A Host System for Form Tolerance Specification in the Next-generation GPS based on AutoCAD

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Abstract. Geometrical specification is the bridge to link function, design, manufacture and verification together for a product. The next-generation GPS utilizes duality principle to combine specification and verification of a geometrical product tightly, and to ensure its desired intention (functional requirements). This makes the geometrical specification of a product complete and unambiguous, to reduce uncertainties at different phases in a product life cycle. The geometrical specification system prevailing currently is designed on the basis of traditional rules so that it can't meet the requirements of the next-generation GPS. This paper presents a host system for form tolerance specification in framework of the next-generation GPS, which is built based on AutoCAD2007.

Keywords: Form Tolerance Specification, the Next Generation GPS, Host System, AutoCAD, Drawing indication

1. Introduction

The next-generation GPS is an important technical standard system developed by the ISO/TC 213 [TC 213; Jiang, 2002]. The motivations for its establishment are: to harmonize the terms and definitions in geometrical product specifications and verification area; to catch up with the digitization trend of manufacturing industry, such as CAD/CAM/CAQ-systems [TC213], etc.; and to enrich the GPS language to have enough tools to express functional requirements of geometrical products.

To achieve these goals, many measures and methods have been employed by ISO /TC213 to improve GPS. One of them is to link specification and verification tightly by the duality principle. All the necessary conditions that might affect any measurement result are stated clearly, e.g. filter type, nested indexes of filter, stylus tip diameter, and mathematical calculation algorithms. The term "operation" [Nielsen, 2001; Nielsen, 2006; Humienny, 2007; ISO/TS 17450-2, 2002] is used systematically and the term "operator" [Nielsen, 2001; Nielsen, 2006; Humienny, 2007; ISO/TS 17450-2, 2002] is developed to improve its implementation.

There are seven types of operations to obtain the geometrical features or the values of characteristics, nominal values and limits, which are partition, extraction, filtration, association, construction, collection and evaluation. These operations and their nested

indexes are critical to measurement result. In other words, these factors are closely related to the functional requirements.

Though there are a few groups have contributed on developing the software for the application of next-generation GPS [Dantan, et al, 2008; Lu, et al, 2006], most of the geometrical tolerance specification softwares that prevail presently have been built under the framework of the traditional GPS. Thereby, this paper presents a host system for the application of form tolerance specification based on the next-generation GPS by using the AutoCAD2007®, which can greatly benefit the implementation of GPS in digital manufacturing.

2. Framework of the host system

Designers and metrology engineers are two main groups who use this host system. The system can provide designers with enough tools such as filtration operation, association operation and their nested indexes, parameter to evaluate the functional quality, and other information that are necessary in the drawing indication to express the various functional requirements of a product. Mathematical algorithms for different types of operations or parameters are integrated in a database that is devised for the host system. The factors in a measurement procedure that have great influences on the measurement results, such as sampling strategy, sampling condition, sampling numbers and so on, should be considered in the design phase. Other requirements, such as maximum/minimum material requirement, reciprocal requirement, common tolerance zone and other appropriate requirements, are also integrated in the host system.

The host system has been built based on the programming environment ObjectARX® provided by Autodesk Inc. It contains six subsystems: User interface subsystem, CAD inner database subsystem, Measurement database subsystem, Function algorithm database subsystem, Information database subsystem, and Help document subsystem. The integration framework for these six subsystems is shown in Figure 1. The software development platforms are .Net, Microsoft SQL Server2000 and ObjectARX®.

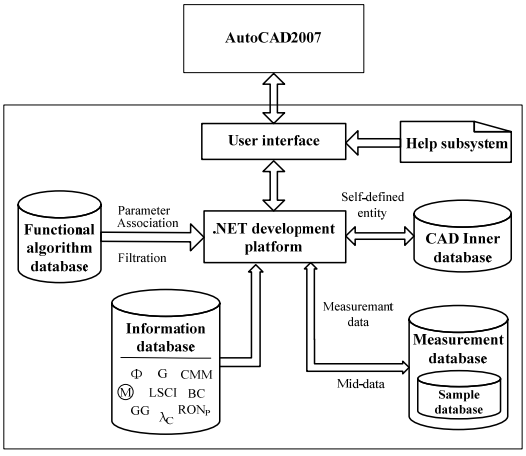

Figure 1 Framework of the host system

- **User interface subsystem**

The Host system runs upon the CAD software. The user interface subsystem integrates all the functional interfaces and the data flows by which the users (including designers and the metrology engineers) use the system. All the commands that the host system sends out are executed by this subsystem.

- **CAD Inner database subsystem**

The host system is nested into AutoCAD as a COM. So, it is necessary to exchange the information between the host system and the AutoCAD2007. After selecting those necessary key elements for a drawing indication, the system can define the determined key elements with proper orders and store them as the AutoCAD inner data format by this subsystem. The entity will be mapped into a block that can be inserted into AutoCAD2007 package.

- **Functional algorithms database subsystem**

This subsystem integrates the various functional algorithms for the next-generation GPS, such as filtration algorithms, association algorithms, parameter evaluation algorithms and so on. It can be extended and revised flexibly with the development of the next-generation GPS.

- **Measurement database subsystem**

The obtained raw data obtained in a measurement procedure is stored within a file in some specific format (such as SDF, SMD, etc.) in this subsystem. The host system can read the file from this subsystem and call the specified functional algorithm from the function algorithm database subsystem to handle the raw data. The result can be sent to the CAD user interface subsystem, or to be stored back to measurement database subsystem for later uses. The measurement database subsystem contains a sample database, so if a designer wants to make a decision on selecting a particular operation from various operations (filtration/association/…), he/she can use the system to call the corresponding algorithm from the functional algorithms database subsystem, and load the appropriate sample data as input to find the effect.

- **Information database subsystem**

This subsystem includes the various codes needed in the drawing indication in the next generation GPS, such as codes for tolerance grade of size, the pre-fit, filter and nested indexes, sampling strategy, association operation, evaluation parameter, evaluation reference, instrument and so on.

- **Help subsystem**

This subsystem integrates all the useful standards, handbooks, and other documents that are related to the next-generation GPS. Moreover, the user instruction for the system is stored in the subsystem.

3. Information flows of the host system

Figure 2 shows the information flow when the designer uses the system to finish a roundness specification. It can be seen from this figure that all the six subsystems of the host system are utilized by the designers to finish the roundness specification.

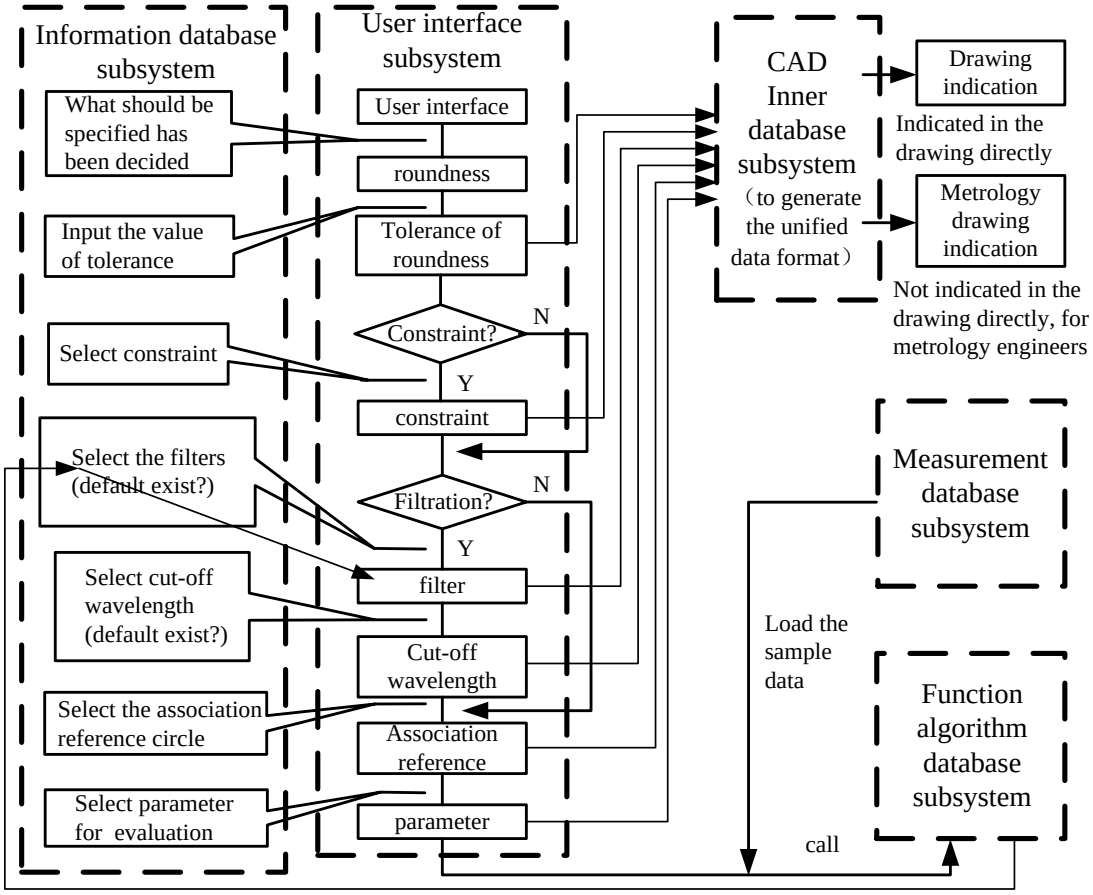

Figure 2 Information flow for designer in roundness specification

Figure 3 presents the information flow when the metrology engineer uses the host system. It can be seen from Figure 3 that four of the six subsystems are mainly used, which are User interface subsystem, measurement database subsystem, function algorithm database subsystem and help subsystem.

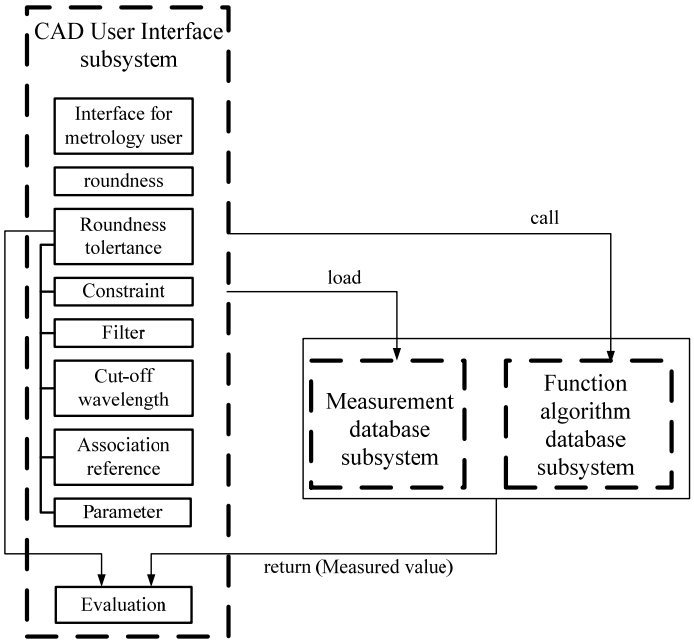

Figure 3 Information flow for metrology engineer in roundness

4. Snapshots of the system

Figure 4 and Figure 5 are the snapshots for the AutoCAD2007 before and after the host system has been loaded respectively. There are two optional ways to load the GPS indication in AutoCAD2007. One is through the menu Tools→Load Application to load the GPS indication system. The other way is to type the command 'appload' in the command line. The GPS indication system can also be removed from AutoCAD2007 by using these optional ways. One way is to use the Exit option in GPS indication menu. The other way is to use the command line. The GPS indication can be saved and recognized by AutoCAD2007 after its being unloaded.

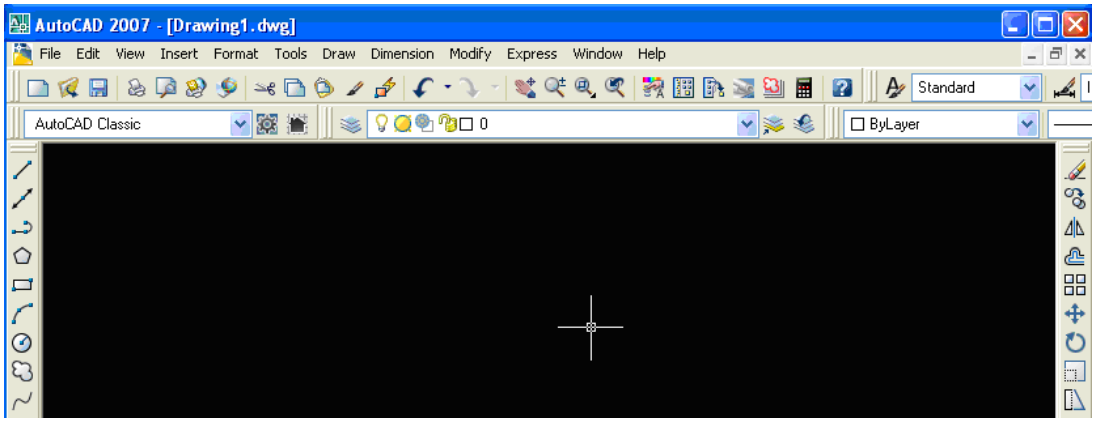

Figure 4 Snapshot of AutoCAD2007

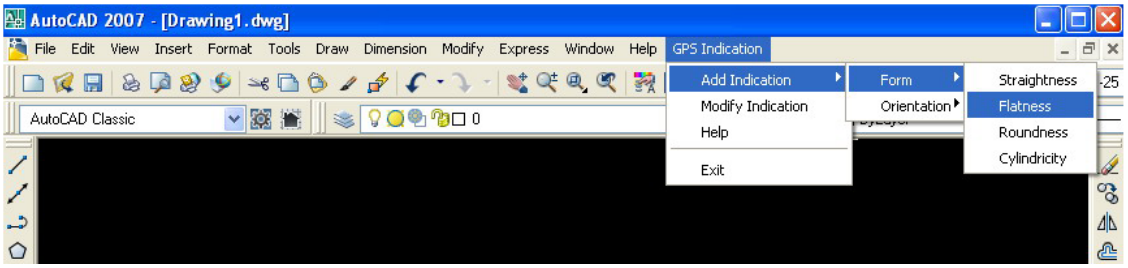

Figure 5 Snapshot of AutoCAD2007 after the GPS Indication has been loaded

Figure 6 is a snapshot for the flatness specification. There is a dialog box for selecting the nested indexes, such as the cutoff wavelength for Gaussian filter, and the time of polynomial for polynomial filter after the different types of filters have been determined, which is demonstrated in Figure 7. After all the necessary factors have been determined, the system will call the CAD inner database system to generate the flatness specification, which is presented in Figure 8. The system provides the mechanism for modification of the specification, which is shown in Figure 5. Furthermore, there are other tools that can be used for the specification framework, for example, the specification framework can be dragged by the point in its up-left corner, and its size can be resized by the four points labeled in Figure 8.

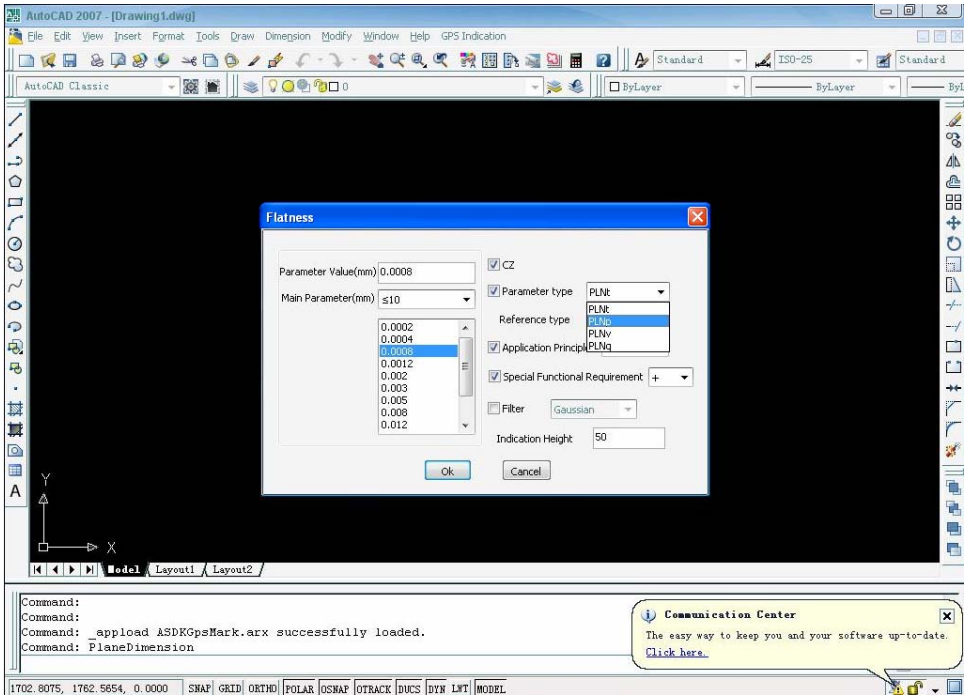

Figure 6 Snapshot for flatness specification

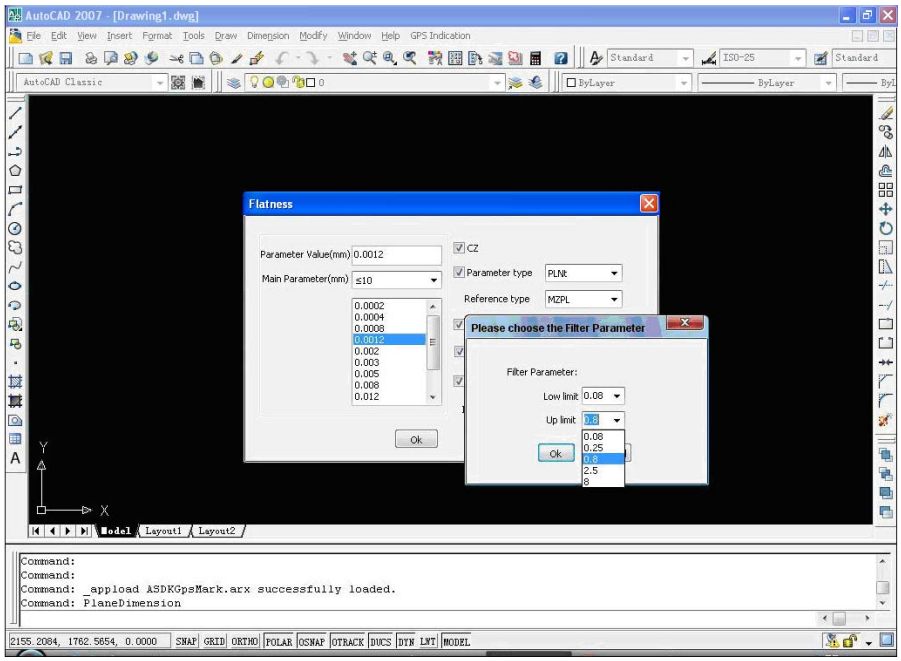

Figure 7 Snapshot for the specification for nested indexes of Gaussian filter

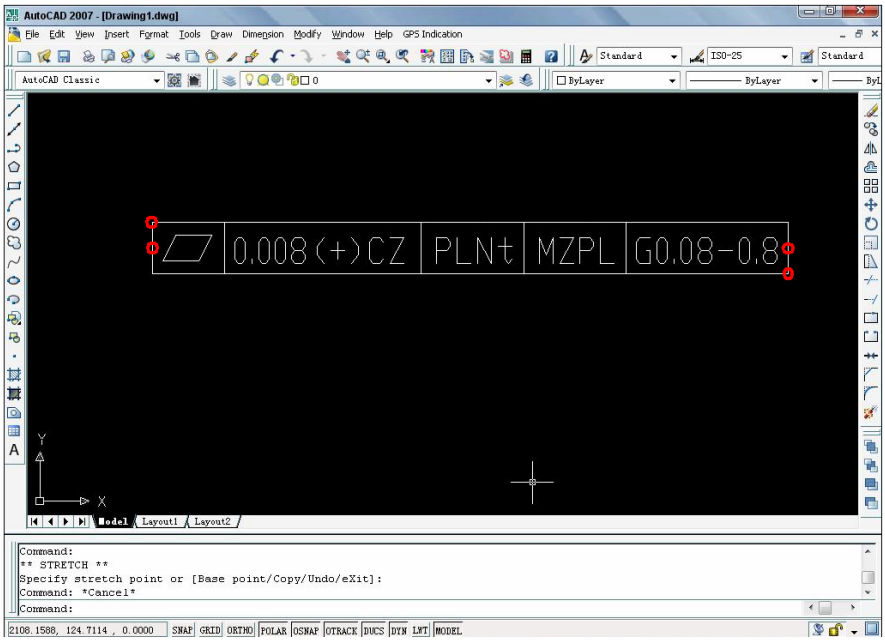

Figure 8 Snapshot for complete flatness specification in the drawing

5. Conclusion

ISO 1101 is the standard for geometrical tolerance specification. But it is not enough. The series standards ISO/TS 12180,12181,12780,12781 for form specification provide a

possibility of completeness and non ambiguity for form specification. The host system presented in the paper for form tolerance specification is necessary for practical applications by incorporating with the new standards in the next GPS standard system. There are still many works that should be done to turn this information system into a knowledge-based stuff.

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