# Free **Interchange** of 3D Measuring Data

X3P – a Flexible, System-independent Open Source Data Format

Until now interchange of 3D measuring data between various measuring systems has presented users with great challenges. To solve this problem the openGPS consortium has now developed a flexible 3D data interchange format for surface profiles, which allows smooth transfer of 3D data from various measuring systems while maintaining its traceability.
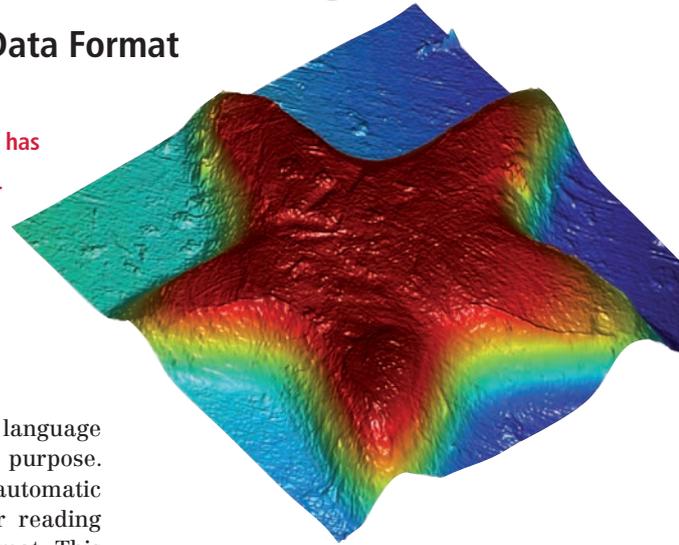
When designing a new data format it is necessary to find a reasonable compromise between the format capability and its simplicity of use. The X3P format (XML 3D Point Format) is therefore limited to use as a standardized interchange format for 3D point data. In developing X3P the openGPS consortium, whose objective was to create reference implementations of standardized algorithms for calculation of surface parameters, used existing standards to the extent possible, without taking on their weaknesses. The principles for the data format design were the tried and tested XML language, the ZIP archiving format and the DIN/EN/ISO Standard 5436-2 published in 2001.

The XML language allows complex hierarchical information to be structured in a unique manner and saved in a form legible for humans. With its aid it is possible to express data types and relations of an XML file's elements in a language designed specifically for this purpose. Special software tools allow automatic generation of the program for reading and writing the new XML format. This avoids practically any programming errors during implementation and allows automatic verification of the data generated.

The ZIP format has already proven itself as a container for numerous data formats, even though users frequently are not aware of it. The contents of such files can be displayed by all applications capable of unpacking the ZIP files. The compressed documents are very compact and can consist of a number of individual files packed together in one file. This is a practical method of storing complex document structures.

Data Storage in X3P

X3P serves for storing and exchanging 3D measuring data. This data is present in the form of coordinate triplets describing measuring points as linear profiles or plane data records for a surface.

The simplest arrangement is a point cloud, consisting of an unordered set of 3D points. Their vicinity relation is unknown and they are distributed in an arbitrary manner in space. Such data is, for instance, generated by coordinate measuring machines.

Line profiles consist of points, each of which has a specific predecessor or successor. The line, on which the points are located on the surface, does not necessarily have to be straight, it can have any shape. However this has no effect on the sequence of points. Every point has a specific predecessor and successor. Profile data are, for example, generated by mechanical contact stylus instrument profilometers or optical point sensors.

The highest order of 3D points is the representation of a surface using a projectable matrix. This type of data can be generated by surface-measuring profilometers as well as point-sensing systems. In this case every point has four direct neighbor points, like each field on a chessboard. It is important to consider this vicinity relation separately from the spatial position of the points. It is not necessary for the points to be positioned in space exactly at the centre points of the chessboard's fields; they can deviate from this position as far as the proximity relationship stays clear. The image of a fishing net can help visualize this concept. Even when the net is distorted or tangled, it is possible to reach the next adjacent knot along the same filament.

Many optical and particularly tomographic measuring systems can measure surfaces with multiple layer coatings and generate a separate 3D profile for each layer. In this case the points in a profile no longer have only four adjacent points in the plane, but in addition one adjacent point each, above and below. The data is therefore organized in the form of a data cube, instead of a matrix.

Basis Information from Metadata

A data record does not consist only of pure 3D point data; its quality is influenced to a significant degree by the supplementary metadata assigned to it. This can be information on the type and serial number of the measuring equipment, its calibration and the time of measurement. Knowledge of the measuring equipment used is frequently essential for interpre-
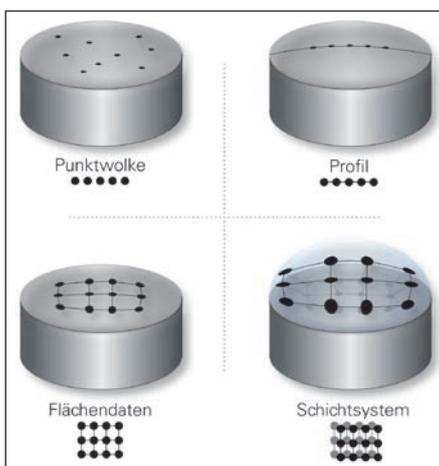
Vicinity relationships of 3D point data: a) unordered point cloud, b) profile line with one dimensional vicinity, c) areal point data with two dimensional vicinity, d) layer system with three dimensional vicinity.

tation of the measurement. For this reason X3P offers the possibility of saving a comprehensive metadata record derived from ISO5436-2. In addition to the creation date and time for the data record, this also indicates whether a contacting or non-contacting type of measurement was used or even if the data originated from software simulation was not created with actual measurement. It also includes the serial number and type of measuring instrument as well as the time it was last calibrated, to guarantee the traceability of the data.

Freeware

The openGPS consortium follows the usual method of standardization in developing the X3P format: A description of the format is developed in text form in the standardization committee and should finally be adopted as a valid international standard. The usual method would then be for each measuring instrument software supplier to develop their own software implementation based on this standard. However, practical experience shows that the implementations by the various suppliers are seldom identical. The consortium therefore decided not only to define the X3P format as a standard, but also to simultaneously provide it at as free software in a reference implementation. This eliminates the necessity of separate implementation by each company, so that all manufacturers at least use identical implementation. Finally freeware eliminates the risk of long-term dependence on a software supplier, because, if necessary it is possible for a company to manage the X3P module itself.

Availability and Applications

The current release of the X3P software is version

number 0.2beta and is available on the openGPS Website at www.opengps.eu. To date, examples of X3P have been implemented in measuring instrument software from NanoFocus, Alicona and Mahr to gain initial experience in practical use. Moreover a Matlab integration is available, which should be interesting particularly for universities.

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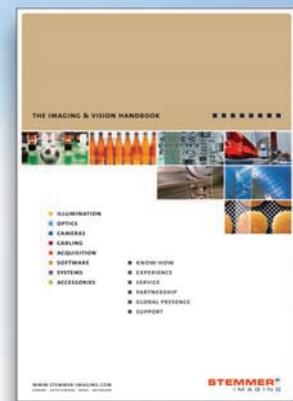
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