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Abstract

The paper deals with a method used many years for example based learning for the virtual prototyping. The authors collaborate since ten years in Erasmus background. It means four french students a year in the bachelor of technology course got a three months placement in Romania supervised by the authors. They are applying this learning method described here. The investigation domain is the virtual prototyping. The virtual product development replaces traditional material object test with digitized form product by building product's digital model. It offers to analyze product's static and dynamic characteristics on the circumstance of digital state, and rebuild and improve the original design. The virtual prototype technology carries out any product optimization. Virtual prototype technology is a kind of engineering method which can shorten new product development cycles by replacing cost physical prototype with virtual digital model. The subject detailed here deals with a virtual prototyping using Delphi programming environment. The example based teaching method is thus applied. There are several potential advantages of example based learning programs, including the ability for people to learn from their homes and study without the assistance of an instructor. As the use of computers in life is increasing, all teaching methods and strategies should be renewed to match with the advancement of technology. It means that videos, texts, lessons, answered homeworks in electronics format should be easily downloaded by any new learners. The method proposed takes 3 main steps. The first step offers the connected student to download as many examples as he wants. Any example is given in an executable format only. The student launches the example, takes notes and comments on the scenario and writes down new ideas on a working platform. The second step is devoted to the discovery of the application language. A given example is given to the student including the source code. At that moment, the student can slightly change any code line and check at once the positive or negative effects. The third step is based on the invention of the personalized virtual prototype. In that last step, the student uses his own imagination in order to create a product and sometimes to obtain a patent. The paper ends with two examples of virtual prototypes created in order to support technical design in construction and automatics engineering and draws some conclusions.

Keywords: virtual prototyping, creative works, modern strategy for learning.

1. INTRODUCTION

The paper deals with a method used many years for example based learning for the virtual prototyping. The authors collaborate since ten years in Erasmus background. A group of French students in the bachelor of technology course got a three months placement in Romania supervised by the authors. They are applying a learning method described here. The investigation domain is the virtual prototyping.

The virtual product development replaces traditional material object test with digitized form product by building product's digital model [1,2]. It offers to analyze product's static and dynamic characteristics on the circumstance of digital state, and rebuild and improve the original design. The virtual prototype technology carries out any product optimization. Virtual prototype technology is a kind of engineering method which can shorten new product development cycles by replacing cost physical prototype with virtual digital model. The subject detailed here deals with a virtual prototyping using Delphi programming environment. The example based teaching method is thus applied.

There are several potential advantages of example based learning programs, including the ability for people to learn from their homes and study without the assistance of an instructor. As the use of computers in life is increasing, all teaching methods and strategies should be renewed to match with the advancement of technology. It means that videos, texts, lessons, answered homeworks in electronics format should be easily downloaded by any new learners. The proposed method here looks like a few years before as the massive on line open courses.

After an overview of the based computer learning methods, the second section details the three steps method in use for learning by examples. It focuses on one major point that is the choice, the definition and the work out of a virtual prototype coming straight from the student's mind. A student guided but not forced by the supervisor draws his own success. A flicker followed by an essential question drives the student to realize his personal application and feeds his motivation all along the placement. The answer of any improvement of his application is given by the machine not the human. This is one of the success to learn with computers. Nevertheless, the teacher's help will be required in order to improve the student 's prototype.

The third section proposes to the reader two examples. The first one is concerned with the civil engineering domain and the second the robotics domain. In the first example the virtual prototyping techniques are applied to the development of models related to the architecture and construction process. When carrying out a project, the use of visual programming and, in particular, the 3D modeling, provides a very positive contribution. The application is concerned with a smart building. The second example deals with a virtual robot prototype using a simulator. The simulator allows quick evaluation of the consequences of actions without interacting with the external world.

The last section draws some conclusions about the virtual prototyping based learning.

2. EXAMPLE BASED LEARNING METHOD

2.1 Overview of based computer learning

The virtual prototypes examples - based learning is a term that describes the way to use computers as a central instrument involving the user imagination [3]. This teaching approach takes advantage of the interactive elements of a computer software, along with the computer's ability to present many different kinds of applications. There are several potential advantages of examples-based learning programs, including the ability for people to learn from their homes and study without the assistance of an instructor. Example-based learning has been used as a tool in the university laboratories of a more traditional team experience. It has also been used as an elementary learning method, especially in many online educational programs.

The use of computers for learning has generally increased with the advancement of technology. The ability of computer hardware to process and present many different media types has allowed for more complex computer learning strategies.

An example would be a training module that uses virtual prototype as model. Code source and pictures are often handled in an interactive manner, and sometimes they can almost be like games, depending on the style of the implementation. A very high-quality education experience can potentially be implemented in a computer-based virtual environment and then distributed widely around the world to people of all economic backgrounds. With computers, the students can potentially spend as much time as necessary to understand a given subject before moving on. Virtual prototypes examples-based learning allows students to have the personal initiative they need. Virtual prototypes examples - based learning often brings up the fact that it is relatively common for a program to mix virtual prototypes examples to obtain a new application.

This learning strategy requires students to revisit multiple virtual prototypes created before by former students for a stronger understanding of that they must do. Working through these examples and discussing with a partner, helps students to gain a deeper understanding of the subject. The students may work together in pairs or small groups to discuss and compare their ideas. But the students can be also asked to work individually. The reason is such that they can prepare their virtual prototype based on personal ideas. Each student will be able to create its personalized application that turns him proud of its work.

A set of design principles for project-based learning also valid in a virtual prototyping based learning background. These items are given below:

-Innovation : a project should use a real world context, emanate from a problem that is significant to students, result in a product or performance that gets a personal and/or social value.

-Academic consistency : a project should address key learning standards, ask an essential question of relevance to the student, develop mind habits and work in connection with academic and professional domains.

-Applied learning : a project should engage students in solving semi-structured problems**,** demand skills expected in high-performance work organizations**,** require students to develop organisational and self-management skills.

2.2 The proposed method

The method described has been applied for many years with two types of students. These are local students or Erasmus students. The first are local students coming from the Transylvania University of Brasov in Romania. They chose the master of technology course in the robotics domain or in the building engineering domain. The final part of their course is concerned with a project in the virtual programming environment. The second kind are Erasmus students coming mainly from the University of Valenciennes in France. To end their bachelor of technology course, the French students in electrical engineering domain follow a 3 months placement at the Romanian university. They are supervised by the teachers mentioned in the paper head.

The method called the DARe method is used to design virtual prototypes based on examples. The word DARe represents the acronym of Discovering, Applying, Realizing. The 3 steps method is described below.

The first step called Discovering offers the connected student to download as many examples as he wants. Any example is given in an executable format only. During one week, the student launches the example, takes notes and comments on the scenario and writes down new ideas on a working platform. Hundreds examples are coming from previous works done by local or foreign students. The general framework matches the robotics or civil engineering domain. During this week devoted to trials, the supervisors are asked to detail the objectives or the specifications of a given application. They focused on the starting motivation and the results. In some cases, the virtual prototype application is coming from local companies and patents can be defined of the realized product. This first step is feeding the imagination of the students to define their own product.

The second step takes one week too and is called Applying. It means that the student gets from the supervisors the source code of the few examples he ran. He is checking the different parts of the source code and their effects when running. The supervisor is proposing to change one elementary part of the source code and its application on the product. At that moment, the student is discovering and applying by his own the new programming language for the virtual prototyping. The supervisor comments the results. This second step is defining the student project he will build himself. At that moment the student is sure to end the product during the placement.

The last step represents the most important work either for quantity and quality and id called Resolving. That part starts 2 weeks after the beginning of the placement.

Programming, compiling and running the code, writing comments in a logged book, proposing new ideas, preparing the final report are the main tasks carried out by the student till the placement end. Once the product achieved, all program source codes are printed out. The running virtual prototype application is installed on a compact disk for archives at the university library and further use.

The programming language is now explained in depth by the supervisor. All menus are detailed. Special lessons are given to the students to improve the fresh knowledge they catch by their own. The oriented object programming delivers its secret to the students helped by teachers, relayed by the notes written in the logged book. These comments are setting the structure of the final report. During the Erasmus placement and thank to the net, all student work are also checked by their home university. At the home university, from the starting week to the last week, a more administrative supervisor is also checking the improvements of students abroad. Each student sends him the details of the working week. One reason is to link all persons involved in the project. The second is a more academic reason. That is, in Erasmus background placement, the home and host universities must prove at any time to the European Community the use of all funds for teaching and continuing collaborative exchanges. Back to the student project, the choice by his own of the product to realize determine and keep going the motivation. The following section focuses on this point.

2.3 From an idea to its achievement.

2.3.1 The flicker

This is where the initial flicker for a project comes from passions, or a colleague's passion. One important thing is that somebody is very excited about the idea, and that person's excitement is infectious. Of course, there is much more to projects than excitement, but if you don't start with something that you feel passionate about, the project won't be much fun, and the quality of the work will suffer. The sooner you start talking to your colleagues about your ideas, the better your project will be. Bring a summary of your project ideas, and a list of things you're excited about and things you're worried about. The students have the total freedom to choose their project about her original idea. A project's initial flicker may take many forms: it could be a question or it could be a product that you'd like students to do. Teachers are no longer their students' primary sources of information. Instead, they are the designers of learning who created the conditions for the students to conduct their own enquiries, and advisers to whom learners can come as they create their product. For both students and teachers, this is work that matters. It can be a good idea to try out a project that a colleague has done in the past that you find interesting.

2.3.2 An essential question

The best project always contains an essential question that both inspires and requires student to conduct serious researches. It's never too early for students to mind an essential question. However, this essential question would probably change once the project 's design is settled. Three criteria for a compelling essential question follow : It should be a question that students ask in the 'real world', It should be a question that has no easy answer for virtual world and It should be a question that ignites students' imaginations. Finding a question that fits these three criteria is not easy: it takes time, trial and error, and lots of discussion with colleagues. Some of the best essential questions are ones that students come up with themselves. By discussing the issue and doing some initial research, groups (or individual students) can come up with a question that will guide each of their enquiries; for example, 'Is manufacturing as efficient as it could be expressed in virtual world ?

2.3.3 Personalize the project

Each student has a model project to show the student before it begin, so the student know what expectations are. Projects offer students many 'points of entry', and many ways to shine. Successful projects are designed so that students make decisions for themselves throughout the process; each student chooses what to focus on. The students have the total freedom to choose their project based on original idea.

2.3.4 Patent or Motivating student to innovation

The most popular way to encourage innovation is to offer students recognition for innovative ideas by allocating time for innovative work and by satisfying with opportunities for career progression. That is to promote innovation is the biggest challenge in the use of virtual prototyping technology. That means having the ability to demonstrate tangible business benefits of new automatic/robotic systems. It may be necessary for students - expectations engineers - to win theirs confidence on virtual prototype first, before moving on to real/physical system- adopting virtual prototyping learning method brings student focused on to master new systems. Recording the number of patents is one of the popular measures of innovation [4]. During the stage the students are preparing to work in the innovative companies which are known for encouraging innovation by freeing up its staff to spend one day a week developing their own innovative projects.

3 TWO EXAMPLES

The use of the virtual prototyping technique is very helpful in areas such as Architecture, Construction or Engineering. In this paper the target users of the virtual prototypes models are Civil Engineering and Electrical Engineering students in bachelor of technology course. Here, the virtual prototyping technique was applied for educational purposes. Two examples follow.

First in civil engineering and second in robotics.

3.1 From civil engineering

In the first example the virtual prototyping techniques are applied to the development of models related to the architecture and construction process [5]. When carrying out a project, the use of visual programming and, in particular, the 3D modeling, provides a very positive contribution. It improves the understanding and the rigorously and correct behavior of all spatial configurations in their environment.

In the architecture domain, the design of a building is given by usually several drawings, which, recently, are often added by 3D models [6]. Architects create 3D models of houses so that their clients can more clearly understand what the house will look like when will build. The development of Computer Aided Design –in short CAD- software has been changing the design methodology. In general, the designers approve of the use of CAD since because it improves designing, but mostly any CAD software is still used only as drawing help. However, the process involved in the design projects could easily derive clear benefits from the use of CAD because it can make drafting and the creation of alternatives quicker and more effective throughout several stages of designing, including the conception phase. For that, however, it is not enough for designers to learn to use CAD properly, they also have to learn how to create and to support their activity with it, which requires, also, a new way of thinking and reacting to CAD [5].The visual programming and the virtual prototyping technique comes in this sense.

In the construction domain**,** the models concerning construction need to be able to generate changes in the project geometry. The integration of geometric representations of a building together with scheduling data related to construction planning information is the basis of 4D models. The 4D models domain combine 3D models and the project timeline. The virtual technology is used to render 4D models more realistic. It allows interaction with the representation of the construction site. The 4D models are used to improve the production, analysis, design management and construction information in many phases and areas of any construction project. The Virtual Building Technique –VBT in short- is developing and implementing applications based on this former technique. It results a a better communication between partners during the construction project [3,6]. The figure 1 shows a shot of the running application. The application is concerned with a smart building.

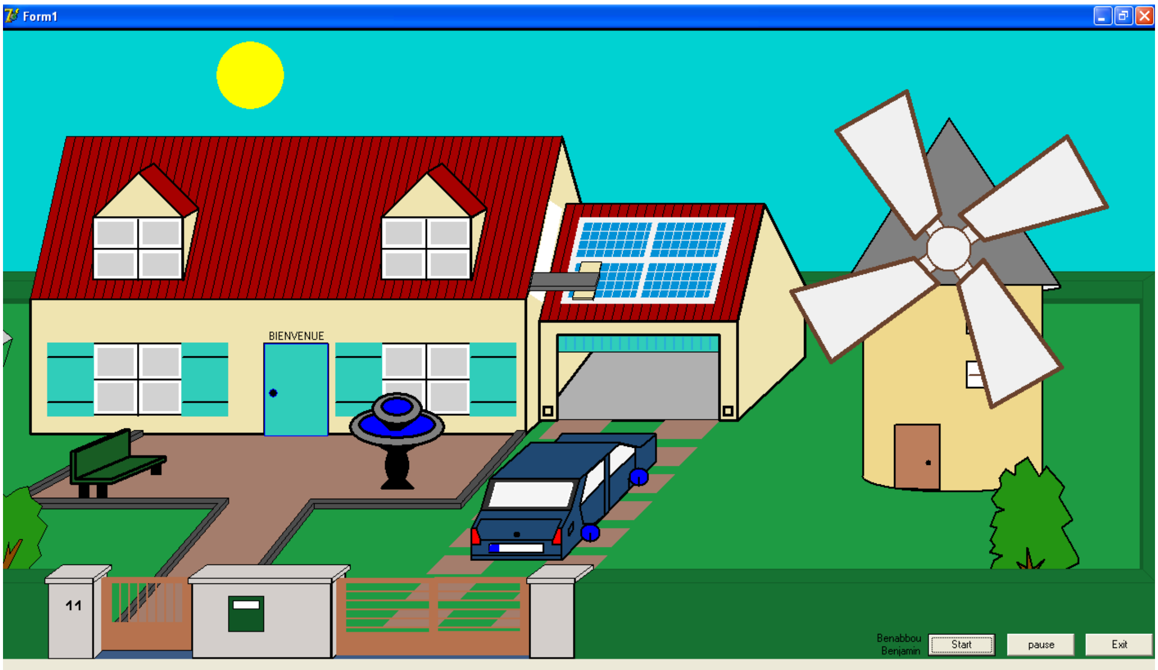

Fig. 1 Shot of a running virtual smart building application

The virtual prototype model, created to help the management of intelligent systems in buildings, allows the visual and interactive transmission of information related to the behavior of the elements, defined as a function of the time variable. These applications allow the visual simulation of the physical progression of each type of work and also assist in the study of the necessary equipment needed and how it functions on site.

The didactic project model presented in the text shows a sequence of the evolution of the diary activity that implies the evolution of the intelligent parts, allowing step-by-step visualization. The models are concerned with a residential house and a wind turbine, as a significant component of an intelligent building, each with different degrees of detail and technical information.

This application demonstrates that the 4D model allowed a quicker understanding of the structural organization of the building and a useful tool for the surveying and mapping of its intelligent parts. The 4D models help to work out many kinds of data and also to identify incompatibilities in the introduction of new elements within old structures.

The virtual prototypes models appear as an important tool for the intelligent structures surveillance and for supporting decisions based on the visual analyses of alternative solutions. In that case, many alternative modeled solutions worked out the optimal solution.

3.2 From automatics engineering

A virtual robot prototype is created using a simulator. The simulator allows quick evaluation of the consequences of actions without interacting with the external world. If there are multiple action options during a work task, the virtual prototype created by simulator could be used to decide which action to choose. Another interesting application of the robot virtual prototype could be to use as an early predictor of possible robot malfunction or hardware problems. This would give an opportunity to change a robot program before it stops working in the middle of a work task.

The virtual prototype is used as a forward model of the controlled robot to predict its behavior in the real world. The predictions are based on a copy of the robot commands acting on the real robot.[7,8]

These predictions are used as intuitive way to motion control method to programming physical robot through the imitation of the virtual robot prototype. Movement imitation requires a demonstrator: the demonstrator is the virtual robot prototype and the imitator is the physical robotic arm. The dynamics of the motion of the virtual robot is reproduced by the physical robot. The virtual prototype is used in an inner control loop to generate sequences of actions that guide the physical robot towards a target state. The fast internal loop is functionally equivalent to an inverse-dynamic model that controls a robot without feedback. The virtual prototype as predictor can greatly improve control performance if the virtual model is correct.

All physical feedback control loops exhibit a certain delay, depending on the system inertia, on the input and output speed and, of course, on the speed at which the system processes information. In order to react as precisely as possible to a given situation and to calculate the behavior of the robots we need to know their exact positions at every moment (i.e. at every virtual frame). However, due to the system delay, the system can actually react to commands only after some delay. When moving faster the delay becomes very important since the error between the real positions of the virtual robot position, used for control, may grow.

The last frame captured from virtual robot reflects a *future* position of the physical robot, and we need to send commands so that they are consumed by the physical robot in a *future* frame. Predicting the present position of the robot is therefore not enough: we need to predict its future position, at the time when the new commands will arrive and will be consumed. These predictions are used as a basis for control. We use real recorded pre-processed data of moving robots to prepare the virtual models and teach the system to predict their positions one frame in advance.

In order to correct the immanent error associated with the system's latency we apply virtual prototyping and programming by imitation to process the actions and sent commands to the physical robot during the last frame captured from the virtual prototype. The concept of robot motion prediction was introduced to clearly understand what the robot must do when trying to localize visual objects. His suggestion was that the physical robot can predict the position and the orientation using her virtual prototype rather than physical sensory signals. Based on virtual model, the physical robot situation is made available before physical sensory signals become available.

Programming problem based on virtual model consists in predicting the position and the orientation of the robot - a frame forward into the future - and in using these predicted values for the behavior control of the physical robot, rather than the values from the vision directly.

One provide the last virtual robot positions and orientations (relative to the current physical robot position and orientation) and one prepare the commands to supply forward the physical model. The physical robot is trained to predict the position and orientation for a given situation. Figure 2 shows a virtual plant with two virtual robot arms. This example can illustrate what can be gained from predicting the positions of the physical robots in future frames using her virtual prototypes for a predictive command.

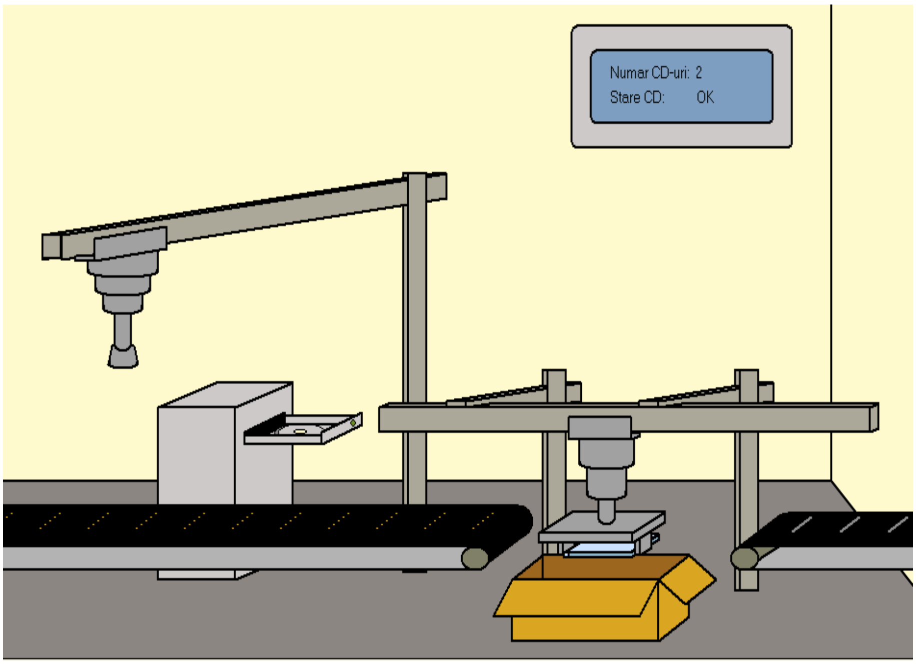

Fig. 2. Driving two robot arms to a given target using a virtual prototype plant as predictor

The homonyms physical arms drive first to the target position with a given speed, but because of the delay it does not stop right on it; the robot drives further against the floor and then, with low speed, again to the target position for a certain time. Another interesting experiment consisted in testing how much the quality of the virtual prototype - as predictor - comes from the dynamics of the robot itself and how much from the knowledge of future states. These virtual models have been successfully developed, implemented and on an experimental platform for predicting the motion of the physical robots.

4. CONCLUSION

There are many possibilities for the creation of computational models mainly where the subject matter is suitable for description along its sequential stages of development. The applications with these characteristics make the advantage of using virtual prototypes techniques, especially when compared to the simple manipulation of complete models.

The pedagogical aspects and technical concepts must be integral elements in the design and creation of these models. With the development of the virtual technologies students can explore more realistic 3D environments and interact with artificial systems of the environment. The interaction allowed by virtual prototypes models could bring an end to passive learner attitudes which are often found in traditional academic teaching situations. In addition, virtual prototypes technology could be applied as a complement to traditional academic teaching, leading to better understanding of the process behavior, whether in training, in education or in professional practice.

Moreover the constant updating of training in the virtual prototypes technologies - frequent used in professions in the fields of engineering or architecture, the universities should adapt its teaching activities to the new tools of visual programming technique. Educational institutions can use virtual technology as a tool, as well as a means of online teaching and virtual prototypes as support teaching. Virtual technology allows students to exchange information about specific domains and interact and learn cooperatively, therefore, the examples of virtual prototypes are viewed as didactic materials too. Today, virtual prototypes models are used in engineering schools to help both the lecturers and students. They offer students the opportunity to visualize the engineering concepts cooperatively; therefore, an aspect that must be improved is the preparation virtual prototypes as didactic materials to support teaching.

It has also been demonstrated, through the examples presented here, how the virtual prototypes technology can be used in the elaboration of teaching material in the construction and automatics areas. The virtual prototypes can be proactive about building a work environment that's ready for the future. Thus, teaching - based virtual prototypes technique may well induce students to consider this knowledge as elementals in their future professional activity, while to establishing the link between virtual technologies and engineering theory. Virtual environments offer new opportunities and possibilities for engineers. This role is particularly relevant to the presentation of processes which are defined through sequential stages as generally is the case in the design of new products and systems.Today, in practical activity, a variety of engineering software is used, but this requires skills and knowledge to develop economical and feasible solutions. The virtual prototypes take full advantage for virtual technologies users, who view them as means to improve the efficiency of the conception activity and as a professional support in their activity as engineers.

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