Journal of Computing and Information Science in Engineering

Guest Editorial

Special Issue: Advances in Computer Aided Manufacturing

In 2007 we have computing power and infrastructure that are remarkable in terms of both speed and cost. A casual observer would expect the effects of this technological "free lunch" on Computer Aided Manufacturing (CAM) to be an equally dramatic advance. However it is a measure of this field's difficulty that very few of the problems, which invariably involve complex three-dimensional geometry, can be solved by brute force computing. Arguably this is because CAM researchers frequently encounter the following two challenges under different disguises across the field.

- First, manufacturing applications have to be concerned with the precision with which shapes need to be defined. This is in contrast to other shape modelling applications which primarily focus on appearance. This need spawned a shape representation (i.e., B-rep) that is unique to mechanical CAD/CAM and presents many algorithmic challenges that are not present in processing of simpler shape models.
- Second, CAM researchers need to reason about shapes, rather than simply display them or compute well defined mathematical properties. For example, the shape to be manufactured needs to be interpreted in terms of domain-specific manufacturing features. The feature extraction or recognition problem has proved extremely difficult in manufacturing applications due to its very close coupling with the manufacturing process optimization problem.

Overcoming these difficulties is still the central problem in many CAM applications and consequently it is not surprising that all the papers of this special issue are concerned with the processing of geometry. But what has changed is the range of shape representations researchers are working with. Less than 10 years ago few CAM researchers would have contemplated using anything other than B-rep models. Other representations existed (e.g., meshes, octrees, point clouds, etc.), but they existed in a world separate from mechanical CAM. Where will this trend go; convergence to a single, possibly, hybrid representation or increasing diversity of digital shape formats all co-existing within in PLM systems? It is too early to know.

In this special issue we can see evidence of this change at several different levels; first, at the machine control level where manufacturing process control instructions are computed directly from geometric descriptions. The article by Sir, Wings, and Jutler considers the smoothing of tool path segments whose geometry is represented by analytical equations. The treatment is purely mathematical and demonstrates how physical processes can benefit from controlled approximations. In contrast Vijayaraghavan and Dornfeld's application brief on modelling geometries for FEA simulation demonstrates how Booleans can be used to generate an exact B-rep model of a drill without recourse explicit mathematical surfaces.

Zhou, Yip-Hoi, and Huang also challenge conventional mono-representation approaches with their report on a hybrid analytical solid modeller they use to calculate tool engagement during machining. But perhaps the most exotic geometry representation exploited by researchers in this issue is the Dexel data structure (often used in computationally intensive applications such as haptic sculpting) from which Weihan Zhang, Leu, Peng, and Wei Zhang reconstruct surface data. Additionally, Miropolsky and Fischer describe how diverse scan data can be processed to extract the sharp features useful for inspection application.

Despite the obvious benefits of alternative representations in these papers, the strengths of the B-rep structure are exploited by several authors. Li and Shah use various kernel modeller APIs to identify Mill/Turn features. Similarly Madan, Rao, and Kundra exploit a component's B-rep data structure to identify die-casting features and then, in combination with manufacturing heuristics, determine parting lines. Perhaps the implicit message from these papers is that despite its complexity B-rep technology is now so highly refined that processes which require sophisticated geometric queries (i.e., ray tracing, edge curvature, etc.) and feature identification can be developed for non-trivial parts. The paper by Medellin, Corney, Lim, Ritchie, and Davies reinforces this impression as the non-manifold cellular structure available within modern kernel modellers is used to support the automatic subdivision and refinement of large components for rapid prototyping production.

The paper by Mervyn, Kumar, and Nee shows how changes in part representations can be used to update the fixture design. Hence, this paper illustrates how two different representations can be coupled and used to drive each other.

Assembly models bring yet another level of complexity and organizational layer in the representations. Complex assemblies can include hundreds of individual parts. Hence simulating the assembly process presents unique challenges. The Technical Note by Butterfield et al. describes how various individual software tools can be combined in a systematic manner to perform complex assembly simulations.

Although the correct choice of geometric representation can transform a difficult problem into an easy one, the downside of having many formats is that communication between different systems becomes harder. This is an issue discussed by Hardwick and Loffredo in an insightful Technical Note on the rationale underlying the STEP-NC Standard.

We thank the authors for their contributions to this special issue and hope that readers will find that the papers included in this issue are a valuable contribution to the field and reflect the recent trends in this important subject.

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