Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnLine 49-29 (2016) 024–029

Robots for Education (Edutainment)

J.Linert and P.Kopacek*.

*TU Wien, Institute for Mechanics and Mechatronics, IHRT
Favoritenstrasse 9-11/E325 A6, A – 1040 Wien.
(e-mail: julia.linert@student.tuwien.ac.at, kopacek@ihrt.tuwien.ac.at)

Abstract: Edutainment is an artificial word based on “Education” and “Entertainment” and was introduced in the nineties.

Lifestyle of young people has changed. Robotics is a very good tool to teach technology while, at the same time, always remaining very tightly anchored to reality. Robots can be used as tools in art. Robots will enable us to build real environments. From the ethical point of view robot toys can become kids’ companions, e.g. “friend”, “brother”, ……..;

Therefore we used robots very early for teaching in our laboratory courses. Some exercises will be described and discussed including the feedback of our students in this contribution. Finally a summary of our experiences and future developments for improving the course under the headline “ Cost Oriented Automation” will be outlined.

Keywords: Robots, education, laboratory

1 INTRODUCTION

Robotics is a very-fast-growing field and confronts us with both a number of exciting possibilities and the threat of significant changes to society, possibly in unforeseeable and undesirable directions.
Robotics is still a relatively new field. Many different types of robots have been developed and significant numbers are in use, both in industry and for service applications.
An overview of robots is presented in Fig.1. The earliest robots were ‘unintelligent’, stationary industrial robots. They were used mainly in production systems equipped with numerical controlled or computer numerically controlled (CNC) machines as well as in computer integrated and intelligent manufacturing systems.

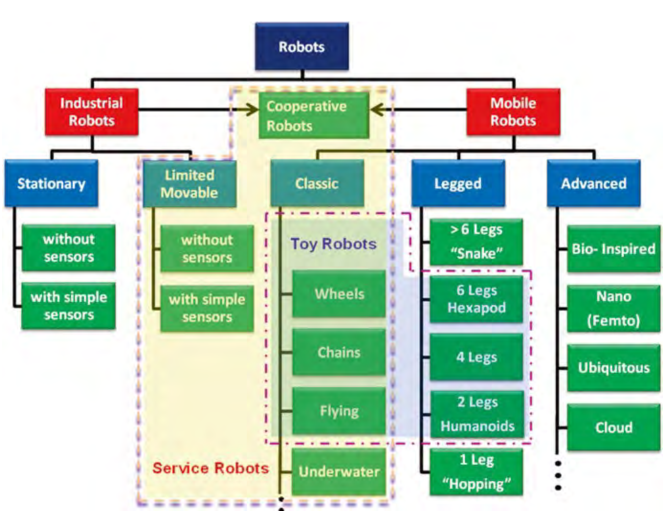


Fig. 1. Robots (Kopacek, 2013)

Subsequently three main developments have taken place, namely, mobility, ‘intelligence’ and cooperation.

‘Intelligent’ behavior is mainly information about the environment, which the robot can process and act to.
This requires the robot to have sensors. They should be inexpensive to reduce overall costs and have high accuracy and reliability to ensure high-quality information which is always available. Technological advances and the maturing of several technologies will facilitate the development of cheaper, faster mobile robots which are able to follow trajectories more accurately.
Robots can also be fun to play, and particularly simpler robots can be built from a kit, allowing children and (young) people to learn about technology design and construction, as well as learning to work cooperatively, for instance, on the construction of the robot. Robots can also have a number of other educational roles.
According to these facts education of the students have to be continuously updated with the main goal to attract for further research and application in this field.
Therefore in the following some of our “scientific” but also “fun” laboratory experiments will be shortly described.

2 LAB EXPERIMENTS

2.1 Industrial robot

The Yaskawa Motoman (Fig.2) is a modern industrial robot with 6 “Degrees of Freedom – DOF” as well as a pneumatic three finger gripping device.
The aim of the exercise was to handle some bowls. For programming a teach panel was used. With this the robot was

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2016.11.065

moved to the desired points with the necessary approach vector. These coordinates were stored.
To realize a movement between two different points it is necessary to drive to the first position and save it and then to the second point in the movement modus on a desired path (MOVJ, MOVL, etc.). Therefore it`s very easy to "write" a path from position A to position B.

An example is described in the following.

Fig.2 Yashkawa sorting bowls

Exercise "sort bowls"
The aim of this exercise was to pick up one bowl after the other from the storage plate in the first step (Fig 2). In the second step the bowls are moved one by one to the entry storage ramp. After opening of the gripping device the bowl dropped (hopefully) into the entry hole of the ramp. The final task was to pick up the bowls from the exit storage ramp and carrying back to the plate to reach the starting situation (Fig 3).

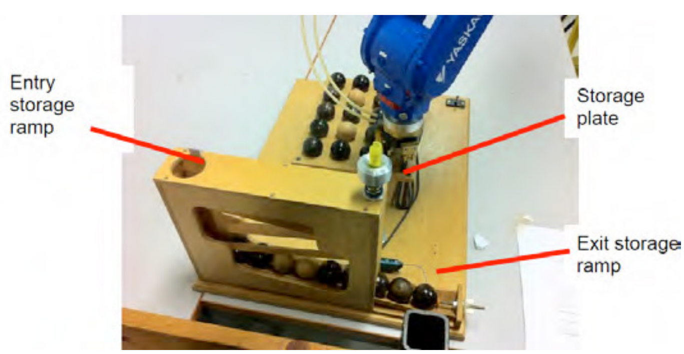


Fig.3. Yashkawa sorting bowls - details

Finally, after some successful tests including adaptions the processes was running with a higher velocity limited only by the maximum gripping force.

"At the end it was an interesting experience to work with a modern industrial robot which is also used in the high end automotive production. Furthermore we know that there are better ways to program the robot. In practice it is not very common to do it via the panel; you do it on the computer. Therefore you have to visualize the whole environment of the robot in 3D CAD software. Due to the lack of time and financial resources it is not possible to implement this interesting task in the university exercise."(Students, 2012).

2.2. Robotsoccer

Robotsoccer is played in teams by 3, 5 , 7 or 11 small mobile wheeled robots with the maximum size of 7.5 x 7.5 x 5.0cm (Mirosot) or 4.0x4.0x5.0 cm (Narosot). It was first introduced about two decades ago to develop intelligent cooperative multi-robot (agent) systems (MAS) and as an easy means of the young generation learning about difficult scientific and engineering subjects through games.
From the scientific viewpoint the soccer robot is an intelligent autonomous agent which carries out tasks with other agents in a cooperative, coordinated and communicative way. In addition, a number of people find it enjoyable and this makes it a useful educational tool (Kopacek, 2009). Soccer robots should be programmed to play ethically, i.e. a hard but fair game, and not try to cheat or commit fouls.
The robots in a team have a common goal – to kick the ball in the opponent goal and to avoid goals against the own team. Therefore cooperation and coordination of actions by means of communication are necessary.
Our system (FIRA Mirosot) works as follows (Putz, B., 2004): A camera approximately 2m over the playground delivers 60 pictures/second to the host computer. With information from colour patches on top of the robots, the vision software calculates the position and the orientation of the own and opponent robots and the ball. By means of this information, the host computer generates motion commands according to the implemented game strategy and sends motion commands wireless to the robots. At our institute 4 generations of soccer robots "Roby Go", "Roby-Run", "Roby-Speed" and Roby-Naro were developed (Fig.4).

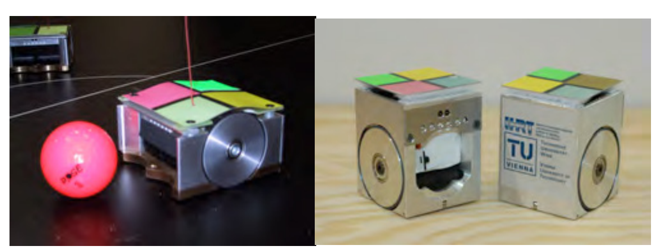
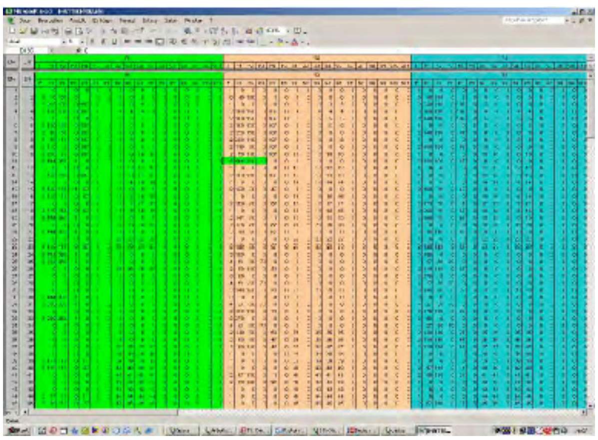


Fig. 4. Roby- Speed and Roby- Naro (Putz, B., 2004)

For our laboratory courses we developed a simple and easy understandable programming interface using a MS Excel spreadsheet (Tab.1) and a SimuroSot simulator. The functions are defined as the number and call parameters and are written with MS Excel in form of a MS Excel Table containing 5 functions (Putz, 2004).
These 5 functions are:
Parade Wait: The robot waits a certain amount of time given in milliseconds.

Parade Position: The robot goes to a specified point.
Parade Rotate: The robot tries to reach a certain angle in the absolute coordinate system.
Parade Circle: The robot moves along a given certain circle.
Parade Time Rotate: The robot rotates for a specified time.
With this programming interface the students have to program a so called “Parade” – “dancing” to a distinct piece of music as a ”fun” part.

Tab. 1 Programming sheet



An example is shown in Fig.5.

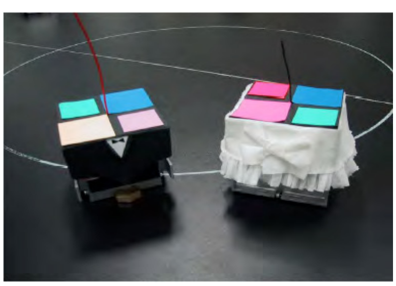


Fig.5 Vienna waltz

“It was really fun for us to learn the a little bit complex programming background on a “nonscientific” example.” (Students, 2013)

2.3 Billy

The low cost toy robot has a modular setup consisting of interconnection parts like joints, hands, feet, a microcontroller, sensors and 18 servo motors (AX-S12). The latter provides him with 18 degrees of freedom (Fig.6). Each of the motors can be moved independently from the others. Most of the sensors (like an IR-sensor, sound sensor, and a proximity sensor) are placed in the head of the robot. Furthermore, a beam and a rope are available to prevent the robot from falling during experiments.

The following experiments have to be carried out by our students.

Clap once
The robot must execute a predefined number of clapping gestures (bringing both hands together above the head) when a button was pressed. The movement should be executed every time the button was pressed.

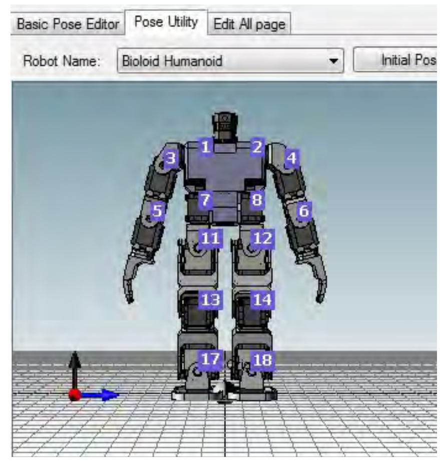
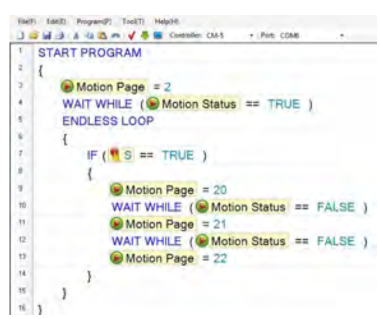


Fig.6 Billy with DOF`s

Full clapping motion
The robot must realize one clapping action when a button was pressed; coming from the initial step, and going back, in a structured manner.
In practice this means the clapping now consists of three separate steps: lifting the hands in the air, the actual clapping gesture and moving the arms back down. In the beginning of the code, the robot was set to its initial position. (Tab 2)

Tab. 2. Program Code for Full clapping motion



```
START PROGRAM
{
    Motion Page = 2
    WAIT WHILE ( Motion Status == TRUE )
    ENDLESS LOOP
    {
        IF ( S == TRUE )
        {
            Motion Page = 20
            WAIT WHILE ( Motion Status == FALSE )
            Motion Page = 21
            WAIT WHILE ( Motion Status == FALSE )
            Motion Page = 22
        }
    }
}
```

Drumming
The robot performs a drumming motion. This consists of lifting the drumming stick, striking the cymbal (a number of times), and lowering the stick again.

Programming the position of all joints for a single movement first. This could be accomplished quite simply by allowing the joints to move freely, physically setting the joints as wanted, and remembering this position. When calling the movement, all joints would then move to the remembered position. As for the code, it is basically a reprise of a former experiment, but with other Motion Pages.

In this exercise the students had to realized that "Billy" touch the hit-hat. "Billy" cannot drum with the rest of the drum kit because it works with a magnetometer. For that the item which hits the drum had to be electrically conducting but the arms of "Billy" were made of plastic, so they were not electrically conducting (Fig.7).

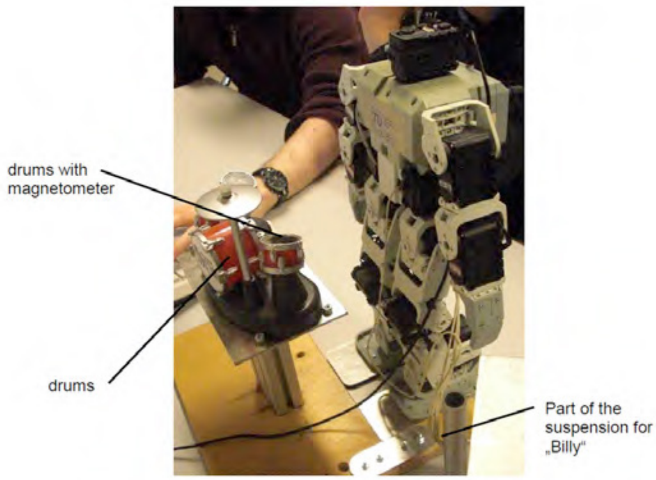


Fig.7 Billy drumming

Stand up / lie down

The robot should recognize if he is in its initial position or instead lies flat on the table. Depending on his starting position, he must change towards the other position. So, as soon the user gives the command (CLAP-Icon), the humanoid should either lay down or stand up.

First of all a motion to lie down and to stand up is generated. Generated Motion Pages contains the steps to lie down whilst another Motion Page contains the sequence to stand up. Each of them consists of six steps. To check for the command to move, the sound count sensor will be used. To determine in which position the robot starts, the infrared sensor (giving a value between 0 and 255) on his head is used.

"After working with Billy 2 days we had nearly a new friend and as usual he had good and not so good moments" (Students 2014)

2.4 Billine

Billine is the follow-up model of Billy. The hardware has been improved. Billine has a microcontroller (CM-530), 18 servo motors (AX-12+), IR (infrared) and Gyro sensors, as well as a sound counter. Furthermore, this new model can be controlled through a remote controller, either through IR or through ZigBee.

Clap as often as I clap

As before with Billy, the students first had to define clapping gestures. The next task was to make the robot clap as often as a student would clap. Therefore the use of the sound counter was needed. The robot performed the motion according to the number of the recorded clapping.

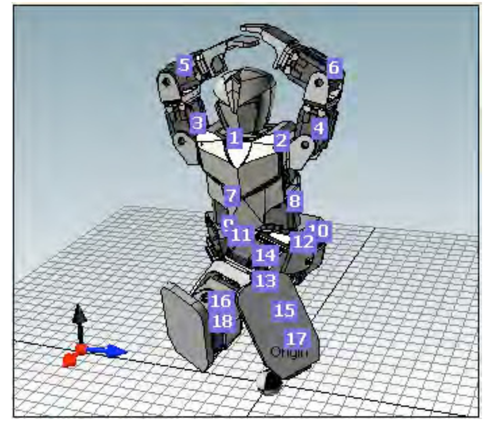


Fig.8 Billine with DOFs

Gyro sensor

A Gyro sensor is used to determine angular velocity (angular variation per second).

If the robot's center of gravity is changed, action can be taken to stabilize the system.

The first task was to correct the position of the robot while standing on a moving platform. The robot must stand still to initialize the gyro sensor. While tilting the platform the gyro sensor (hopefully) detected an angular velocity increase in a specific direction and the servo value was adjusted in the opposite direction to straighten the robot.

In order to deepen the comprehension of how to use a gyro sensor the next goal was to adjust the position of the robot while walking a slope up and down.

Another purpose of the gyro is to prevent Billine from falling down or to avoid serious damage either by making another step or by protecting the head and trunk by stretching out the arms.

When the robot tilts and angular velocity increases in a specific direction, the servo motor's value can be adjusted in the opposite direction to straighten the robot.

Remote Control

Billine can be controlled through a controller using IR or ZigBee. As to be seen in Fig. 9 there are several buttons which can be used to execute certain tasks. It is also possible to synchronize and control several robots at the same time with one remote controller. An example for a program is shown in Tab.3.

Fig.9 Remote Controller (Robotis, 2016)

Tab. 3. Program Code for Remote Control

```
START PROGRAM
{
    Motion Index Number = 1
    CALL WaitMotion

    ENDLESS LOOP
    {
        IF ( Remocon Data Received == TRUE )
        {
            ControlData = Remocon RXD
            IF ( ControlData == U )
            {
                Remocon TXD = ControlData
                Motion Index Number = 11
                CALL WaitMotion
            }
            ELSE IF ( ControlData == D )
            {
                Remocon TXD = Remocon RXD
                Motion Index Number = 32
                CALL WaitMotion
            }
        }
    }
}
FUNCTION WaitMotion
{
    WAIT WHILE ( Motion Status == TRUE )
```

Acrobatics

Billine seems to have a natural talent for acrobatics.

After programming all the classical motions the students were free to choose extraordinary movements. So it was decided to make Billine perform a headstand (supported by the hands). In order to achieve this difficult (even for many humans) task, the movement had to be divided into sub-steps. The students analyzed the headstand while doing it themselves.

Robotics is not just about programming, but about creativity and the challenge of analyzing one's own movements to translate them into the robot's language.

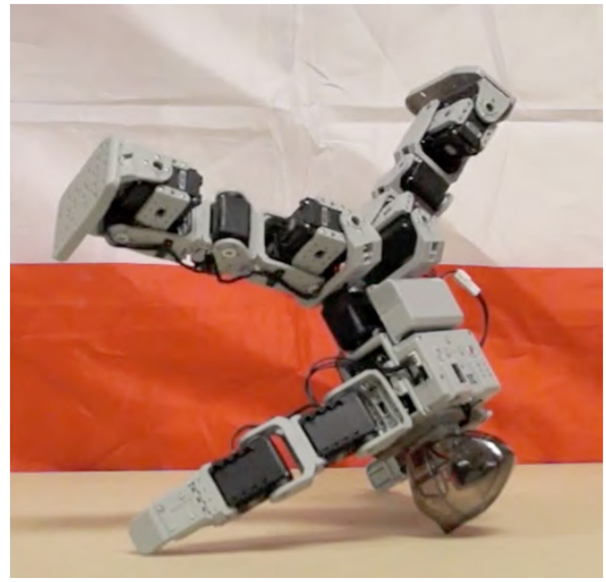


Fig.10 Billine headstand (Linert, Kopacek,2015)

2.5 Archie

Fig 11 shows our "Cost Oriented Humanoid Robot (COHR) Archie" with some details. "Archie" had at this time no arms, but they are completed now.

In the joints motors and sensors were placed. The on/off buttons for parts of the robot were placed at the "head" of the robot. With this buttons every other parts were disabled instead of the left foot. On every leg the students had three joints (hip, knee and ankle) to create a movement similar to a human walk.

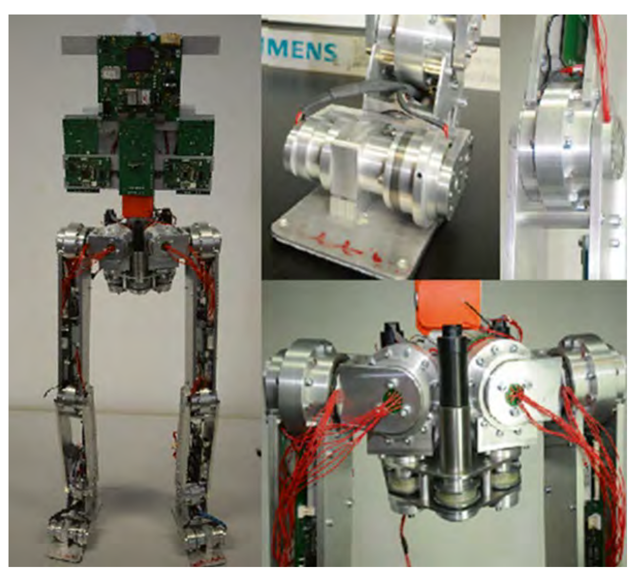


Fig 11 Archie with some construction details

To run one movement the students have to follow some instructions:

1. To set the values for step length a and step height b. (Fig. 12)

2. Activate joints hip, knee and ankle.
3. Checking the commands box and loading the initial position
4. Now they were able to run the simulation. In this simulation the true values of the angles were given back as result. They had to figure them out of executed data window and put them into the left window. Pivotal were only the three values for theta 1 and theta 2 and theta 3.

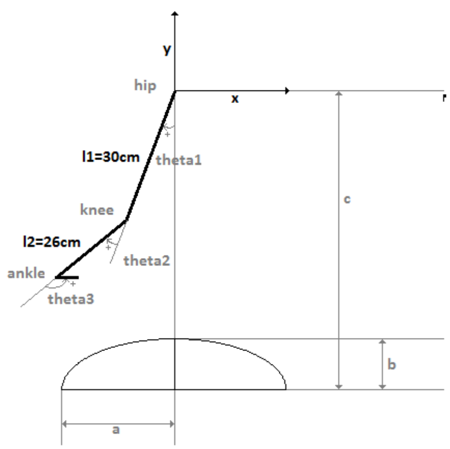


Fig. 12 Archie's leg.

5. After uncheck the commandos box they can visualize the movement with press the "Play Robot" button.
6. Before starting the next trial with the robot they have to move back to the initial position by unchecking the commands box and pressing the "Initial Position" button.

As an example one result is shown in Fig. 13

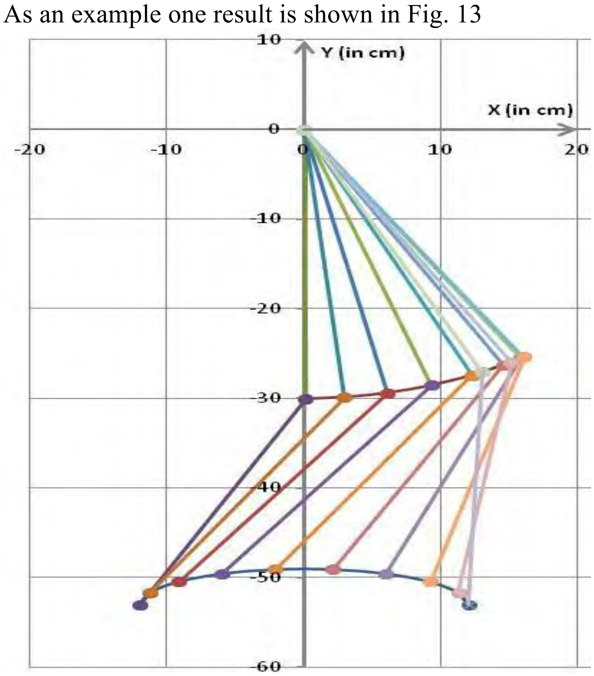


Fig.13 One step for a = 12cm; b = 4cm

"For us it was definitely a new experience to get some insight in the control of multivariable, nonlinear, time varying systems" (Students 2014).

3.SUMMARY AND OUTLOOK

Robots as a very important tool in production automation have advantages as well as disadvantages (Kopacek and Hersh; 2015).
Therefore our main goal is and will be in the future to make our students familiar with advantages and disadvantages of robots under the headline "A robot will support you as a companion and probably as a friend".
According to Fig.1 another goal is to give our students an overview to the whole world of robotics. Starting with conventional industrial robots, cooperative robots via different mobile robots to humanoid robots. All these topics where taught in different kind of courses like lectures, project works, seminars and laboratory.
The laboratory courses with 2 ECTS are for MSc students and organized in groups of 3 – 4 students. After an introductory "kick off" meeting the students have to work three full days in the lab. under continuous supervision.
Because of our limited financial resources our laboratory equipment has to be "Cost Oriented" but " High Tech". Therefore we try to cover the keywords of TECIS Robotics, Mechatronic Systems, Cost Oriented Automation and EoL.
In the future we will try to make our students familiar with the latest developments of robotics with the philosophy
"Scripts and powerpoint slides are nice but hardware is better"
"Fun is primary – theory is in the back but is introduced in the "background".

REFERENCES

Kopacek P (2009) Automation in sports and entertainment. In: Nof,S.(ed) Springer handbook of automation. Springer, Berlin/Heidelberg, pp 1313–1331.
Kopacek P (2013) Development trends in robotics. Elektrotechnik Informationstechnik 130(2): p42–47. Published on line under doi 10.1007/s00502-013-0129-1, Springer Verlag, Wien, 2013.
Kopacek, P., Hersh, M. (2015): Roboethics. Ethical Engineering for International Development and Environmental Sustainability, Springer London 2015, p. 65 – 102, DOI 10.1007/978-1-4471-6618-4.
J.Linert, P.Kopacek (2015): www.ifac-austria.at. Last visited June 6, 2016
Putz, B. (2004): Development of the new Soccer Robots "Roby-Speed" and "Roby-Naro". In: Proceedings of CLAWAR/EURON/IARP Workshop on Robots in Entertainment, Leisure and Hobby, ELH '04, December 2 - 4, 2004,Vienna, Austria, ISBN 3-902161-04-3, p. 47 – 52.
Robotis (2016): http://support.robotis.com/en/. Last visited, June 5, 2016
Various unpublished protocols from our students in the years 2012 to 2014, TU Wien.