An Approach to Augmented Reality Technical Drawings

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Abstract: - This paper presents a system based on Augmented Reality (AR) technologies that enables creation of a new class of technical drawings called Augmented Reality Technical Drawings (ARTD). With this system the users wearing a see-through Head Mounted Display can visualize 3D CAD models co-located with 2D representations. The users have the possibility to translate, rotate and scale the overlaid 3D CAD model by using a tangible user interface composed from indicative markers. A demonstrator of the system has been developed with the standard CAD system SolidWorks. The methodology for automatic translation of CAD model to AR, overall architecture of the system, techniques for interaction and the main facilities offered to the user are presented. Finally, the conclusions are presented, examining the good and weak points of this solution.

Key-Words: - Augmented Reality, Technical Drawings, Computer Aided Design.

1 Introduction
On current product development activities the visual perception of complex products using 2D technical drawings increases the cognitive load because it requires mentality reconstruction of the 3D model product shape from 2D views. In [1] was demonstrated the efficiency of direct visualization of a 3D picture compared to 3D construction from 2D pictures.

Augmented Reality (AR) is a relative new research direction that allows creation of an interactive virtual space embedded into the physical word. Unlike Virtual Reality (VR) systems, in which users are completely immersed in the virtual environment, AR users see the virtual objects and the real world co-existing in the same space (co-located). It is the goal of AR to supplement reality rather than completely replace it as in conventional VR applications. The AR technology provides useful information about the environment enhancing perception and interaction with the real world. The user is able to manipulate both real objects, and the virtual ones. In the last years, AR technology has started being used to a certain extent in industrial applications [4]. Thus, an important goal of the current research efforts worldwide is to facilitate the implementation of AR in industrial processes and assess the impact and its feasibility into the workplace and everyday life contexts in terms of cost-effectiveness, human-machine interaction and side-effects on the users, as well as their impact on the actual working environment, at both individual and organizational level [5].

Most research on virtual and augmented environments with the aim of development Computer Aided Design applications are confronted with a complex task such as integration of CAD models[3]. This paper present an AR system integrated with SolidWorks® CAD software that enables creation of a new class of technical drawings called Augmented Reality Technical Drawings (ARTD) as an alternative to the classical 2D engineering drawings. ARTD enhances the visual perception through co-located 3D virtual objects with the 2D representations, offering less perceptive ambiguities and effective quick recognition. This is an important opportunity for engineering applications where users must have a better and direct appreciation of product shape.

2 CAD to AR methodology
The CAD to AR methodology involves the next steps:

(1) CAD Model data translation: consists in extracting the entire geometric data of the faces that compose the shape of the CAD model and conversion of standard CAD file to an appropriate common exchange file format (for example 3ds, VRML, X3D etc.) that can be loaded by general AR software.

(2) Generation of a unique marker: consists in the generation of a unique fiducial marker for each 3D
CAD model and storage the marker shape data in the AR software.

(3) Generation of a custom technical drawing template: consists in the generation of the technical drawing of the 3D CAD model using a custom template that allows insertion of the fiducial marker associated with the model.

(4) Model integration: consists in the generation of a configuration file that contain the marker tracking setup and the 3D scene file.

3 Overview of the System Architecture
The architecture of the system is presented in figure 1. The essential component of this architecture is the CAD2AR software module. This module extracts automatically the geometric data from Solidworks® models in order to generate a 3DS model, an identification marker and handles the aspects of tangible user interaction. For the co-location of the 3D models on the physical technical drawing an open source library called osgAR[5] is used.

![Fig.1 Overall architecture of ARTD system](image)

4 Automatic Data Translation from Cad to AR model
In order to integrate the 3D CAD model into the AR environment the first step is to create a software module called CAD2AR that will allow the automatic conversion of the information of the SolidWorks CAD models to AR system. The information of SolidWorks CAD models can’t be transferred to AR directly because there is not a data exchange standard. The CAD system can export the CAD graphical models in other formats (for example VRML) but this format not maintains all the data of the original model. Important features of the CAD model are not transmitted, such of topology of parts. Therefore it is necessary to develop a suitable model representation to support visualization and interaction with the model in the AR environment.

SolidWorks use the Boundary Representation (BREP) model for the representation of the model in the database. There are two data types used to represent the BREP model in the SolidWorks: topology data (body, face, edge, coedge, edge, vertex) used to manipulation of the boundaries of all the geometry entities in the model and geometry data (surface, curve, point) used to manipulate the actual data that define the geometrical shape surrounded by the topology elements.

Based on the Application Programming Interface (API) of SolidWorks the CAD2AR software module traverse and extract all the CAD model data. The result it is the generation of a neutral file which contain all the geometry information of the entities that compound the CAD models discretized into triangle tessellations and the topology structure that stores the hierarchical relationship between assembly, parts, surfaces and tessellations. Each entity of the CAD models is treated as an individual object and has a unique identity that corresponds with the entity names from the CAD database. The file generated is saved on a AR database and overlaid on the physical technical drawing when the unique fiducial marker associated with the CAD model is recognized.

5 AR visualization system
In order to augment human’s visual sense, a physical display device is used allowing combining real and virtual images and present them to the user. Many forms of video display can be used: Head Mounted Displays (HMD), portable displays (like PDA), monitors and projectors. HMD is a common choice for AR because it is portable, and it is placed directly on the users’ visual range. In this research, it was used a Trivisio stereo video see-through AR display (see fig. 2).

6. Interaction Techniques
Using the conventional 2D interaction devices like 2D mouse and keyboard within the AR environment it presents several limitation for the user due to a difference between degrees of freedom required by the 3D CAD system. Also using the voice command it not a good choice due to the noise from industrial
workplaces which causes low accuracy of recognized command. In this research an intuitive interaction interface is provided for the user, based on occlusion interaction method [2]. The user is able to translate, rotate and scale the 3D model by simply covering with the hand the indicative marker (figure 2). The markers are attached in line on the side of the technical drawing (see fig. 2).

Fig. 2 See-through HMD AR display

7 Experiment
In order to test the proposed ARTD system a user study has been performed. Various ARTD have been generated for fairly complex CAD previously generated in the SolidWorks®(see fig.3). Twenty students visualize and interact with the models using the developed system. The users appreciate that displaying the 3D CAD model co-located in the real environment offers a better method to perceive and understand the information from the physical technical drawing. However, out of these positive results the system has its limitations, since problems can come out when the intensity of the light is weak, which make the identification of markers difficult. Also the lower resolution of the HMD affects the performance of the perception of the 3D model.

Fig. 3 Co-location of a 3D model on a technical drawing

8 Conclusion
Augmented reality technologies represent very useful tools to visualize and interact with 3D CAD models. The co-location of the 3D CAD model in the real environment provides to the users the possibility of a realist perception for the physical technical drawing. A methodology for automatic translation of CAD model to AR system was presented. The advantage of the developed system is the reduction of the time needed for the users to understand the technical drawings. This approach proved to be a powerful tool that improved user efficiency compared to the classical methods. The future research is focused on adding functions for edit 3D CAD models using an augmented reality environment.

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