) works as autonomous system and it has two microcontrollers for parallel controlling of processes. Robot is able to find and recognize puck and place it to home position defined with same colour. The designed robot Tukebot attended the competition RobotChallenge 2012.

Our students obtain many experiences and skills from robot design. For this reason, we are sure that this competition is perfect possibility for improvement of knowledge base of our students. Practice will also asks for solving of many complicated problems and situations.

Educational mobile hovercraft robot (fig. 10) has been developed by students. For lift and movement of hovercraft were selected blowers of type GWS 40B 6000KV, which have a built-in three-phase brushless motor with revolution KV=6000 (6000 revolutions per minute to 1V). The engine belongs between the inrunners, because the rotor spins inside. This brushless motor was preferred before DC motor and it's mainly due to the performance and service life. DC battery voltage is to be transformed into a three alternating voltage with phase displacement 120°, which will be fed into the blower. This transformation of the DC voltage to AC voltage allows us regulators of brushless engines.

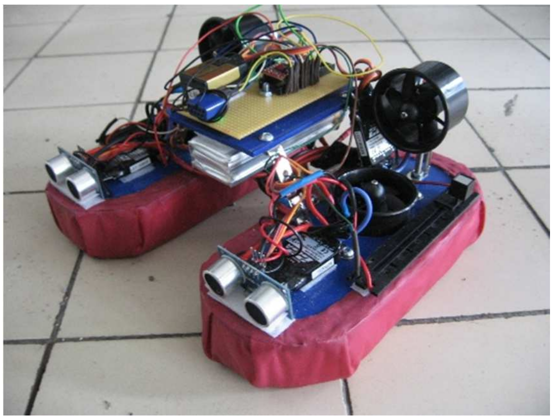

Figure 10 Mobile hovercraft robot

4 Conclusion

Mechatronics is multidisciplinary scientific area and training and exercises should be realized very practically. Everything what students learn at lectures is possible to try at exercises with working on didactic models. Students can also build own structures from basic building units. They can practice case study on real models through the heuristic methods. Teacher only defines the problem and input conditions. After that students can generate the possible solution with analysis and experimental verification of partial problems. Students can practice the team collaborative work or individual work. Consequently, students learn through the play. They can also attend of competition as RobotChallenge or Istrobot. Didactic models help to prepare our students better for practice in real word [7-14].

During the educational process it is important for students to absorb the theoretical knowledge earned during the lectures and then to realize it practically in the laboratories. The level of the presented absorption of the knowledge depends, to a great extent, on realized cognitive methods and utilized didactic tools. The proposed didactic models are supporting the applied educational approach by solving the defined problem situation. This approach, first of all, applies the problem interpretation-method and heuristic and the research methods. The problem solving philosophy of the education is based on the fact that during the problem task solving and the same by the model situation problem solving processes the students are acquiring the experience from their creative activity and they are creatively mastering their knowledge and the ways of their activity. The students are joining the problem searching and problem solving processes through the activities of the teacher. This way the students are learning how to earn the new knowledge independently and they are applying their earlier acquired knowledge and along with it they are personally experienced from their creative activities. The practical realization of the task and the personal involvement in problem solving are imitating the team work and the individuals may be aware of their importance within it. This approach is also of psychological and social natures both for the individual person and for the realization team.

The creative thinking rises during the problem solving situation when the student collides with an obstruction, some difficulty in his activity, some conflict if he impacts something unknown and uneasy and surprising and incomprehensible, whereas he does not know the way of overcoming the problem or the obstruction and he can not solve it on the basis of his actual knowledge. In other words, the mechatronics is not only about the lectures and it has to pass to the students´ hands. So that the hands may act, they are directed by the brain. The brain has to think what directive to get out and what activities will be performed by the hands. If something is coming to the student's hands really it means the integral chain of consideration and researching and the individual study and consultations among the team members and also with the pedagogue who is both the guardian and the anchorman of the entire project. In this manner the students are learning the philosophy of the mechatronics approach to the project of the products. Their, both the thinking and the creativity, are getting a new dimensions enabling the student's capability to get under better control the problem situations solving in the practice. And this manner trained graduates markedly increase the probability of their practice. The same they may to fortify the competitiveness of their employers [7-17].

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