Using a Remotely Controlled Automated Device for Measuring Linear Dimensions in Teaching Activities in Secondary Vocational Schools

Brajan Bajči
(Teac. Ass., Faculty of Technical Sciences, Trg D. Obradovića 6, Novi Sad, Serbia, brajanbajci@uns.ac.rs)
Vule Reljić
(Teac. Ass., Faculty of Technical Sciences, Trg D. Obradovića 6, Novi Sad, Serbia, vuketa90@uns.ac.rs)
Ivana Milenković
(Ass. Prof, Faculty of Technical Sciences, Trg D. Obradovića 6, Novi Sad, Serbia, ivanai@uns.ac.rs)
Jovan Šulc
(Ass. Prof, Faculty of Technical Sciences, Trg D. Obradovića 6, Novi Sad, Serbia, sulc@uns.ac.rs)
Predrag Vidicki
(Ass. Prof, Faculty of Technical Sciences, Trg D. Obradovića 6, Novi Sad, Serbia, pelac@uns.ac.rs)

Abstract

Remotely controlled automated device for measuring linear dimensions is presented in this paper. This device is designed and developed at Faculty of Technical Sciences in Novi Sad. It is dedicated for teaching activities in secondary vocational schools. This device will be used in four technical schools in different cities in laboratory exercises. The paper provides a brief description of the experiment as well as preparation of the questionnaire for the pupil's evaluation. The questionnaire is related to design, quality of use and application results of the presented remote experiment.

Key words: *remote control, remote experiment, measurement, linear dimensions, evaluation*

1. INTRODUCTION

One of the major problems that technical schools and even faculties are facing nowadays is the lack of adequate laboratory equipment. Namely, new technologies are developing at high speed and it is difficult to track them by financial [1-2]. For this reason, at Faculty of Technical Sciences in Novi Sad, the development of remote experiments or laboratories is in a progress for a long time [3-6]. This can be helpful for teachers and pupils in teaching activities. It also can be interesting for students who want to organize their own schedule [7-8].

There are two types of remote laboratories:

1. laboratories that represent a simulation of a real environment and

2. laboratories based on remote access to the real device via an Internet.

In the case of the second type of laboratories, a several basic components are needed:

- a device used to control a system (experiment),

- a server computer with Internet access which communicates with the control device,

- a user interface that serves for communication between remote participants and the laboratory, and

- a web camera for live monitoring of performing an experiment.

This paper presents a remotely controlled device for measuring linear dimensions. The paper is organized in the following manner: in the Section 2 is given a short description of the device – mechanical construction and possibility of remote control of it. Section 3 shows the way for using of the device in secondary vocational schools. At the end, in Section 4, the most important conclusions are performed.

2. DESCRIPTION OF THE DEVICE

The automated device for measuring linear dimensions is designed and developed at Faculty of Technical Sciences in Novi Sad. This device is used to measure the diameter of the workpieces that have cylindrical shape. The measurement is carried out using a standard digital caliper. This device is remotely controlled, via Internet.

2.1 Mechanical construction of the device

The device is shown in Fig. 1. Labelled components in Fig. 1 represent:

1. Web camera for live monitoring of operation of the device,

2. standard digital caliper,

3. workpieces (measuring objects) – in this case there are four shafts,

4. a system, used for positioning of the digital caliper, that consists of three pneumatic cylinders,

5. a system, used for positioning of a carrier with the mounted shafts, that consists of two pneumatic cylinders, and

6. the basic platform of the device with belonging control electronic unit, pneumatic control valves and additional necessary elements.
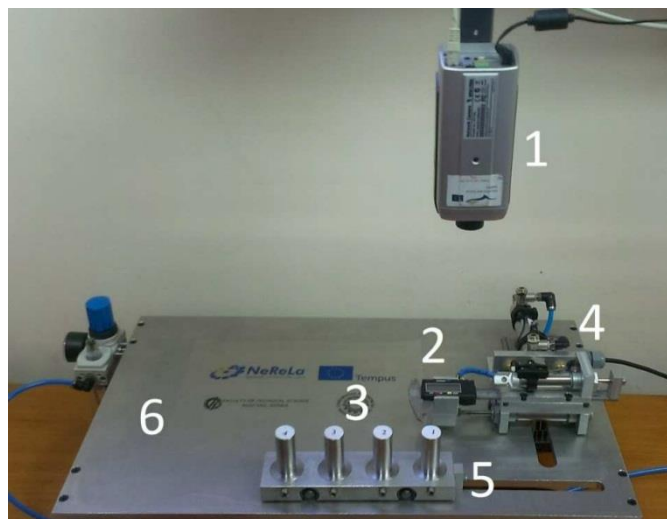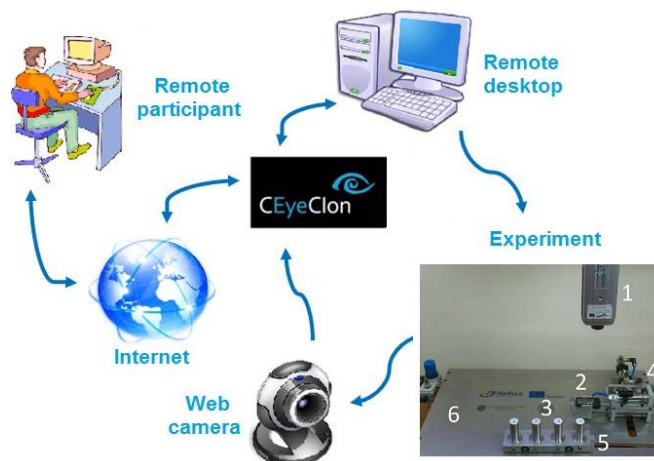

Figure 1. Remote controlled automated device for measuring linear dimensions [3]

As previously noted, measuring objects are four shafts that are mounted on a carrier. Movement of the carrier is provided by using two pneumatic cylinders. Due to various characteristics of cylinders, it is possible to achieve four different positions for measuring. The digital caliper is used for the measuring with help of three pneumatic cylinders. One of them is bringing the caliper in the position for measurement. The remaining two pneumatic cylinders are used for opening and closing the caliper.

2.2 Remote control of the device

A remote control of the device via Internet is performed using the platform called CEyeClon [9]. In that way, the users connect to a remote computer which is installed in faculty laboratory. The communication between the device and the computer is accomplished by using serial communication. The ways of communication are shown in Fig. 2. The device is controlled by Arduino Yun board. Live monitoring of operation of the device is enabled using web camera.

Figure 2. Ways of communication

3. USING THE DEVICE IN SECONDARY VOCATIONAL SCHOOLS

The remotely controlled automated device for measuring linear dimensions is intended for use in four technical school:

1. Technical school in Novi Sad (School course: Mechanical technician, IV year):

   - the 1st teaching course: Computers in mechanical engineering and

   - the 2nd teaching course: Modelling of the mechanical elements and constructions,

2. Electrotechnical school "Mihajlo Pupin" in Novi Sad (School course: Computer technician, IV year):

   - the 1st teaching course: The basics of automatic control,

3. Technical school in Trstenik (School course: Technician of mechatronics, II year):

   - the 1st teaching course: Mechanical elements,

4. Polytechnic school for new technologies in Belgrade (School courses: Technician of mechatronics, II year, Technician of mechatronics, III year, Mechanical technician for computer engineering, III year):

   - the 1st teaching course: Mechanical elements.

   - the 2nd teaching course: Control systems and

- the 3rd teaching course: Construction of mechanical elements and structures.

A teaching classes in aforementioned schools will be held as laboratory exercises. At the beginning of the class, teachers will introduce a brief theoretical background of the teaching topic (linear dimensions and tolerances on dimensions) to the students. Also, the steps of the experiment execution will be presented to the pupils. After that, each pupil will be able to perform the experiment and to analyse the obtained results.

3.1 **Activities before the experiment execution**

A detailed description of the experiment and the approach to the experiment can be found at LiReX platform [10]. To perform the experiment, it is necessary

to have a stable Internet connection and software called CEyeClon Viewer. The pupils need to have an access key and to enter it into the CEyeClon Viewer, in the field Access Key. If the access key is correct, the pupil can select and start the appropriate experiment. At any moment, only one pupil can start the experiment. In additional, it is necessary to run VLC player and to choose a card Media/Open network stream/Network from a title bar and to press Play button for starting a live stream from web camera.

3.2 **Activities during the experiment**

The experiment is starting by using a user interface (C# application) called "Linear dimensions.exe" that is located on the server desktop. The application is shown in Fig. 3.
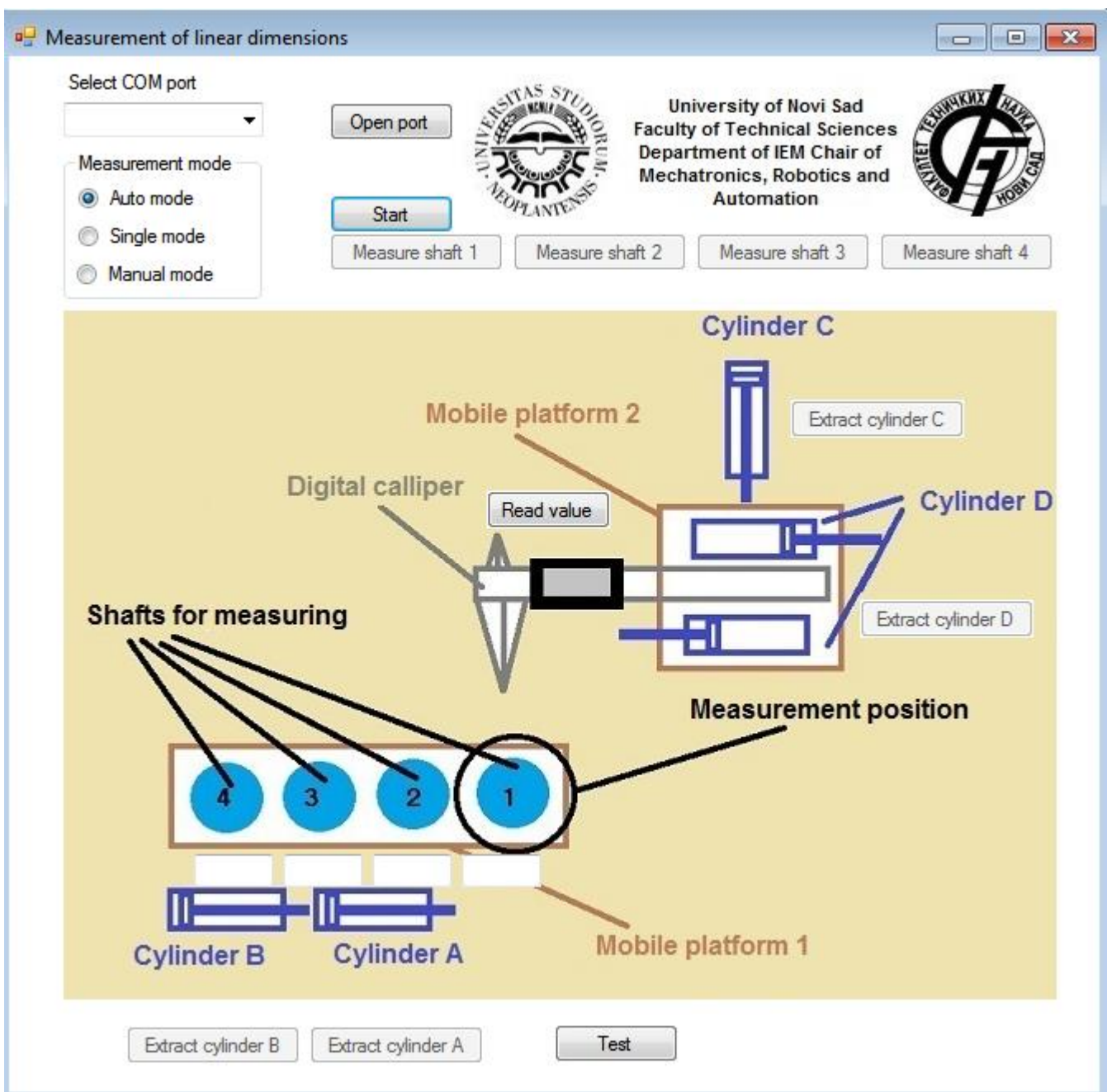

Figure 3. User interface [3]

Before starting the experiment, it is necessary to select the appropriate port in the drop-down menu "Select COM port" (not COM1!) and press the "Open port" button. Three different modes of measurement are developed:

- auto mode,
- single mode and
- manual mode.

In "Auto mode", it is possible to automatically measure all four shafts by pressing the "Start" button. After completing the measurement, the results are shown automatically in four white fields in the application, under four blue circles that represents the shafts.

In "Single mode", it is possible to measure just one specific shaft by pressing "Measure shaft n" button where 'n' represents a number of a shaft. After the measurement, only the measured value will be displayed in appropriate field.

In "Manual mode", it is possible to individually manipulate with the actuators. Each of the actuators has a button for extracting/retracting its own piston rod. If all cylinders are brought into the appropriate positions, the user can read the diameter of selected shaft by pressing "Read value" button.

After the experiment, by pressing the "Test" button, a new window appears. That window contains a test with 10 questions for checking the acquired knowledge. The questions are solved by selecting one of the offered answer or by entering the corresponding value in appropriate fields. Results are generated automatically as shown in Fig. 4.
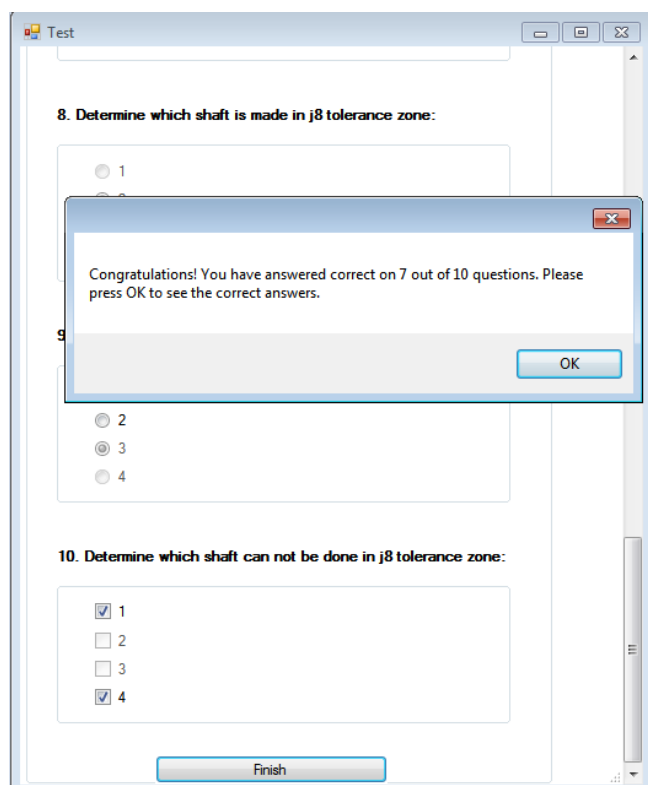

Figure 4. An example of the test results

Test questions are shown below:

1. Which of the following tolerance may form a fit with a tolerance Ø20H9:
   - Ø17m6,
   - Ø20j8,
   - Ø20N8 or
   - Ø22p7?

2. For the selected fit determine the TYPE of fit:
   - clearance,
   - interference or
   - transition.

3. For the selected fit determine the SYSTEM of fit:
   - common tolerances of internal measures or
   - common tolerances of external measures.

4. For the selected fit determine the upper and lower deviations:
   - ES =
   - EI =

5. For the selected fit determine the upper and lower deviations:
   - es =
   - ei =

6. Depending on selected fit calculate the Pg, Pd, Zg and Zd:
   - Pg =
   - Pd =
   - Zg =
   - Zd =

7. For the selected fit calculate the value of tolerance Tn:
   - Tn =

8. Determine which shaft is made in j8 tolerance zone:
   - 1,
   - 2,
   - 3 or
   - 4.

9. Determine which shaft can be done in j8 tolerance zone:
   - 1,
   - 2,
   - 3 or
   - 4.

10. Determine which shaft cannot be done in j8 tolerance zone:

   o 1,

   o 2,

   o 3 or

   o 4.

3.3 Activities after the experiment execution - reporting

After the experiment execution and learning about the basic concepts of tolerances of linear dimensions, pupils will need to complete the evaluation questionnaire (Table 1.). The evaluation questionnaire consists of 16 questions. The first part of questionnaire, that is consisting of 13 questions, relates to evaluation of the remote experiment and its usefulness in learning related course topic. The second part of questionnaire consists of 3 essay questions related to pupil's opinion about advantages and disadvantages of the presented remote experiment. Questions are answered by numbers from 1 to 5 that must be entered on the appropriate place, where 5 represents strongly agree and 1 represents strongly disagree.

Table 1. Evaluation questionnaire

No	Questions	1	2	3	4	5	Not relevant
1	Conducting of this remote experiment helped me to achieve learning module's objectives.						
2	The remote experiment helped me to learn to use lab equipment.						
3	A remote experiment within this learning module is prepared on appropriate technical level.						
4	This remote experiment is easy to understanding and using.						
5	Written manual for remote experiment is clearly understandable and helpful.						
6	This remote experiment was supported by adequate explanations of teacher before its starting.						
7	User interface for remote experiment within this learning module is easy to use.						
8	Response time after user action within starting the experiment is satisfying.						
9	Capture of the experiment results is enabled.						
10	Storage of the experiment results is enabled.						
11	Quality of visual display is satisfactory.						
12	There was no problem or stalling while working with this remote experiment.						
13	I would like to use remote lab in other lessons of this subject, too.						
14	Please, specify the advantages of this remote experiment:						
15	Please, specify the disadvantages of this remote experiment:						
16	Additional comments:						

4. CONCLUSION

A remotely controlled automated device for measuring linear dimensions is presented in this paper. This device represents one remote laboratory. With integrated software environment and test for checking the acquired knowledge, it can be used for purpose of distance learning, especially in secondary vocational schools. The application of this system can be very helpful for teachers and pupils in teaching activities. For the beginning, as previously stated, the device will find application in four secondary school. If pupil's reviews will be positive as we hope, in the future research, a system for measuring the internal diameter and system for automatically change of workpieces will be developed. Further, the user interface will be improved with additional options for control and additional questions and answers. It will significantly increase a use value of the device.

5. REFERENCES

[1] Lowe, D., Newcombe, P., Stumpers, B., (2013*.), "Evaluation of the use of remote laboratories for secondary school science education"*, Research in Science Education, Vol. 43, pp. 1197–1219.

[2] Koprivica, B., Milovanović, A., Damnjanović, Đ., (2016.), "*Remote experiments – New quality in realization of the laboratory exercise in the field of electrical measurement"*, available at: http://www.trend.uns.ac.rs/stskup/trend_2016/radovi/W1/W1.1-1.pdf (accessed: 21 June 2017)

[3] Bajči, B., Reljić, V., Šulc, J., Šešlija, D., Dudić, S., (2017.), "*Remotely controlled measurement of linear dimensions*", Proceedings of The 8th International Conference of Engineering and Technology (ICET 2017) in Novi Sad, Serbia, P.No. T10-1.1, pp. 1-4

[4] Reljić, V., Bajči, B., Šulc, J., Šešlija, D., Dudić, S., (2017.), "*Remote Control of Pneumatic Circular Manipulator Using CEyeClon Platform*", Proceedings of The 4thExperiment@International Conference (exp.at'17), IEEE, in Faro, Portugal, pp. 103-104

[5] Bajči, B., Dudić, S., Šulc, J., Milenković, I., Šešlija, D., Reljić, V., (2016.), "*Remote System for Measuring Geometric Tolerances: Roundness",* Proceedings of The 13thInternational Conference on Remote Engineering and Virtual Instrumentation (REV 2016), IEEE, in Madrid, Spain, pp. 279-280

[6] Bajči, B., Šulc, J., Reljić, V., Šešlija, D., Milenković, I., (2017.) "*Remote Laboratory for Learning Basics of Pneumatic Control",* Proceedings of The 14th International Conference on Remote Engineering and Virtual Instrumentation, (REV 2017), IEEE, in, New York, USA, pp. 118-124

[7] Daineko, Y., Dmitriyev, V., Ipalakova, M., (2017.), "*Using virtual laboratories in teaching natural sciences: An example of physics courses in university"*, Computer Applications in Engineering Education, Vol. 25, pp. 39–47

[8] Zubia, J. G., Alves, G. R., (2011.), "*Using Remote Labs in Education*", University of Deusto, Bilbao, ISBN

[9] Web page: http://ceyeclon.com/en/home/ (accessed: 25 June 2017)

[10] Web page: http://lirex.ftn.kg.ac.rs/ (accessed: 25 June 2017)