

<u>Title:</u> Point-oriented Identification for Exchanging Parametric CAD Data

Authors:

Mutahar Safdar, mutaharsafdar@kaist.ac.kr, Department of Mechanical Engineering, KAIST Soonhung Han, shhan@kaist.ac.kr, KAIST Soonjo Kwon, soonjoy@kaist.ac.kr, KAIST Ilhwan Song, ssong82@nate.com, Hanwha Aerospace Co., Ltd.,

Keywords:

Persistent Identification, Point-oriented Naming, Macro-Parametrics Approach, TransCAD, Ambiguity Resolution

DOI: 10.14733/cadconfP.2019.59-63

Introduction:

As the manufacturing industry has shifted from sequential engineering to concurrent engineering over the past decade, product data sharing has been the center of attention among designers and developers. Product data can be exchanged either using a direct translation approach or through a neutral format like STEP or IGES. The exchange of parametric CAD information was not possible with these neutral formats and to overcome this issue the macro-parametrics approach was proposed [1], [6].

A CAD model is exchanged through an XML-based neutral format of a macro file consisting of modeling commands [7]. A trouble in parametric CAD data exchange has been the consistency of identifiers throughout the process of exchange. To achieve this consistency, entities in a model should be identified persistently and unambiguously. However, the current reference module of TransCAD is based on the topology naming and it suffers from the ambiguity, which arises because of the splitting and merging of topological entities [5], [6]. This problem, commonly referred to as the ambiguity issue of persistent naming, is explained in Fig. 1(a). Additionally, such a neutral format lacks geometric reference that may otherwise be required in a case where target system has a geometry-based identification approach. This problem, referred to as the exchange issue of persistent naming, is explained in Fig. 1(b). These problems increase the time and effort required to build a translator. The aim of this work is to resolve such issues through the integration of geometry and topology into a standard reference module.



Fig. 1: Problems (left to right); (a) Topologically similar edges in TransCAD introduce ambiguity resulting in the wrong placement of fillet feature, and (b) Source assembly model in TransCAD lacks geometric reference which results in the wrong placement in NX.

Related Works:

There has been considerable research into the issue of persistent identification in CAD models. These approaches can be broadly classified into two types, single CAD system (homogeneous) and CAD data exchange (heterogeneous), based on their application. In all these works, persistent identification was based on either topology or geometry. Here, we only look at the identification approaches previously proposed and implemented for history-based parametric translator.

Mun and Han proposed an identification mechanism for topological entities with a focus on exchanging parametric CAD models [8]. A topology-based face-oriented approach which is similar to Wu's method was proposed and implemented for history-based translator TransCAD [10]. In order to resolve ambiguity, a geometry-based instancing method was used to differentiate among ambiguous entities. Farjana et al. extended this work to pattern feature naming by using a similar geometry comparison [2]. Song and Han introduced a geometry based neutral macro file for eliminating the issue of ambiguity altogether [9]. Recently, ISO-10303 part 57 was published where procedural identification of entities was done through topology-based naming mechanism [4]. In all these mechanisms, geometry was not integrated for use during the exchange process.

Point-oriented Naming Method:

The idea of naming a point in a fashion that it's geometric reference (position coordinates) is integrated with its topological reference (neighboring elements) was first proposed by Dr. Song of KAIST [3]. A point is the most basic entity in space. A geometric point is semantically similar to a topological vertex. This encourages the development and implementation of such a method. The method is defined in Fig. 2. where each entity is represented in terms of its associated vertices.

Most of the commercial CAD systems are feature-based parametric modeling systems. A featurebased point-oriented syntax is introduced. A point in a CAD model can be created through the following methods: feature creation, feature transition, or feature imitation.



Fig. 2: Definition; A model is generated through different feature interactions, and each entity (vertex, edge and face) is named in terms of its associated points.

Components of the Point-oriented Name

Points can vary in terms of the information associated with them inside a CAD system. This is because feature-based modeling systems provide different approaches to create points. A point can have following information components depending on how it was created:

- **Coordinate information (CI)** represents the location (local/global) of a point in design space of a CAD system
- Entity information (EI) includes the name of topological entity (TE) which is represented by the point
- **Sketch information (SI)** includes the sketch name (SN) and its elements (SE_s) in the case a point is generated through a sketch-based feature
- **Feature information (FI)** represents the features with which a point is associated. A point can have more than one feature associations. In this category, we have generating feature information (GFI), transition feature information (TFI) and reproducing feature information (RFI) For feature-based parametric modeling systems, this information can be summarized as in Fig. 3.



Fig. 3: Information components; A point-oriented name is hybrid of topology and geometry information.

Points through Feature Creation

Points can be generated inside a CAD model by inserting new features. A feature can be inserted by referencing a base sketch or an entity. In this case, the name will have sketch information, coordinate information and feature information. Such features include Extrude, Sweep, Revolve and Cut etc.

The point-oriented name (PON) will have the following information components:

$$PON = [SI, CI, GFI]$$

Points through Feature Transition

Transition features are an example of entity-based features. The representative types include fillet and chamfer features. A topological entity is referenced for the creation of these features. In this case, the name will have feature information as transitioned feature information (TFI) and the name of transitioned point (TP). The name of transitioned point can in turn have any of the above information depending on how it was originally created.

The point-oriented name (PON) will have the following information components:

$$PON = [TP, TFI]$$

Points through Feature Reproduction

A feature-based parametric modeling systems provides the functionality to copy or mirror the existing features in user specified patterns. These patterns take the selected features of a CAD model and reproduce them inside the part or an assembly model. As a result, new points are generated inside the CAD model. In this case, the name will have feature information and the name of reproduced point (RP). The name of reproduced point can in turn have any of the above information depending on how it was originally created. This is shown by the example of Fig. 4.

The point-oriented name (PON) will have the following information components:

$$PON = [RP, RFI]$$

Generalized Expressions

Summarizing the above point creation approaches and the information that is related to points in a 3D model, a general point and the corresponding topological entities can be named as follows:

Point Name (PN) = [SN, SE₁, SE₂, CI]

Vertex Name (VN) = [EI, FI, PN]

Edge Name (EN) = [EI, FI, VN_s]

Face Name (FN) = [EI, FI, VN_s]

The reason to separate a point name from a vertex name is to adopt a more conventional outlook for naming topological entities i.e. naming of Vertices, Edges and Faces.



Fig. 4: Multiple features; A model shown (with its vertex cloud) is generated through a generating feature (GT), transition feature (TF) and reproduction feature (RF). The point-oriented name of face contains the information listed in the box.

Implementation and Verification:

A point-oriented naming method is being developed for the history-based macro-parametrics translator TransCAD. The implementation is performed by using the topological hierarchy of ACIS geometric modeling kernel.

Component	Туре
Operating System	Windows 10
Language	C++
Geometric Modeling Kernel	ACIS R25
Visualization Tool	HOOPS 1919
IDE	Visual Studio 2010
CAD systems	CATIA V5, NX 10

Tab. 1: Implementation specification.

The target CAD systems at this point are CATIA and NX. Once the method is implemented inside TransCAD, it will be put to use for exchanging parametric CAD models between CATIA and NX. This process is usually referred to as the naming mapping and is logically the next step of this ongoing development. The implementation specifications are summarized in Table 1. For the verification of point-oriented naming, P-models will be exchanged between CATIA and NX as shown in the Fig. 5.



Fig. 5: P-models as test cases for point-oriented naming method.

Conclusions:

It has been a long-standing desire to resolve the problem of persistent identification in CAD models. The same problem is responsible for inaccurate results in the macro-parametrics translator TransCAD that is a specialized CAD system for exchange. It is possible that geometry can distinguish among topologically similar entities and hence resolve this problem. From the viewpoint of CAD data exchange, the newly attached geometric reference can be a substitute of missing geometry information if the target system is based on geometry. The proposed method will be tested with commercial CAD systems to exploit its potential in real CAD data exchanges.

Acknowledgements:

This research was supported by the Plant Research Program [Project ID: 18IFIP-B091004-05] funded by the Ministry of Land, Infrastructure and Transport, and by the Industrial Core Technology Development Program [Project ID: 10063452] funded by the Ministry of Trade, Industry and Energy of the Korean Government. The authors gratefully acknowledge their support.

References:

- [1] Choi, G.; Mun, D.; Han, S.: Exchange of CAD part models based on the macro-parametric approach, International Journal of CAD/CAM, 2(1), 2002, 13-21.
- [2] Farjana, S.H.; Mun, D.; Han, S.: Implementation of persistent identification of topological entities based on macro-parametrics approach, Journal of Computational Design and Engineering, 3(2), 2016, 161-177. <u>https://doi.org/10.1016/j.jcde.2016.01.001</u>
- [3] iCAD Laboratory, <u>http://icad.kaist.ac.kr</u>, KAIST.
- [4] ISO TC184/SC4, ISO 10303- Industrial automation systems and integration -- Product data representation and exchange -- Part 57: Integrated generic resource: Persistent identification of elements in procedural shape modelling, 2018.
- [5] Kim, B.C.; Han, S.: Integration of history-based parametric translators using the automation APIs, International Journal of Product Lifecycle Management, 2(1), 2007, 18-29. <u>https://doi.org/10.1504/IJPLM.2007.012872</u>
- [6] Macro-Parametrics Approach (MPA) Homepage, <u>http://www.macro-parametrics.org/</u>
- [7] Mun, D.; Han, S.; Kim, J.; Oh, Y.: A set of standard modeling commands for the history-based parametric approach, Computer-Aided Design, 35(13), 2003, 1171-1179. https://doi.org/10.1016/S0010-4485(03)00022-8
- [8] Mun, D.; Han, S.: Identification of topological entities and naming mapping for parametric CAD model exchanges, International Journal of CAD/CAM, 5(1), 2005, 69–81.
- [9] Song, I.; Han, S.: Parametric CAD data exchange using geometry-based neutral macro File, Proc. 7th International Conference on Cooperative Design, Visualization and Engineering, Calvia, Mallorca, SPAIN, 2010, 145-152. <u>https://doi.org/10.1007/978-3-642-16066-0_23</u>
- [10] Wu, J.; Zhang, T.; Zhang, X.; Zhou, J.: A face based mechanism for naming, recording and retrieving topological entities, Computer-Aided Design, 33(10), 2001, 687-698. https://doi.org/10.1016/S0010-4485(00)00099-3