A proposal for a common language for sharing surface texture data

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1. Introduction

There is a large amount of metrology data along with associated information regarding the manufacturing process or function that needs to be transferred, stored or analyzed. As more data is being collected, there is a need for sharing data and associated information effectively to eliminate redundancy in data collection and analysis. While formats currently being used such as the SDF data format [1] cover the representation of discrete data points along with some header information, they do not convey information about the measurement operation, the manufacturing process or the functional requirements of the component.

This document is a proposal for the specification of a common language for expressing metrology data along with related process and functional data. The language being proposed is based on XML (Extensible Markup Language) [2]. XML is increasingly used in various areas as the medium of communication because it provides an intuitive, machine and human readable structure, it is hierarchical and flexible, accommodates industry leading data formats, supports freeware conversion and analysis tools. A similar information model has been developed at NIST [3] to describe the properties and results of machine-tool performance tests.

2. Metrology Markup Language

The proposed Metrology Markup Language is XML based, with user-defined tags that serve as attributes for the data. The tags form the basis for a Document Type Definition (DTD) that serves as the reference for all data files generated by any instrument. A sample DTD for the surface finish application is shown in Fig. 1. There are three major elements in the DTD – metrology, process and function. The 'metrology' DTD covers measurement and analysis aspects such as part (name, number, material), instrument (name, type), data file (name, number of points, spacing) and analysis (filter, cutoff, Ra, Wa). The 'process' DTD covers process information such as process name, number, tool (radius, speed, feed). Additional attributes include user-defined 'ProcessAtt' that stores any process related information that is gathered during measurement of part. This could include information on tool wear, force measurement etc. The 'function' DTD stores information about the functional intent of the component. The 'symbol' attribute provides broad information on the functional intent of the part such as two-body contact, hydrodynamic drag, etc. Additional attributes include user-defined 'FunctionAtt' that stores any function related information that is gathered during measurement of part such as torque measurement data, optical reflectivity etc.

```
<!DOCTYPE DATA[

<!ELEMENT DATA (METROLOGY+, PROCESS+,
FUNCTION+)>

<!ELEMENT METROLOGY (PART+,
MEASUREMENT+, DATAFILE+, ANALYSIS+)>
<!ELEMENT PART (NAME, NUMBER, MATERIAL)>
<!ELEMENT NAME (#PCDATA)>
<!ELEMENT NUMBER (#PCDATA)>
<!ELEMENT MATERIAL (#PCDATA)>

<!ELEMENT MEASUREMENT (DATE, TIME,
INSTNAME, INSTTYPE, PRBRNG, PRBRES)>
<!ELEMENT DATE (#PCDATA)>
<!ELEMENT TIME (#PCDATA)>
<!ELEMENT INSTNAME (#PCDATA)>
<!ELEMENT INSTTYPE (#PCDATA)>
<!ELEMENT PRBRNG (#PCDATA)>
<!ELEMENT PRBRES (#PCDATA)>

<!ELEMENT DATAFILE (FILENAME, NUMPTS,
SPACING, CLASS, DATAPOINTS)>
<!ELEMENT FILENAME (#PCDATA)>
<!ELEMENT NUMPTS (#PCDATA)>
<!ELEMENT SPACING (#PCDATA)>
<!ELEMENT CLASS (#PCDATA)>
<!ELEMENT DATAPOINTS (#PCDATA)>

<!ELEMENT ANALYSIS (FILTER, CUTOFF, PA, RA,
WA)>
<!ELEMENT FILTER (#PCDATA)>
<!ELEMENT CUTOFF (#PCDATA)>
<!ELEMENT PA (#PCDATA)>
<!ELEMENT RA (#PCDATA)>
<!ELEMENT WA  (#PCDATA)>

<!ELEMENT PROCESS (NAME, SPEED, FEED,
DEPTHOFCUT, TOOLMATL, TOOLRAD,
PROCESSATT)>
<!ELEMENT NAME (#PCDATA)>
<!ELEMENT SPEED (#PCDATA)>
<!ELEMENT FEED (#PCDATA)>
<!ELEMENT DEPTHOFCUT (#PCDATA)>
<!ELEMENT TOOLMATL (#PCDATA)>
<!ELEMENT TOOLRAD (#PCDATA)>
<!ELEMENT PROCESSATT (#PCDATA)>

<!ELEMENT FUNCTION (SYMBOL, DESCRIPTION,
FUNCTIONATT)>
<!ELEMENT SYMBOL (#PCDATA)>
<!ELEMENT DESCRIPTION (#PCDATA)>
<!ELEMENT FUNCTIONATT (#PCDATA)>

]>
```

Fig. 1 Sample DTD

3. Process and functional toolbox for surface & form metrology

The proposed DTD has been implemented as part of a process and functional toolbox for surface and form metrology, that is currently being developed at UNCC. As current metrology analysis systems are not geared towards analyzing multiple profiles or in performing correlation analysis with functional or process data, they are limited in their capabilities. The toolbox being built is designed to understand the temporal relationships in the datasets and handles metrology, process and functional data in one framework. The toolbox is itself not discussed in this report, but the database is presented here to demonstrate the application of the proposed XML format. Because the toolbox is designed to handle both surface texture and associated process and functional data, the proposed XML format proves to be useful in describing the data, in inserting to, retrieving from, and querying the database, and also in transferring the data to another schema that understands the same DTD.

4. Entity-Relationship diagram for surface texture database

A database for storing surface texture and associated process and functional information has been built in Oracle. The database has been built as the backend for a process-specific and functional toolbox for surface metrology. The database schema is similar to that reported by Bui et al. [4], but with some modifications. A key addition to the schema is the attributes for the entity ‘Datafile’. A ‘class’ attribute has been added to indicate some user knowledge about the class of the data file. Thus, a sequence of data files collected from a process could fall into one of many classes, depending on the process or the function. Also, more user-defined attributes can be added, such as ‘ProcessAtt’ or ‘FunctionAtt’ that convey information about the process or the function. Examples of these include cutting force measurement data, tool wear information etc. The database schema is shown in Fig. 2. A sample data retrieved from the system is shown in Fig. 3 to illustrate the format and tags of the output. As mentioned before, the output conforms to the DTD specifications laid out earlier.

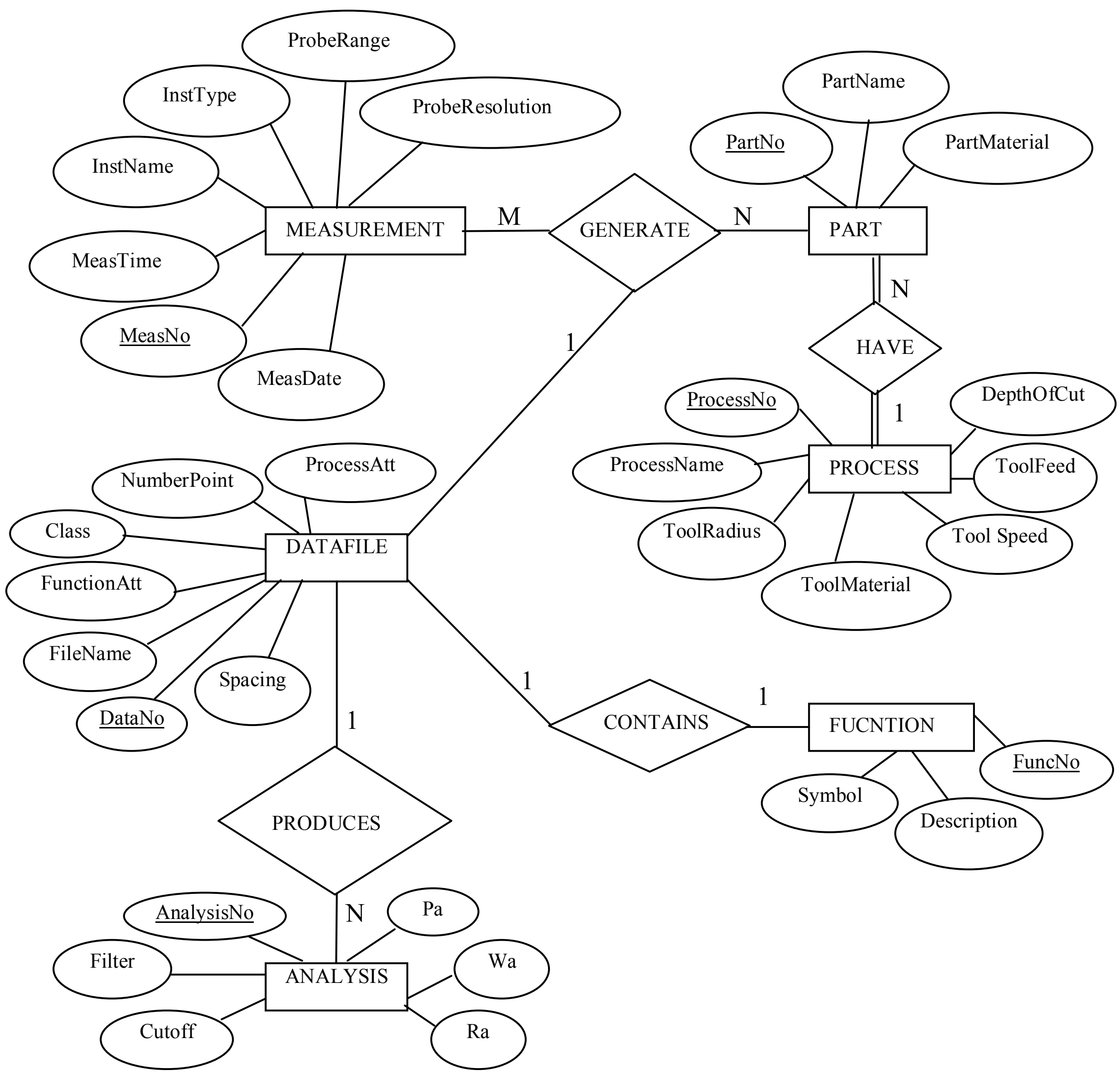

Fig. 2 Entity-Relationship diagram for surface texture database

5. Conclusions

This article has laid out a proposal for a common format for exchanging surface texture data across different platforms. There is no current industry wide standard format for transferring data and this leads to creation of several vendors specific and other data formats being used. XML based languages are increasingly becoming popular among the manufacturing and metrology community. Therefore, it is natural to consider an XML based language for sharing surface texture and form data as well. Currently, a process and functional toolbox for surface metrology is under development. The system recognizes and reports outputs in this XML format. The sample DTD shown in this report is not exhaustive. There is considerable room for additional tags; but the capability of this system to accept additions makes it remarkable in its utility and value.


```
<?xml version="1.0" encoding="ISO-8859-1"?>
<DATA>
<METROLOGY>

<PART>
<NAME>SHELL</NAME>
<NUMBER>TURN25</NUMBER>
<MATERIAL></MATERIAL>
</PART>

<MEASUREMENT>
<DATE>06-04-2002</DATE>
<TIME></TIME>
<INSTNAME>TAYLORHOBSON</INSTNAME>
<INSTTYPE>STYLUS</INSTTYPE>
<PRBRNG>6MM<PRBRNG>
<PRBRES>0.01UM<PRBRES>
</MEASUREMENT>

<DATAFILE>
<FILENAME>TUNR25-1.DAT</FILENAME>
<NUMPOINTS>20000</NUMPOINTS>
<SPACING>0.25UM</SPACING>
<CLASS>1</CLASS>
<DATAPOINTS>223.21,223.22,225.37,…,234.45,145.34
</DATAPOINTS>
</DATAFILE>

<ANALYSIS>
<FILTER>GAUSSIAN</FILTER>
<CUTOFF>0.8MM</CUTOFF>
<PA>24.5</PA>
<RA>12.3</RA.
<WA>16.4</WA>
</ANALYSIS>

<PROCESS>
<NAME>HARD TURNING</NAME>
<SPEED>300</SPEED>
<FEED>0.66</FEED>
<DEPTHOFCUT>21</DEPTHOFCUT>
<TOOLMATL>CAST IRON</TOOLMATL>
<TOOLRAD>23</TOOLRAD>
<PROCESSATT>0.234UM</PROCESSATT>
</PROCESS>

<FUNCTION>
<SYMBOL>TB</SYMBOL>
<DESCRIPTION></DESCRIPTION>
<FUNCTIONATT></FUNCTIONATT>
</FUNCTION>
```


Fig. 3 Sample output data format

6. References

1. P.J.Sullivan and K.J. Stout, The specification of a flexible file format for storage and retrieval of engineering topographic data, Proceedings of the ASPE 1992 Annual Meeting
2. http://www.w3.org/XML/
3. Y. Tina Lee, J A Soons, M A Donmez, Information model for machine-tool performance tests, Journal of Research of the NIST, 106, 2, March-April 2001
4. S. H. Bui, V. Gopalan, J. Raja, An internet based surface texture information system, International Journal of Machine Tools and Manufacture, 41 (2001) 2171-2177