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INTERACTIVE 3D PRESENTATION AS A TOOL IN LEARNING OF THE TECHNOLOGICAL PROCESSES DESIGN

Abstract: Paper describes 3D interactive e-learning application developed for teaching the design of technological processes. This application is a part of project "INTEREDU – Interactive Education of Engineer", intended to provide applications supporting different aspects of engineering education. Applications are presented in 3D environment and should allow full or partial interactivity.

1. Introduction

Education of engineers in conditions of dynamic progress in many fields of knowledge becomes more difficult task because of growing number of issues to teach and its growing complication level. The number of subjects is growing, while number of lessons is fixed, consequently there is less time for teaching specific subjects. In this situation there is a need to develop more effective and attractive methods of teaching.

Distant learning and e-learning are examples of solutions of modern education. E-learning term covers many aspects and methods of learning with use of electronic media, used in different situations. In some cases it can completely replace classical forms of learning. One of the most important advantages of e-learning is that it allows to provide education for disabled people, unable to take part in classical forms of education [1]. It can also provide education to people living in remote locations, without easy access to classical education.

Generally its application is limited because of inability to cover all aspects of education and other limitations. Especially application of e-learning in technical education is difficult because of need to provide laboratory experiments.

Practically nowadays more often used method is blended learning, combining classical learning with a support of some e-learning techniques in form of multimedia materials and courses [2].

Development of modern multimedia technologies and the growing popularity of 3D images presentation, combined with decreasing prices of this technology (hardware and software) allows the use of virtual reality 3D technology in education, especially engineering education. Application of 3D image allows clear and understandable presentation of complex issues, requiring expensive laboratory equipment and materials. 3D virtual reality applications can be interactive, allowing presentation of tasks that are very difficult or expensive to

provide in reality. It also allows to present modern and expensive equipment without need to buy it. Presentation of processes taking place in inaccessible places, micro-scale, macro-scale or extreme temperature, radiation or pressure conditions is also possible.

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Paper presents one of applications developed in "Interedu" project, intended to support learning of technological processes design.

2. Interactive engineer education support with the use of virtual reality and 3D technology

Distant education methods are difficult to apply in technical education because of need to use laboratories and special equipment [3]. Therefore, there are many attempts to omit this limitations, resulting in different applications using virtual reality, virtual and remote laboratories [4, 5, 6, 7, 8, 9].

Technical sciences belongs to group of sciences difficult to be completely learned using e-learning techniques, furthermore there is a need to make lectures more attractive and better explaining technical issues, more understandable for members of modern information society. These reasons resulted in realization of "INTEREDU – Interactive Education of Engineer" project. Interactive educational materials provided in the project has been designed for 3D presentation. The primary method of presentation requires 3D projector and special glasses allowing 3D picture reception. 3D projection set can be provided in portable or stationary version, installed in classroom. Stationary version is based on twin 3D projector and requires polarised passive glasses, allowing participation of up to 120 students. Portable 3D presentation set designated for use in smaller classrooms, consists of a laptop computer and a portable 3D projector, requiring active shutter glasses for 3D picture reception. In both cases picture is displayed on typical projection screen.

3. Application supporting learning "The technology of machines" subject

During the Interedu project realisation many applications supporting learning of different subjects has been developed. Most of applications are prepared for learning technical subjects that require access to specialised laboratories or production plants, are difficult to present in normal conditions or very expansive. Application described in paper is designed for support learning the technology of machines. It should allow to show issues of designing technological processes without the need to visit actual production plant. The main part of application is presenting exemplary technological processes of machining. The design of technological process is shown from the beginning – firstly presentation of basic possibilities of machining using different types of machines, secondly preparation of technological process documentation, in the last stage simulation of machining using specific machines is available.

The exemplary technological process available in the application is presented in a few variants, using different types of machines (conventional, CNC) and a different stock. Application is focused on machining, other technologies like thermal treatment or incremental technologies are presented in other applications, as well as many other aspects of machining.

Rules of technological processes organisation, typical technological operations, tools, machines and structure of technological processes [10] are also presented in the application.

The main scene of 3D presentation is production engineer office – a room with desk and shelves, technological documentation and education materials are collected in file binders. The simulation of machining takes place in a workshop equipped with required machines.

Issues presented in application can be divided into two main groups: exemplary technological processes and additional materials explaining the rules of technological processes design.

Technological processes

There are three technological processes modelled in the application, each represented as a file binder on the desktop in the technological office. File binders contains a complete set of technological documentation.

The main document of the technological process is a technology card, containing list of technological operations necessary to manufacture required part. The operation is a primary part of process, executed continuously on selected machine. Picking the one of operations user of application can move to one of instruction cards, containing detailed description of the operation and technical drawing showing surfaces to be machined, its shape, surface quality and dimensions after machining (Fig. 1). By clicking description of cuts user can move further to simulation of operation. The simulation is presented on 3D model of machine. Simulation shows how machine is working during operation, starting from fixing a stock on the machine presentation, then basic cuts and tools changes (if necessary) are presented.

Technological processes presented in application:
- machining of the shaft - rod type stock,
- machining of the shaft - forged stock,
- machining of the shaft with use of CNC lathe.

Available simulations of technological operations are as follows:
- cutting off rod piece on metal cutting band saw,
- milling the faces of stock and centering – drilling the centre holes,
- roughing of shaft using universal lathe (Fig. 2),
- shaping of shaft using universal lathe,
- roughing and shaping using CNC lathe,
- milling of keyway using universal miller,
- milling of gear using gear hobbing machine (Fig. 3),
- finishing of surfaces – grinding.

Each machine can be viewed from different angle and zoomed, some parts of machines are linked – moving of lathe support causes rotation of knob or handwheel. Machining simulation can be replayed.
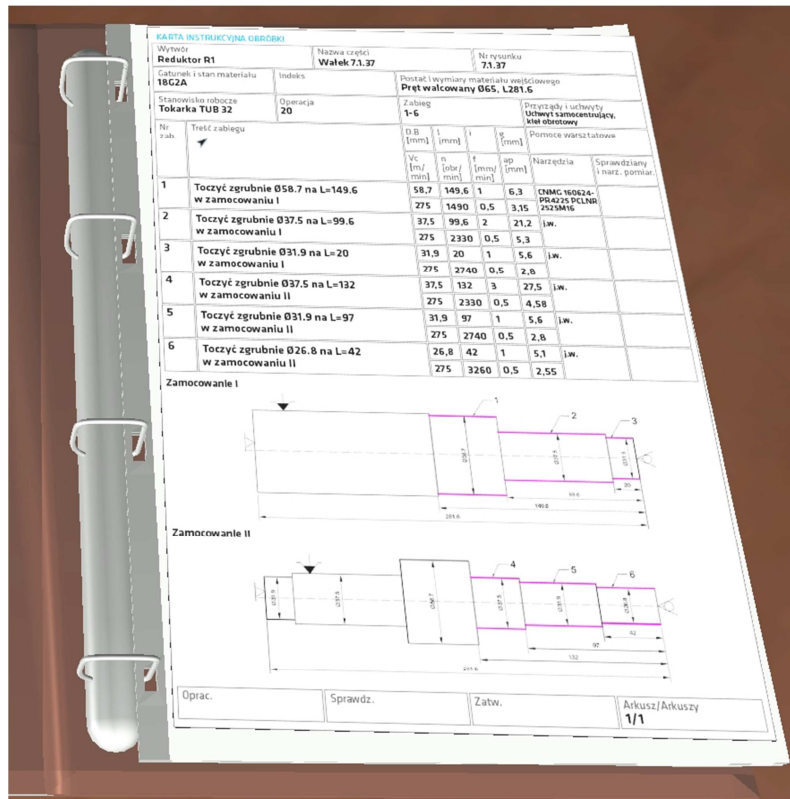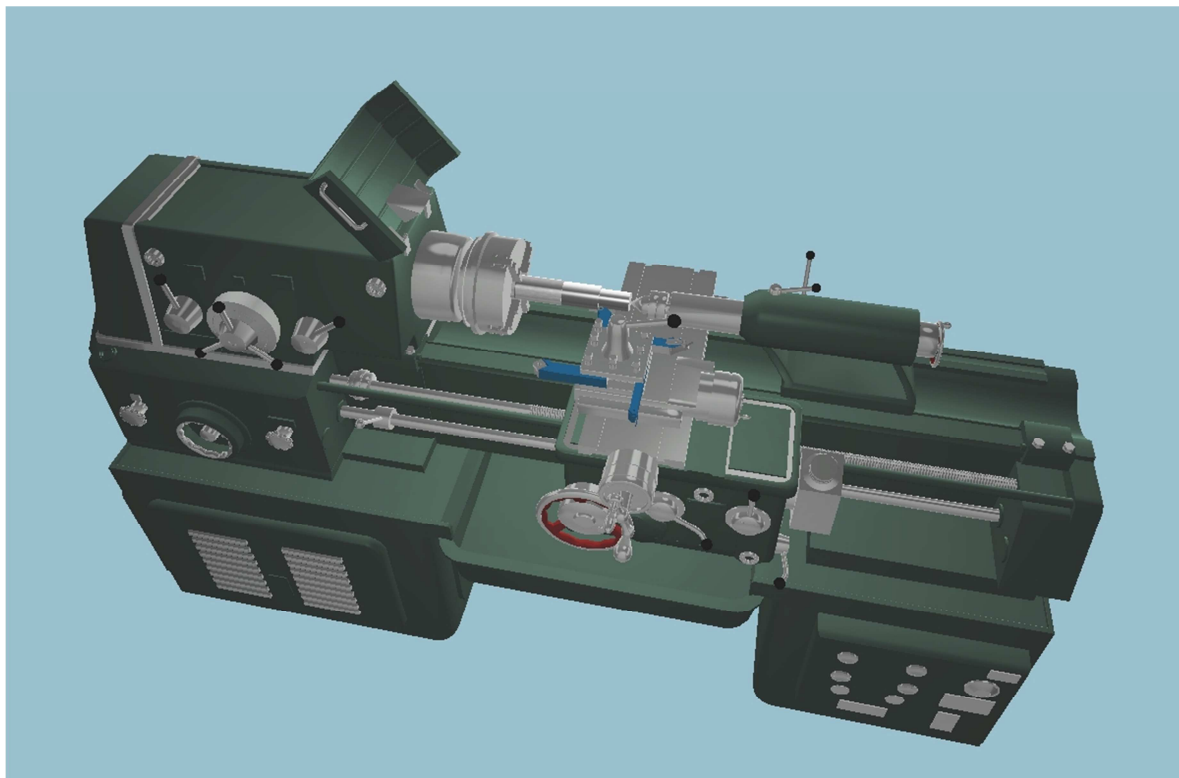
Fig.1. Instruction card of roughing

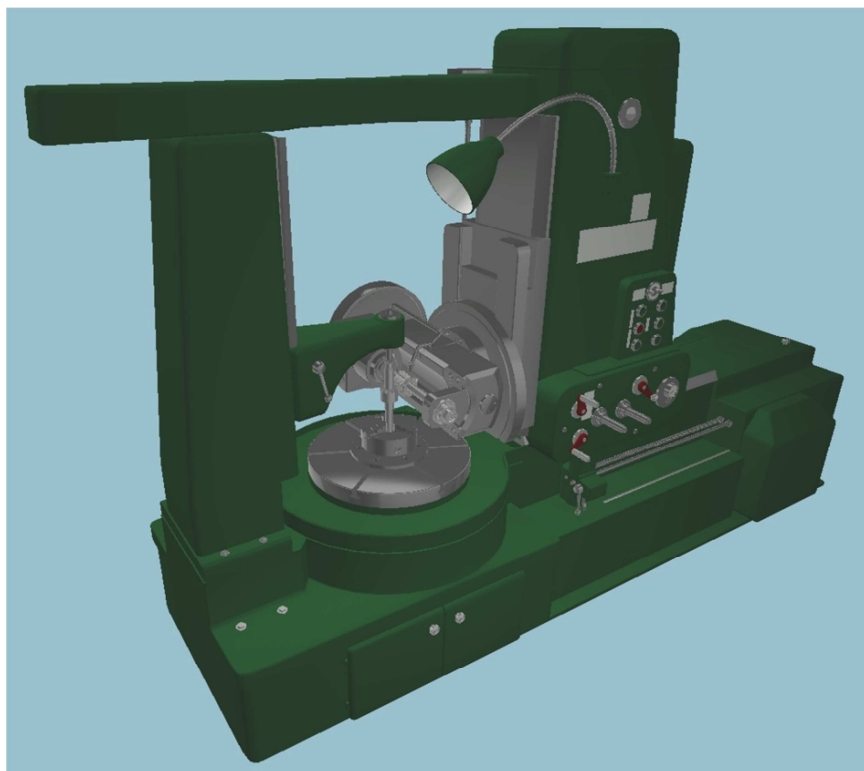Fig.2. Roughing of shaft using universal lathe

Fig.3. Gear milling using gear hobbing machine

Additional materials

There are additional materials and simulations showing some important issues helpful when learning the technological processes design available in the application:

- the production plan and its impact on design of the technological process –charts,

- the technological processes – fundamentals - informational chart,

- the interactive exercise - setting a proper order of the technological operations,

- machines – presentation of typical machines (universal lathe, universal milling machine, metal cutting band saw, cylindrical grinder, milling-centering machine, gear hobbing machine), each machine can be viewed from different angle and zoomed; a control panel window is available, allowing to move main modules of machine, switch on spindle rotation etc,

- typical operations carried out with milling machines (cylindrical milling, frontal milling, keyway milling),

- typical operations carried out with lathes (sliding, facing, conical turning, cutting and grooving, threading, boring, drilling),

- tools used in turning, milling and other operations - 3D models of tools: turning (ISO 1-13), milling (face cutter, modular cutter, hobbing cutter etc.) and other tools.

4. Conclusion

Application presented in article is used as a support during the technological processes design lectures, being a kind of virtual laboratory. Students taking part in lectures with 3D interactive presentation support confirmed that this form of lectures support it is a significant facilitation and allows to see thing difficult to show and explain in conventional laboratory or

production plant. The application allows to show details of technological process without the need to visit a production plant and expose to production plant conditions – loud noise, coolant spattering around during metal cutting and obscuring the view of machining. It is also possible to show processes taking place under covers of machines, in high temperatures or under high pressure.

Probably virtual reality simulation will not eliminate entirely need to visit actual production plants and contact with real machines, but it allows to shorten process of learning. This form of presentation is also attractive for students used to modern forms of communication and expecting contact with contemporary technology. Important advantage of 3D interactive presentation for university is that it can be easily upgraded when new technologies and machines are introduced, it is also much cheaper than buying machines as a laboratory equipment.

References

1. Ćwikła G., Kampa A., Gołda G.: E-learning platform as a support in the technical education of disabled people. International Conference on Engineering Education ICEE-2010. Proceedings CD, session T11D E-learning and e-assasment, July 18–22, 2010, Gliwice 2010.
2. Mikropoulos T.A., Natsis A.: Educational virtual environments: A ten-year review of empirical research (1999–2009). Elsevier, Computers & Education 56 (2011) 769–780.
3. Ćwikła G., Kampa A.: „Zastosowanie Platformy Zdalnej Edukacji do wspomagania nauczania przedmiotów technicznych". Komputerowo Zintegrowane Zarządzanie, Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2010, Tom I. str. 306 – 315.
4. Mzoughi T., Herring S.D., Foley J.T., Morris M.J., Gilbert P.J.: WebTOP: A 3D interactive system for teaching and learning optics. Elsevier, Computers & Education 49 (2007) 110–129.
5. Jara C.A., Candelas F.A., Puente S.T., Torres F.: Hands-on experiences of undergraduate students in Automatics and Robotics using a virtual and remote laboratory. Elsevier, Computers & Education 57 (2011) 2451–2461.
6. Huang H-M., Rauch U., Liaw S-S.: Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. Elsevier, Computers & Education 55 (2010) 1171–1182.
7. Ramasundaram V., Grunwald S., Mangeot A., Comerford N.B., Bliss C.M.: Development of an environmental virtual field laboratory. Elsevier, Computers & Education 45 (2005) 21–34.
8. Lu J., Pan Z., Lin H., Zhang M., Shi J.: Virtual learning environment for medical education based on VRML and VTK. Elsevier, Computers & Graphics 29 (2005) 283–288.
9. Jou M., Wang J.: Investigation of effects of virtual reality environments on learning performance of technical skills. Computers in Human Behavior (2012), http://dx.doi.org/10.1016/j.chb.2012.04.020
10. Feld M.: Podstawy projektowania procesów technologicznych typowych części maszyn. WNT, Warszawa 2003.