**Proposed ANNEX II to WIPO Standard ST.91**

**3D Model Search**

*Working Draft for Consultation*

This Annex is to provide recommendations for developing and implementing search systems for three-dimensional (3D) models included in patent, trademark or industrial design documents. There are two main categories of 3D model search methods: text-based and content-based (shape-based).

## Text-Based search methods

These methods are the most common used for searching 3D models, where users enter keywords or phrases that describe the desired object. These methods are simple to implement, but at the same time, the efficiency of searching for similar models may decrease because the conceptual description of the objects does not always correlate with the visual similarity. These methods also involve manual input of object descriptions, which would not allow the complete automatization of the process. However, if an intellectual property (IP) office stores into the database the 3D model description, manually entering or using algorithm, a text-based search method may be used in addition to content-based (shape-based) method.

## Content-Based (Shape-Based) search methods

Content-based (shape-based) search methods compare 3D models based on their shape on the geometry rather than relying on text descriptions. This allows users to find models with similar forms, even if their keywords or tags are different. It is especially useful when a model has little or no accurate metadata but a distinctive shape.

To identify similarities between 3D models that visually represent digital objects protected as a part of a patent, trademark or industrial design, it is recommended to use a geometry-based search in 3D model arrays, which is a type of content-based method.

When a 3D model is composed of multiple distinct parts, it is recommended to process and analyze each part individually. This approach facilitates part-level indexing and retrieval. Additionally, it complements whole-model processing by supporting detailed analysis, comparison and reuse of individual components.

When IP offices collect 2D images or extract 2D images from 3D models, and have the capacity, they may implement 2D image search in addition to content-based (shape-based) method.

The geometric-based search system for 3D models processes the search query through the following steps:

### Step 1: Pre-processing the search query

#### Extraction of geometric data

This step involves extracting geometric data from the 3D model provided as the search query.

The 3D model file formats recommended in this Standard are either mesh-based or solid-based formats.

* Mesh-based formats represent objects by describing their surfaces using interconnected polygons, forming a mesh that stores and represents the geometry of 3D models.
* Solid-based formats represent both the internal and external geometry of 3D models as solid volumes, using predefined shapes to define the model.

If the 3D model is in a mesh-based format, geometric data can be extracted directly. For solid-based formats, the 3D model must first be converted to a mesh-based representation before geometric data can be extracted.

The extracted geometric data can also be converted into a point cloud data format, which consists of a discrete set of data points in space, typically used to represent the shape or surface of a 3D object. Each point has a specific position defined by Cartesian coordinates (X, Y, Z). In addition to position, points may also store other attributes such as RGB color values, timestamps, and more.

### Step 2: Descriptor creation

In this step, a geometric descriptor is generated from the 3D model’s geometry. This descriptor is a compact numerical representation that captures the shape’s key characteristics, enabling effective comparison.

The following mathematical and neural network techniques are recommended to be considered as a basis for creating the descriptor:

* Compute a shape descriptor from:
* the mesh by analyzing vertex positions and/or the connectivity structure to produce a numeric representation; or
* from the point cloud by analyzing point positions and their local spatial relationships.
* Generate embedding vectors from mesh or point cloud data using neural network techniques.

### Step 3: Descriptor comparison

Once the descriptor of the query model is created, it is compared with the descriptors of existing 3D models in the database to find the models whose descriptors are most similar to the query. As a result, the system retrieves the most relevant 3D models that closely match the shape and features of the input.

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