

NURBSMARK: Reversible Digital Watermarks for 3D CAD Models

Wolfgang Funk

Introduction

Digital Watermarking is the art of embedding additional information into a digital work, such that it can be used in exactly the same way as the original. The watermark is imperceptible, that is, the user is not able at all to find out if a digital work contains a digital watermark. The information encoded by the digital watermark is useful in a wide range of application scenarios, such as track and trace, resolving copyright disputes and augmenting a work with meta data.

NURBSMARK is a system for embedding a reversible digital watermark into high quality 3D surface models that are represented as Non-Uniform Rational B-Splines (NURBS). The digital watermark introduces slight imperceptible changes to the geometry of the original data such that additional information is encoded by these modifications. As the digital watermark is interwoven with the original data, it is not destroyed by moving data between different systems and file formats, and is also robust against various processing operations. In some application sce-

narios, even the slight modifications introduced by the NURBSMARK algorithm may be not acceptable. Due to the reversibility property of the algorithm, the original geometry of the model can be restored based on a secret key.

Track and Trace

By using a specific digital watermark for each point of delivery, the watermark can be used to track and trace the distribution paths of models. Each item that is sent out is made unique by carrying a watermark that is specific to the person or institution that receives the data. If the model turns up at a point outside the pre-defined workflow, it can be linked and traced back to its point of delivery.

Copyright

A digital watermark that encodes the creator can be used to proof ownership of the model. In addition, it may also establish a link to a database for looking up the copyright situation and further information about the model.

German Abstract

Seit einigen Jahren steht am Fraunhofer-Institut für Graphische Datenverarbeitung eines der weltweit ersten Systeme für digitale Wasserzeichen in dreidimensionalen Polygonmodellen zur Verfügung. Nun wurde ein vollkommen neues Verfahren für digitale Wasserzeichen in NURBS-basierten Modellen entwickelt, das auch CAD-Modelle, wie sie im Automobil-, Flugzeug- und Schiffsbau verwendet werden, mit digitalen Wasserzeichen versieht.

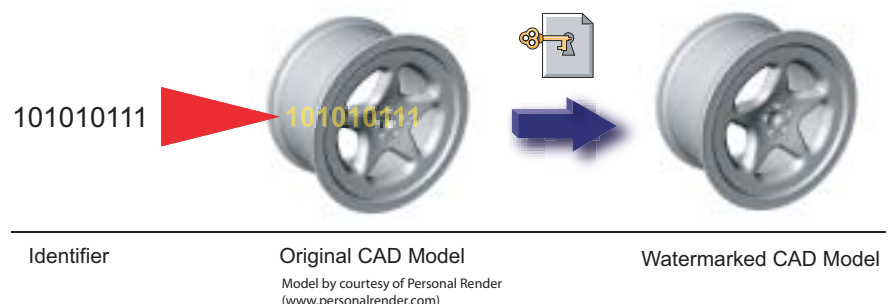


Figure 1: Watermark embedding process.

Convenience

A digital watermark may also provide added value by holding meta information, such as optimum rendering parameters for the model or indexing information that helps administrators of large model databases.

Robustness

Digital watermarks should be resistant to processing steps that do not substantially degrade the visual quality of the data.

The NURBSMARK watermark is robust against operations that are used to fit the models into a particular position in world space, namely rotation, translation and isotropic scaling. Another important processing step is tessellation, which transforms the NURBS model into a polygonal mesh. NURBSMARK provides a water-

mark that can be verified in tessellated versions of the model.

Algorithm

The NURBSMARK algorithm works directly on the NURBS representation of the data. By slightly shifting control points according to a predefined tolerance setting, the impact on the quality of the model can be exactly specified.

As a unique feature of the algorithm, the original model can be restored from the watermarked version. The information to reverse the modification is secretly encoded within the knot vectors of the model. In order to access the watermark as well as the information for watermark reversal, a cryptographic key is required.

Point of Contact

Wolfgang Funk
Fraunhofer IGD, Darmstadt, Germany
E-mail:
wolfgang.funk@igd.fraunhofer.de

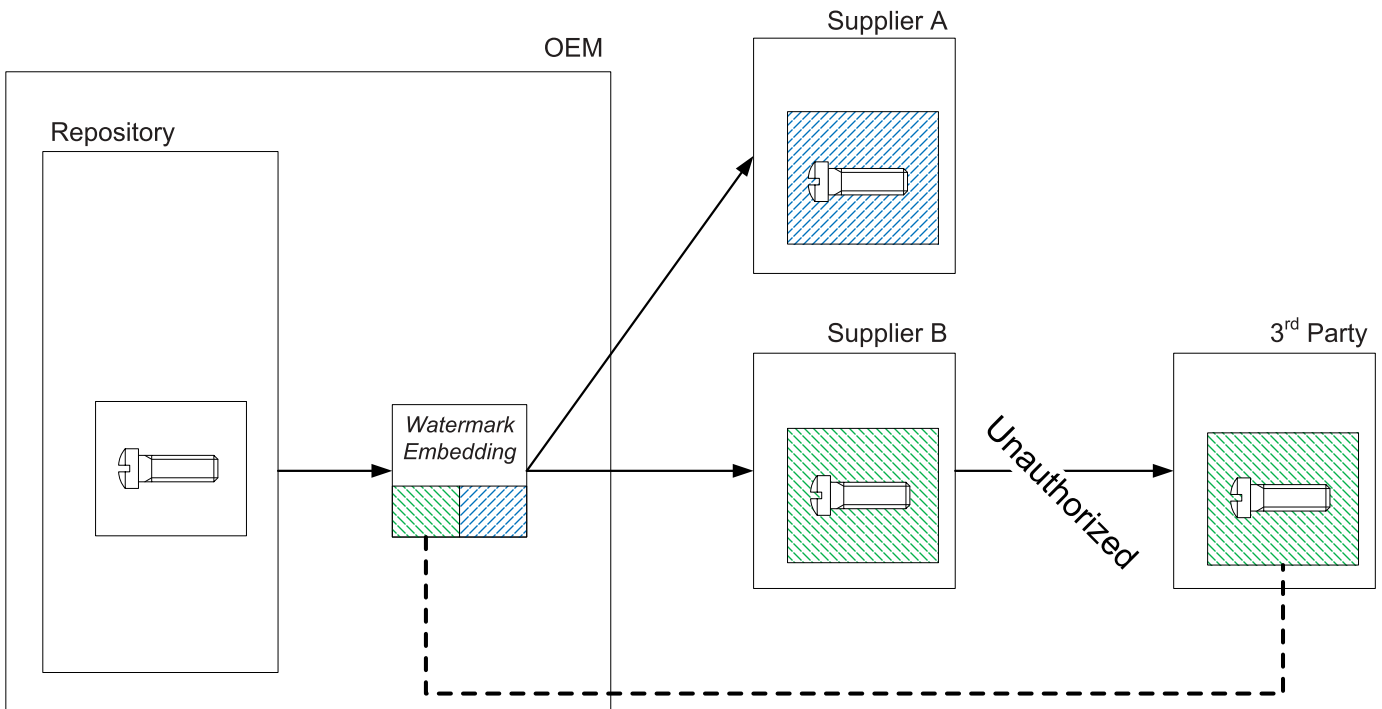


Figure 2: Establishing a back link to the point of delivery.