Standards in Industrial AR Applications - Towards A Standardized Method
From CAD To AR Based Manual Work Instructions

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ABSTRACT
One of the main challenges introducing Augmented Reality technology into industrial applications is fast, reliable, low-cost authoring of animated AR content of product data created in 3D CAD systems. In this paper we present a product data information pipeline from industry used commercial CAD systems to a augmented reality system. The pipeline utilizes ISO 10303 (STEP) data protocol.

1. INTRODUCTION
Augmented Reality (AR) is considered a useful technology for assisting manual factory work. AR is particularly well suited for complex, short manufacturing series or in a customized production factory environment. Each individual product may have a slightly different configuration: the order of assembling parts may vary for different products and/or the number of phases in the assembly line may be large. The traditional approach is to use assembly drawings (blueprints) and possibly instruction manuals to describe the content of each work task. As the production series become even smaller, the need for guiding the worker with all available tools becomes increasingly important. The AR system can also reduce assembly times, accelerate learning of the assembly tasks and provide more quality assurance to the factory floor.

The emphasis in this paper is in content authoring for AR and suggestions for standardization. The focus in this paper is on integrating 3D CAD systems with Work Instruction (WI) software; and further with AR based work instructions. Our suggestion demonstrates the natural links between each component for streamlined data transfer and AR content authoring system.

2. RELATED WORK
Manual factory work has been recognized as one of the most potential application fields of industrial AR ever since the work by Boeing [1], providing augmented assistance to installation of cable harnesses. Various other AR systems have been presented since that, e.g. head mounted display based systems [2], [3]. A hand held PC based system for industrial augmented assembly applications is implemented by project ULTRA [4]. Related systems which could also be utilized for assembly tasks include e.g. the PDA based system [5] providing augmented operation instructions for home appliances, and BMW's augmented car maintenance system based on markerless tracking [6].
Existing implementations typically concentrate on augmenting software, algorithms and devices, while the problem of content creation (authoring) for industrial AR applications has not been so widely addressed. Visual and marker based interaction based AR authoring tools e.g. [7], [8], [9] are better suitable for artistic and entertainment applications than precision demanding industrial use. Also these systems typically assume the models to be provided directly in some convenient data visualization format e.g. VRML. There exist also more industry oriented authoring systems e.g. related to projects AR-PDA [10], MARIO [11], and AMIRE [12], but even they do not address the complete content creation pipeline from design to visualization as in such a production driven way as proposed in this paper.

3. METHODOLOGY

Figure 1 below shows the proposed methodology how the AR instructions are created from the product’s 3D model. First the CAD model is exported to standard STEP (ISO 10303 1994) format file, that includes the product structure and 3D models of the parts. Detailed 3D STEP models are in many times too complex to be utilized efficiently so STEP model is triangulated with an appropriate coarseness level. The original product structure is remained with references to part models.

Because of the designer’s preferences, company specific part libraries and features of typical CAD systems the generated product structure usually does not conform to the real parts to be assembled in assembly line. Therefore, the assembly structure (i.e. the definition of the assembled parts) and work phases have to be re-configured. The assembly structure and geometric models are taken into content creation phase and animations in which way components have to be assembled and which tools to be used are defined. Finally, the created animations are played based on markers or other tracking technology applied in a real augmented environment.

1) Simplifying geometry

The STEP model from a commercial CAD system is first triangulated using a STEP Tools Inc software. Triangulation level can be selected to make models lighter. The triangulated ASCII file is read together with original STEP file into an XML schema. The schema has three main elements:

![Figure 1. Overview of the method.](image-url)
hierarchy (structure/assembly), triangular boundary representation for each part or subassembly and property set

The hierarchy is separated from geometric representation to make it easily accessible by the different phases of production, e.g. assembly.

2) From design structure to assembly structure

The assembly structure is created by organizing the parts into the right assembly order and adding all the needed tools, operations and notes. Separate subassemblies can be defined in order to illustrate cases in which subassembly is done e.g. in different assembly stations. All the assembly

3) Content creation

The WI software are used to create animations of the parts for the assembly work. Working Instruction software

Software vendors like for example Lattice 3D, Dassault Systems and AutoDesk provide software packages for working instruction (WI) creation from 3D assembly models. With aid of these software packages this model can be automatically simplified, lightened and imported from CAD system to a WI software environment. The production process planning can be done in this same environment or imported from another information system such as PLM or ERP system. In the WI the parts are animated. The animation steps can be linked to textual instructions and to the process steps. The software maintains the link between the original 3D drawing and the generated 3D instruction. This link enables an automatic updating of design changes to the instructions. The digital 3D instruction can be distributed with aid of PDF or HTML document or viewed with a vendor specific freeware player. These software systems also provide open programming interfaces as well as open data formats like 3DXML (Dassault 3D Via Composer). This gives developers a possibility to realize more automated concepts for creating working instructions.

When the animations have been defined for each assembly phase, the whole assembly process can be simulated. The user can move to any assembly phase using a slider control (and see the animation defined for that phase), or simulate the whole assembly process.

4) Augmentation

Finally, an AR terminal device is used to provide augmented reality instructions.

In this paper we show a method to retrieve assembly knowledge to AR-system. Our approach relies on usage of ISO 10303 (known as STEP) (Figure 2), so that smooth information flow to content creation software can be realized. From content creation to AR terminal is the most critical part from standardization point of view. Content creation software and augmentation software are tightly bound to together. Our suggestion relies on usage of STEP. STEP is a collection of Application Protocols and the ability to support many protocols within one framework is one of the key strengths of STEP. All the protocols are all built on the same set of Integrate Resources (IR's) so they all use the same definitions for the same information. For example, AP-203 and AP-214 (the most used STEP protocols) use the same definitions for three dimensional geometry, assembly data
and basic product information. Content creation information could also be expressed using IRs and therefore utilize the huge work done already in standard bodies.

![Diagram of standards usage in "From CAD to AR" process.](image)

**Figure 2. A schematic view of usage of standards in "From CAD to AR" process.**

4. CONCLUSIONS AND FUTURE WORK

In this paper we are suggesting a method to streamline AR based work instruction creation process. The method can be a way to standardize interfaces when applying product data created in commercial CAD systems for AR applications. The data pipeline exploits STEP data protocol that is available practically in all CAD systems. The challenges are in transforming and transferring product data through software tools that are needed to make augmented assembly instructions, as smoothly as possible.

REFERENCES


[12] AMIRE project homepage: http://www.amire.net/