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ANIMATED 3D TRAINING SOFTWARE – INOVATIVE TOOL FOR THE WEEE REUSE AND RECYCLING INDUSTRY

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Abstract

Animated 3D training software is an innovative tool describing the dismantling process step by step for 50 most common electrical appliances. The tool is intended for two groups of WEEE reuse and recycling industry workers: low skilled workers (including non-native, disabled or marginalized workers) and corporate management personnel.

Using a combination of a popular game engine (Unity3D), C# and JavaScript code, and external calls to web services, 3D representations of the WEEEs and their parts become manageable through a WEB 3D CMS. All the information that is connected to the 3D Objects is dynamically set by content authors. Multilingualism is another key feature of the platform. There is a tool to easily translate all the content of the application to the preferred language online. This technology will produce Virtual Scenarios with a crucial advantage: a 'content author' will be able to modify or replicate them, create new scenarios, combine knowledge from existing one, present differences between the same type of devices, model their parts and materials with the help of ontology on WEEE.

The tool will be available from the Internet in seven languages (English, German, French, Czech, Greek, Romanian and Slovenian) and the basic version will be free of charge.

Key words: WEEE, recyclation, training, interactive, 3D

INTRODUCTION

The production of electric and electronic equipment (EEE) is one of the fastest growing areas. Since the 1980s, with the development of consumer-oriented electrical and electronic technologies, countless units of electronic equipment have been sold to consumers. The useful life of these consumer electronic devices (CEDs) is relatively short, and decreasing as a result of rapid changes in equipment features and capabilities. This development has resulted in an increase of waste electric and electronic equipment (WEEE), or electronic waste (e-waste) (Hai-Yong and Schoenung 2005).

For example, in 1994, it was estimated that approximately 20 million PCs (about 7 million tons) became obsolete. By 2004, this figure was to increase to over 100 million PCs. Cumulatively, about 500 million PCs reached the end of their service lives between 1994 and 2003. 500 million PCs contain approximately 2,872,000 t of plastics, 718,000 t of lead, 1363 t of cadmium and 287 t of mercury (Puckett and Smith 2002). This fast growing waste stream is accelerating because the global market for PCs is far from saturation and the average lifespan of a PC is decreasing rapidly — for instance for CPUs from 4–6 years in 1997 to 2 years in 2005 (Schnellmannc and Böni 2005).

PCs comprise only a fraction of all e-waste. It is estimated that in 2005 approximately 130 million mobile phones will be retired. Similar quantities of electronic waste are expected for all kinds of portable electronic devices such as PDAs, MP3 players, computer games and peripherals (O'Connell 2002). In view of the environmental problems involved in the management of WEEE, many counties and organizations have drafted national legislation to improve the reuse, recycling and other forms of recovery of such wastes so as to reduce disposal (Cui and Forssberg 2003).

Currently, the main options for the treatment of electronic waste are involved in reuse, remanufacturing, and recycling, as well as incineration & landfilling. In many cases, electronic equipment which is no longer useful to the original purchaser still has value for others. In this case, equipment can be resold or donated to schools or charities without any modification. Reuse of end-of-life (EOL) electronic equipment has first priority on the management of electronic waste since the usable lifespan of equipment is extended on a secondary market, resulting a reducing of the volume of treated waste stream. Remanufacturing is a production-batch process where used products or cores, are disassembled, cleaned, repaired or refurbished, reassembled and tested to produce new or like-new equipments (Cui and Zhang 2008). Reuse is dependent on WEEE being collected and channelled to this aktivity; this is not always the case (Kahhat *et al.* 2008, Ongondo and Williams 2012, Ongondo *et al.* 2013).

One crucial element of the recycling process is the early identification and removal of the toxic parts of the aforementioned products. EU legislation (EU, 2002) restricted the use of hazardous substances in EEE and promotes the collection and recycling of such equipment. Then the screening and disassembly of the different parts of each device follows, and the different materials are forwarded to the relevant factories.

Knowledge is a key point of this procedure. Due to the huge number of different manufacturers, and the evolution of the relevant industries, it becomes sometimes hard to identify all parts of the devices and handle them properly (safe extraction without damages to valuable or dangerous materials).

Project RECDEV – Innovative 3D Training Platform for recycling of WEEE is developing an innovative 3D training platform, ICT-based, self-and distance learning, familiarizing learners/users with the disassembly of Electrical and Electronic Devices and the identification of types and qualities of materials embodied. This paper presents project RECDEV and the pilot version of mentioned 3D tranining platform, too.

Partners Description

The consortium brings together the resources of seven participating organizations from five countries of which three partners with expertise in Waste Recycling, Environmental Protection and Waste Management, two universities with research work in the recycling sector, a consulting company dealing with implementation of sustainable development and preventive environmental protection, as well as an ICT partner with expertise in 3D content management systems.

Project partners are: Arvis Environmental Enterprises of Greece SA (Greece), Hellenic Solid Waste Management Association (Greece), University of Maribor (Slovenia), BAN Sozialökonomische BetriebsgmbH (Austria), National Centre of Sustainable Production and Consumption (Romania), Mendel University in Brno (the Czech Republic) and Omega Technology Ltd. (Greece).

Project Aims and Objectives

RECDEV project's objective is the development of ICT (based self and distance) learning training courses familiarizing learners/users with the disassembly of EEE and the identification of types and qualities of materials embodied. The project aspires to deliver in a simple and easy way what hazardous waste is, how it looks and the correct way of storing, transporting and disposing of it. Moreover the target group, i.e. people with low academic level, will be able to follow a comprehensive training program regarding WEEE understanding, disassembly and disposal methods, giving them rather easy to comprehend skills and ability to work in the WEEE sector.

In order to serve the needs of the unskilled workforce, the 3D scenarios will have an optional "video mode" where the whole procedure will be presented without the need for interaction from the trainee. This applies to the situation where the trainees do not have the technical skills for the completion of the interactive training. Part of the pilot implementation is to train them how to use the tools and to access the effectiveness of this training.

In order to respond to the above challenges, RECDEV project develops a set of high quality 3D training scenarios that simulate WEEE disassembly and offer information on the parts and materials included (types and qualities). The pedagogical context targets low skilled users to upgrade skills, make them more efficient in activities such as disassembling and packaging, require less supervision and minimize risks in the disassembly of electronic devices, as well as higher level personnel to develop skills quickly and easily, identifying types and qualities of materials contained in EEE. The specific objectives of the RECDEV project are to (Somakos *et al*. 2016):

- integrate existing practices and experience of the partners into the design of high-quality 3D training scenarios,
- develop, pilot implement and evaluate an interactive, multimedia and multilingual training approach that will familiarize low level trainees with the WEEE disassembly and packaging before going to the physical device,
- develop, pilot implement and evaluate an interactive training approach that will help higher level personnel of the recycling industries to develop skills on identifying the types and qualities of the material in the WEEE,
- modernize WEEE educational content with state of the art ICT tools and ontology on WEEE,
- offer visual multilingual, easy to understand training tool for economic immigrants that constitute a great deal of the workers in WEEE recycling,
- enhance networking between WEEE employers and experts in the sector from different European countries,
- offer an incentive to EU Recycling businesses towards a periodical training of their managerial and technical staff in aspects of modern disassembly methodologies and to the Health & Safety issues arising,
- ensure dissemination and further exploitation of its outcomes**.**

Target groups

Prepared 3D tool is intended for all persons and entities that offer or require training in the management of WEEE. For this reason long term target groups include:

- Vocational Education and Training (VET) Institutions as well as any entities at National and European level that are involved with recycling,
- recycling companies (public and private) that want to train their employees or newcomers to specific requirements or to upgrade skills,
- VET and all types of education providers that want to integrate virtual environments in their training tools.

Main Problems of the Training Ontology

Before training scenarios were created, it was necessary to identify the specifics of target groups (especially recycling companies employees) around EU countries:

- different economic, infrastructural and industrial conditions around EU countries
- different level of environmental education and environmental awareness around EU countries
- low skilled trainees are represented by:
  – marginalized persons (long-term unemployed, former prisoners etc.) – for example in Austria,
  – disabled people – for example in the Czech Republic,
  – non-native employees,
  – almost illiterate employees,
  – immigrants and refugees – indreasing in the future.

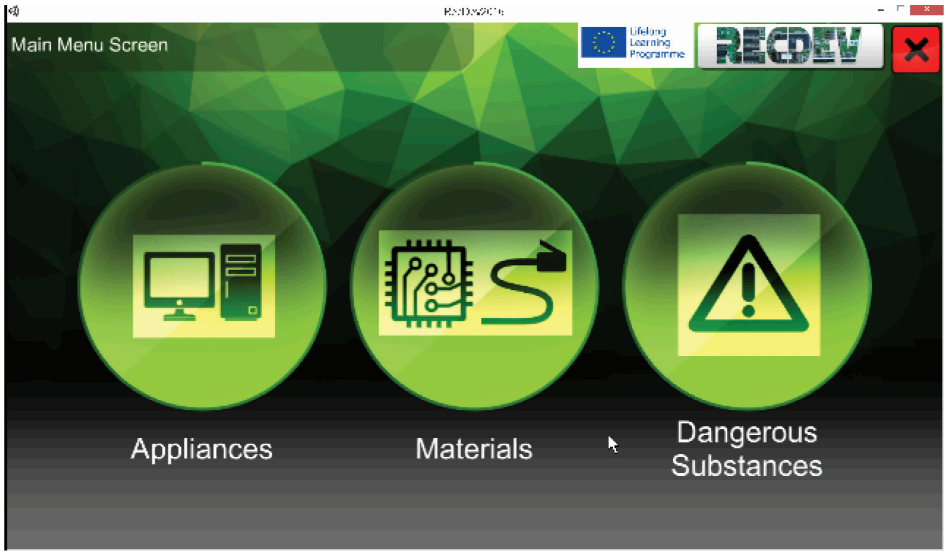

Figure 1. Main menu of 3D Tool

These reasons led the project team to create a training material for low skilled trainees as simple as possible. This version of 3D tool contains little text, the menu is realized by pictograms, description of dismantling process is supplemented by photographs, etc.

Training scenarios and courses description

Two distinctive training courses have developed addressing two different levels of skills of the EE waste management staff: a course for low skilled employees working on the disassembly of WEEE, and a course for higher level personnel, decision makers in the WEEE industries. The training material scenarios are using all the information gathered. The proposed scenarios have been enhanced by using a multimedia format and allowing an interactive way of educational courses – Virtual Environment applications (ICT). The beneficiaries and learners are able to disassemble the devices to their parts.

The use of virtual technologies and the innovative training pedagogies are going to lead to the enhancement and transformation of existing training material to interactive content, offering attractive and instructive disassembly and material identification courses to people not used to reading manuals and technical details. Using a combination of a popular game engine (Unity3D), C# and JavaScript code, and external calls to web services, 3D representations of the WEEEs and their parts become manageable through a WEB 3D CMS. All the information that is connected to the 3D Objects is dynamically set by content authors. Multilingualism is another key feature of the platform. There is a tool to easily translate all the content of the application to the preferred language online. This technology will produce Virtual Scenarios with a crucial advantage: a 'content author' will be able to modify or replicate them, create new scenarios, combine knowledge from existing one, present differences between the same type of devices, model their parts and materials with the help of ontology on WEEE.

Pilot 3D Tool version

The first concept of 3D Tool was evaluted by RECDEV Project partners themselves. Moreover, a group of students in the exercises in the computer lab installed, online tested and evaluated the first version of 3D Tool. In this way it was received lots of critical comments and positive suggestions that were carefully assessed. The main critical comments concerned the software stability, operating speed and quality of graphics processing. Moreover, the hardware requirements and the requirement of Microsoft Windows 7 or newer operating system instalation were unacceptable to most plants. Thanks to honest feedback the second version of 3D Tool was significantly improved so it is user-friendly and easier to comprehend.

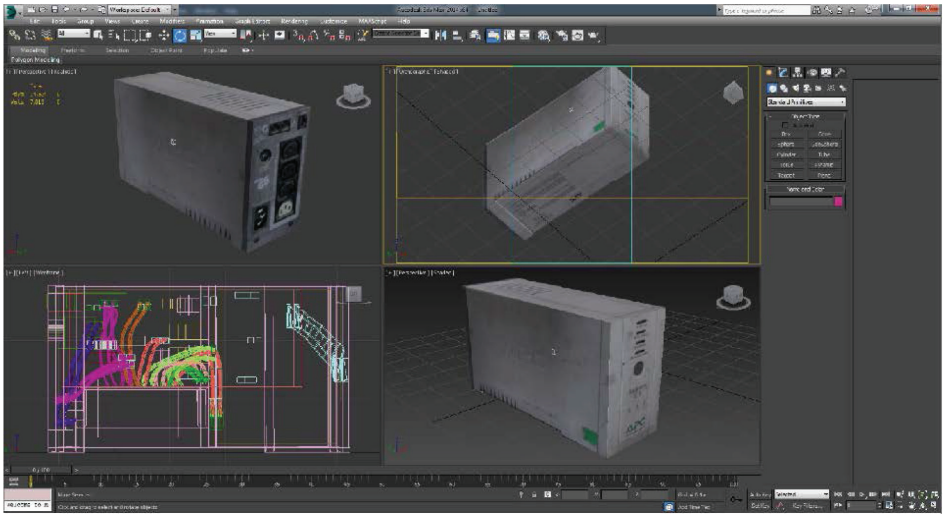

Figure 2. Process of 3D Tool animation creating

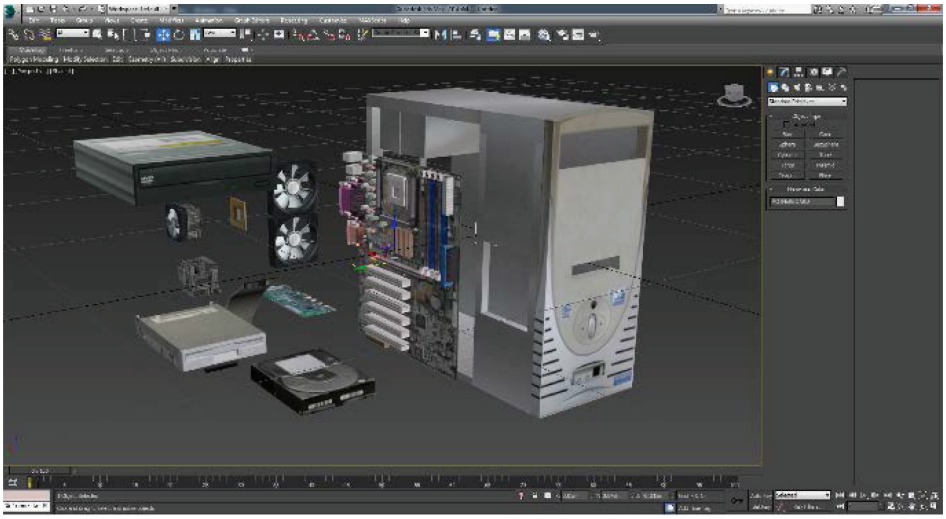

Figure 3. Disassembled desktop PC.

CONCLUSIONS

RECDEV project comes to offer a brand new solution to the gaps in the training offered in the sector by the development of specialized training meth-

odology and content for the disassembly of WEEE and the identification of the type and quality of materials in these. The 3D tool is still in progress, faults are corrected and the tool continuously improves. Basic version of Animated 3D training software will be describing the dismantling process step by step for 50 most common electrical appliances. The tool will be available from the Internet in seven languages (English, German, French, Czech, Greek, Romanian and Slovenian). The basic version of 3D tool will be free of charge.

Moreover, the developed methodology and tools can be developed and adjusted further, aiming to be easily extended to other industries beyond the WEEE recycling sector. The 3D tool is implemented in the sense of the open code so that any Professional Sector can adapt it to its needs or further develop it with new modern tools and data.

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