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From using virtual reality in the training process to virtual engineering

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Abstract

This paper firstly presents the reasons for virtual reality implementation, with immersion, in the processes of theoretical and practical training in the area of mechanics. There are some considerations related with the methodological implications and we propose an extension of the Wegener model. We describe a pilot station which tests the use of virtual reality in the training activities concerned. We present the first achievements in populating virtual settings, by interconnection of Cyber Gloves with the virtual setting, handling virtual parts for visual observation and easy assembling operations. Secondly, this paper describes a possible involvement of virtual reality to shift from traditional engineering to virtual engineering to resolve the current crisis of manufacturing engineering in a significant manner. Thus, we present the general structure of a virtual engineering entity, its main activities and organizational structures. Furthermore, we briefly review the main types of virtual reality equipment and technologies useful for highlighting virtual engineering for services and environment.

Keywords: teaching methods, virtual reality, classical engineering, virtual engineering.

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1. Introduction

Labour market dynamics requires an adaptation of the educational offer by schools, both at high school and university level, and the market is highly influenced by the current global crisis. Therefore, in terms of qualifications, number of graduates, and especially their knowledge quality, it is necessary to consider seriously this issue for the future. Obviously, the problem should be considered particularly in the context of labour market trends in Europe, which tries to overcome barriers related to the integration of local graduates.

In the context of the above mentioned problem, the idea of ”New Skills for New Jobs” study [1] is righteous, in which the following priorities are introduced. The first priority is improving anticipation and timing ability in the case of the labour market, as well as skills required at European level. Another priority is achieving objectives set within the EU strategy for economic growth and employment, and then it is essential to enhance existing initiatives and instruments. Besides, collecting comparable results at European level, promoting a truly European labour market, with jobs and training that meet expectations and mobility needs of citizens, are also priorities [1].

Therefore, major challenges in education today lead to competences corresponding to requirements of various activities on the labour market in a short time, which keep diversifying, with increasing complexity. These challenges also lead to continuous modernization of methods, techniques, and equipment used in the instructive educational process.

An effective modern solution for the issues mentioned above can be the use of virtual reality in training. Obviously, most experts know that the future belongs to 3D interfaces, hesitations being mainly related to the costs of equipment which are fortunately getting lower in these days, and their quality (e.g. resolution, response time).

2. VR System Type Architecture from the Perspective of Virtual Reality Application in Teaching

Qualifications in the field of applied mechanics generally involve complex technical skills and competences. The need for professional training, based on key abilities highlighted in Professional Training Standards, requires completion of a curriculum, whose specialty culture includes some technical subjects with modular structure, with contents based on theoretical and practical aspects found in technology laboratory and practical training activities.

Conducting training based on modern strategies, such as student-centered, requires laboratories with appropriate equipment and this is a difficult condition for many schools nowadays. The solution proposed in this article aims to set up a technological laboratory based on virtual reality techniques providing the description of the equipment and the technologies required.

VR type systems have three main distinctive characteristics. These characteristics are interaction, immersivity, and movement in a virtual environment (navigation) [2, 3,4,5].

In this respect, as a computer aided training process, learning applications based on virtual reality techniques must be integrated to the theories and models of computer aided instruction systems. Specialty literature provides a rich bibliography for this purpose [6]. There are many names and terms, in which the dominant acronym is CBT (Computer Based Training) included in the model proposed by Wegener [7].

In the case of this model and its components, it should be made clear that virtual reality does not have only a simple quantitative contribution to 3D equipment (gloves, goggles, headphones). Since virtual reality is a computer-generated environment where the trainee performs activities in real time without any contact with the outer environment through immersion, the characteristics of such a system will be different from CAI (Computer Assisted Instruction) systems. Computer assisted training systems in Wegener model are no immersive desktop applications, with high interactivity at the level of mouse, joystick, up to touch screen.

Therefore, the applications of virtual reality techniques corresponds at least within one extended Wegener model, if not a stand-alone model to reflect the characteristics mentioned (Figure 1). Modalities specific to the computer aided training system through virtual reality have different characteristics. Tutorials, practice, educational games, modeling, simulation and problem solving should be adapted to reflect virtual reality. Learning activities are also different, from a learning style to another, and applications should meet this requirement.

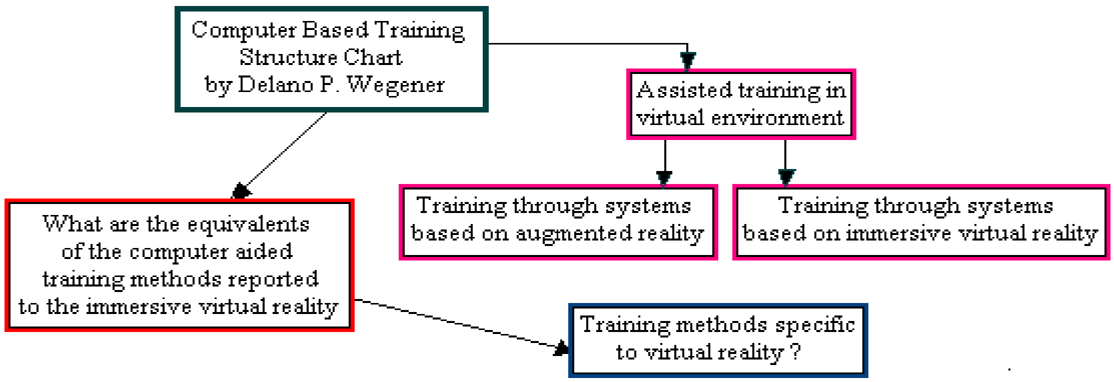


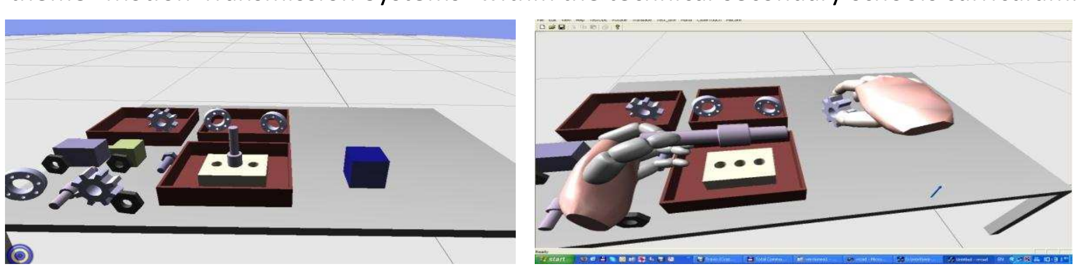
Figure 1. Wegener extended model

3. Structure of a Pilot Training Station Using Virtual Reality - Partial Achievements

Virtual reality training in applied mechanics, in the case of technology high school curriculum during first stage, aims to implement a pilot station [8] with appropriate teaching materials covering the steps required for approval of this procedure.

The pilot station structure consists of an HMD, or to begin with, a pair of stereoscopic glasses, a pair of gloves, CYBER GLOVE type, corresponding interface between them and the virtual environment (VRML), a computing system and appropriate software. First, an appropriate virtual scene is created. Thus, for applications in the academic subjects concerned (mechanisms, applied mechanics, machine parts), this virtual scene is designed as a workbench (Figure 2, a) with different parts (screws, nuts, sprockets, bearings, shaft-axis) placed directly on the table or in boxes (containing several pieces of the same type). At this stage, these pieces do not have physical properties. In the virtual scene, there are two virtual hands (Figure 2, b), and the problem of handling virtual parts by virtual hands is solved, including simulation of a two-piece assembly.

During the next period, these applications will be improved. Assemblies which are more complex, necessary adaptations for training in the case of subjects such as applied mechanics, and in the case of the students' activity will be obtained, and finally we seek approval of this learning-training procedure. We identify features of virtual reality based training application for the theme "Motion Transmission Systems" within the technical secondary schools curriculum.



a b

Figure 2. Configuration of the virtual scene and handling of virtual objects

In addition, we create a virtual scene for applications of various subjects as a worktable, where simple pieces and mechanical structures are placed. Modelling is possible in Solidworks (Figure 3).

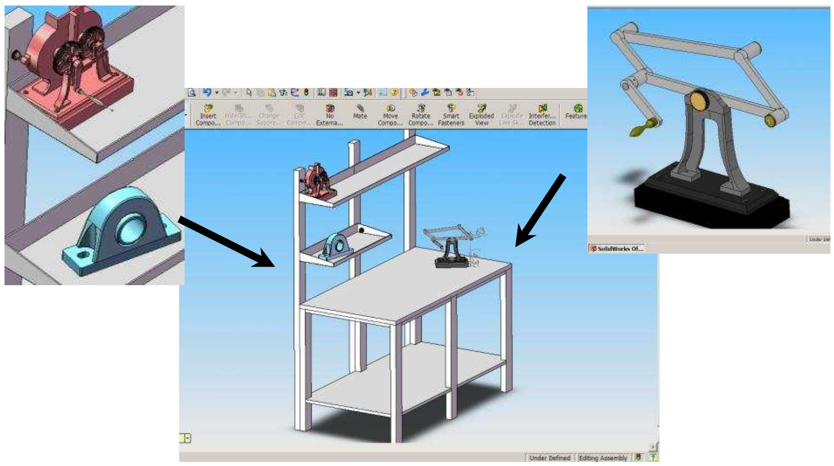


Figure 3. 3D scene modelling and objects location

The virtual reality pilot station is located in the real applied mechanics lab, so that the teacher can combine elements of the real lab and the virtual lab. This is an activity which will stimulate creativity, imagination, develop abstract thinking, decision-making ability, initiative, team spirit i.e. precisely curriculum targeted skills. The virtual lab allows the application of modern training principles such as learning by doing-learning through practice, interaction - interaction with the scene and the objects, hands on - the possibility to touch objects (haptics). Students can identify various machine parts; they can achieve assemblies of components, and they can identify and fix various errors in mounting, with a great variety of exercises combined with real laboratory activities.

All these activities can be implemented in the Romanian education system through an appropriate environment and long-term strategy. Training through these means and methods is useful in activities that may take place in a company whose activity is based on virtual reality techniques and technologies for purposes specific to the production of goods, and industrial products, and to services. In various structures of such a company, high school and university graduates may find their vocations. In the next section, we will mention the features of such structure in detail which will undoubtedly be one of the next period priorities and might serve as an appropriate solution to overcome the current crisis.

4. The General Structure of an Entity to Be Used in Virtual Engineering

Virtual reality is considered as one of the most fundamental areas among computers and robotics. Virtual reality might be able to reconfigure the global society of this century and even further, can be regarded as a solution to overcome the current structural crisis, deep crisis with multiple consequences most negatively. One of the main aspects of this crisis which is less evident, is related to product manufacturing techniques and technologies, e.g. [9,10,11,12].

Practical solutions which are used to manufacture most products have remained significantly behind the development of other sectors, behind general human activities such as creation, processing and sharing information, general circulation of goods (products and services), interpretation of human society and nature in general, or human mentality. The main aspect of the manufacturing lag refers to the existence of another important role of the human factor. Through its behaviour, it leads to violation of structural and functional features of technical means of processing, technical means of handling and transfer, of the equipment and processing technologies, of technical and technological information pertaining to product design, technology design and technology management, product testing, transport to the beneficiary, maintenance, or technical support during product life. In this approach, we add services to actual products as well. In this context, virtual reality can be a solution. At least, it can eliminate the sluggishness of manufacturing engineering in general.

This paper describes a possible involvement of virtual reality to shift from traditional engineering to virtual engineering to solve the current crisis of manufacturing engineering in a significant manner. Thus, we present the general structure of a virtual engineering entity, its main activities, and organizational structures, and we briefly review the main types of virtual reality equipment, and technologies useful for highlighting virtual engineering for services and environment.

An entity based on virtual reality equipment and technology is similar to a current organization with the distinction that all activities, from the idea for a product or service to the final documentation, are required for manufacturing a new product or service providing. Its' implementation is also involved, and everything is resolved through appropriate solutions based on virtual reality.

Manufacturing, as a phase of physical manifestation of the product, takes place outside the virtual engineering entity, in an appropriate location, usually computerized and robotized, with a great capacity for reconfiguration, where the human factor has only a supportive role, both during periods of use, and conservation, until a new order.

As far as this material is concerned, the simplified structure, of activities, of a virtual engineering entity is given in Figure 4.

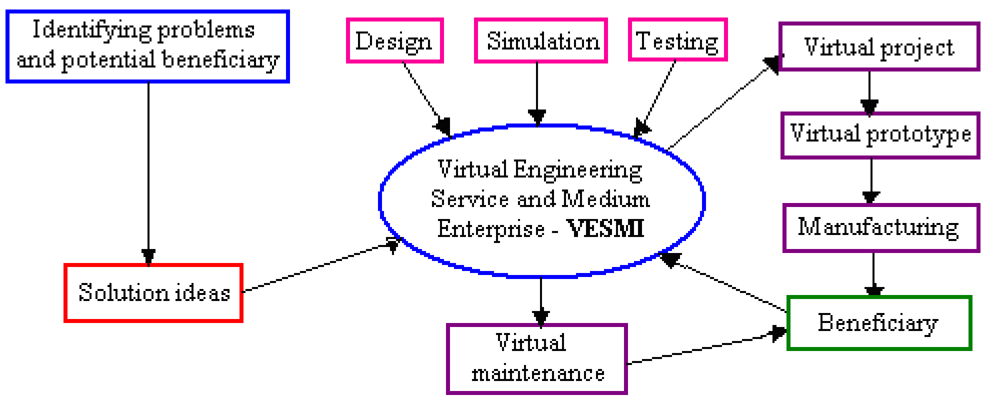


Figure 4. The structure of the activities of a virtual engineering entity

This entity carries out the activities which are mentioned below in appropriate sections. The first one is identifying problems of behaviour in market prospecting. Then, there is finding the optimal solution in the section of creativity, and invention, through design, and simulation activities.

It follows the functional-design department through constructive design. Next, there are activities of technological design, and virtual prototyping - department of virtual technologies.

We continue with virtual testing and technical evaluation activities of the functional and constructive performances, and certification department. Besides, there are activities of solution identification, and location for manufacturing, manufacturer identification section (usually close to the beneficiary), activities of commissioning, and delivery, and implementation section, maintenance, and technical assistance activities along the life of the product, remote compartment of technical support online.

Thus, an entity of virtual engineering provides a virtual product, including all technical documentation necessary to its manufacture (once obtained this project similar to the current one, corresponding to the series 0, a manufacturing solution is identified, and the location can be virtually at any distance, preferably near the beneficiary). One moves to that stage, where corrections are performed on the computer. Once done, the physical product is delivered to the beneficiary, and receiving and commissioning steps are covered. During the life of the product; technical support, maintenance and any repairs will even be performed online by the entity's virtual maintenance department VESMI. A direct consequence of such an approach is the possibility of decoupling the design extensively, from the production stage, which can be performed where a solution is identified, financially and qualitatively affordable, as well as from the distance, from the perspective of the beneficiary. Obviously, virtual and possibly online maintenance activities can take place throughout the product life.

In addition, it would be beneficial and interesting to separate specifically the concept above in the form of *virtual engineering for services and environment*.

Thus, we can tackle globally activities that exceed the service area in the current sense, by including in their category, manufacture, and related issues like proper training, and management activities dealing with environmental problems, analysis, protection, configuration, and reconfiguration, especially in residential areas. Therefore, one can study various scenarios to develop or restructure the environment, piecewise or globally, in short, medium, and long term.

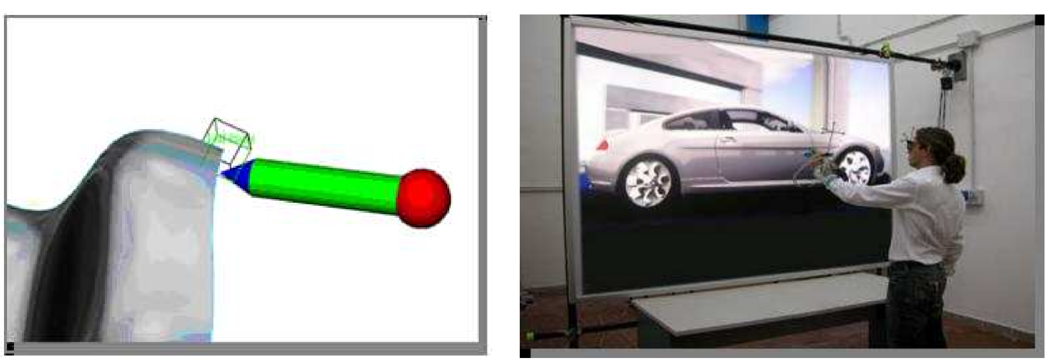
It is not less important to note the possibility of a virtual reconstruction of existing situations in the past, and in the future, including the possibility of dynamic change simulation by introducing virtual time (such as an urban area, a city, village or other settlement otherwise, but also an existing natural area in the past or future estimated to be). Therefore, the immersion in inner and outer areas, and interaction with virtual scene components, can lead to a unique perception and experience including the cognitive aspect.

5. Main Types of Equipment Recommended For Specific Virtual Engineering Activities

5.1 For Design and Functional Simulation

Design work is typically conception, and project activity, including functional, and constructive design [13].

For design, we used advanced software like CATIA, Pro-Engineering, AUTOCAD, SOLIDWORKS that for certain issues can turn to specialized software such as the finite element ones, like NASTRAN, PATRAN; see Figure 5 [14].



a b

Figure 5. Virtual design: special device (a) and an example to use its (b), e.g. [6]

For functional simulation, the role of virtual reality is much more important, and equipment in this category is more varied, and of unquestionable utility. 3D functional simulation is possible through CAVE type equipment or similar (which covers some of the CAVE equipment amenities, sufficient for the solved problems), Figure 6a. Following this simulation, improvements are possible so that we can approach the optimal solution of the product or service.

Functional simulation is more significant as it can use real virtual reality versions with increased virtual reality or improved virtual reality (see Figure 6b).

a b

Figure 6. CAVE equipment: general structure (a), e.g. [15] and used at robot simulation (b), e.g. [16].

Following these simulations, we can make improvements so that we can approximately attain the optimal solution of the product or service.

5.2 For Virtual Manufacture - Virtual Prototyping and Testing

Production simulation is possible in virtual environment [17, 18, 19, 20, 21, 22, 23, 24, 25,26,27]. The succession of technological stages, hence of operation, handling, transfer, and processing, can be simulated in a virtual environment, even if currently there are not performed simulations for the entire physical-chemical processes specific to manufacture, and transfer (see Figure 7).

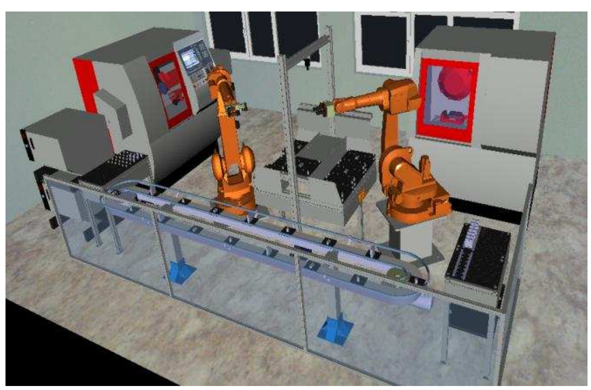


Figure 7. Virtual robotic cell for manufacturing and transfer [28].

They are already solved and operational (virtual simulation can be highlighted in the case of physical and chemical process of welding operation, electric arc cutting and processes specific to alloy casting). An important area is virtual simulation of cutting processes (processing) of different metallic materials (turning, milling, drilling, threading, grinding, etc.), non-metal (wood, plastic) or composite materials, simulation of forging, and hot or cold cupping etc.

Virtual simulation of most technological processes should be a priority for research in the next step.

Virtual testing is also very important view on the high costs of testing of real prototypes, [29], [30]. In this sense, achievements are important; one can discuss complete virtual solutions for virtual prototyping testing like virtual cars (see Figure 8) from which solutions can be extrapolated successfully to other types of products, and services.

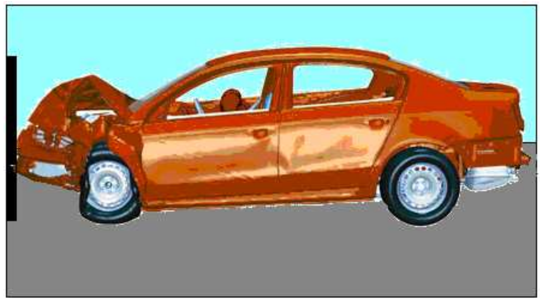


Figure 8. Virtual testing of the car

5.3 For Maintenance

Having the virtual model of the product, all maintenance activities, including the replacement of defective parts, can be simulated in the virtual environment. Even if current attempts faced with some difficulties, leading to scepticism, solutions during the next period will successfully solve all the current problems.

Thus, maintenance can be achieved on the virtual product online with the actual product (see Figure 9: an instructor can track all trainees in the field, using a free view camera available as a window on the instructor station, e.g. [31]. It is similar to virtual remote surgery. This example is not exaggerated, view the maintenance, including in the case of equipment operating outside the Earth, such as satellites and circum-terrestrial stations, but they can operate as well in hostile environments, such as seas and oceans at great depths (e.g. interventions in the underwater infrastructure of a sea platform, aboard a submarine, etc.).

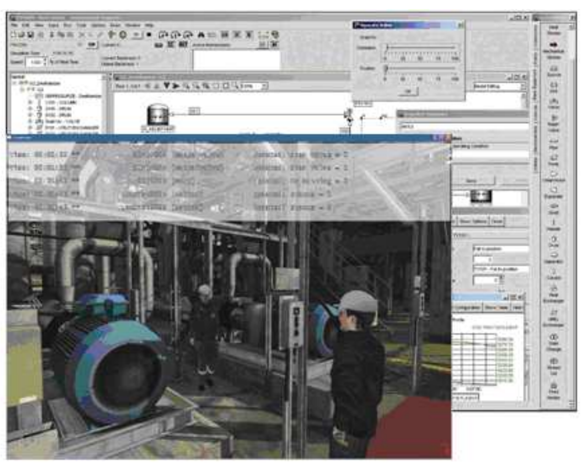


Figure 9. An example of virtual maintenance [31].

5.4. For Promoting Products and Services

Virtual promotion presents special perspectives because the product can be presented in the work environment, but also in hypothetical environments, and situations, and possible alternatives may be presented, identifying specific advantages. It can be made available for interested parties by means of remote information sharing.

A very important application is related to virtual exhibitions, e.g. [www 2]; see Figure 10. The main advantage of virtual exhibitions is the modern promotional online method, for the first time in the car parts area, with the chance to promote each exhibitor's products. The method seeks to relate companies and buyers, in an easy-to-use and direct environment, like the internet, sharing everything about car parts, the latest services in the automotive sector, in the same area [www 2]. The main objectives of the application are to stimulate the interest of the public, with its originality and innovation, to become an annual online meeting point, and to provide agreement between exhibitors and visitors [www 2].

For example, the first **virtual exhibition AutoP-Expo 2011** hosted up to 500 exhibitors with products and services, such as car parts, and systems, repair, and maintenance equipment, lab equipment, medical equipment, and car painting, car washing, sound accessories, IT parts, and electronic management, environmental protection, energy-saving, new products, quality certification, banks, financial organizations, insurance companies, media associations [www 2].

Figure 10. Virtual exhibition [www 2]

Obviously, a virtual product in the future will be tested, and used online for a limited period of time, similar to the current situation of trial use, after which the product may be returned. Thus, a virtual product can be changed based on demand, and adapted as a customized product, with much lower costs than today's similar activities.

Therefore, training activities, functionality development increasing, and products, and utility of services have become more effective and continuous today.

5. Conclusions

Based on the data presented in this paper, we can draw two important conclusions:

- recent progress in information sharing requires new methods of learning and training, consistent with the Internet, and mobile phones possibilities, but with powerful learning features, corresponding to virtual reality techniques, and technologies which are already on the market;
- traditional engineering, particularly manufacturing, is in crisis despite the powerful promotion of simultaneous engineering and re-engineering;
- virtual engineering in a global approach can be a viable solution to overcome the current critical situation of manufacturing engineering, and new release of engineering particularly. It is possible primarily by covering steps to virtual prototyping from the actual production, and by the transition to a stage when interaction between customer

and virtual product can acquire new meanings, with optimized effects on functionality, and efficiency of use, in the case of very important financial resources, at occupational level.

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