ME - PhD Thesis Colloquium

Multi-linear disassembly path determination: A geometric approach

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Meeting link: Click here to join the colloquium **(Microsoft Teams)**

ABSTRACT

This thesis presents a geometric approach for determining the orientation-preserving disassembly paths of polyhedral assembly components. Exact disassembly path determination of the components is essential because the reversal of the disassembly paths provides the paths for the components to assemble into a functional product. Single straight-line paths for disassembly algorithms are available in the literature. Multilinear disassembly requires the determination of the exact Minkowski sum. Minkowski sum approaches, which are related to configuration space, have been used in path planning in both robotics and assembly. But they fail when the assembly components have mating boundaries. This limitation arises due to the failure to capture the contact spaces between the mating boundaries in the Minkowski sum. We have used non-regularized Boolean to capture these contact spaces in the form of lower-dimensional features, which are usually eliminated in regularized Boolean. These lower-dimensional features are characterized into different path elements, which provide the local motion space for a component to move in configuration space. The composition of these path elements models the disassembly paths. To accomplish this board goal, a few sub-problems have been solved. The Minkowski sum of a pair of arbitrary solids requires both Boolean and convex decomposition, which is then used to determine the disassembly paths for a component of an assembly. They are as follows: a) An algorithm has been developed for Boolean of a large number of polyhedral solids. It is based on cell classification without a priori point classification using Slice representation. Contact spaces are accurately captured as lower-dimensional features, which is the requirement of the present problem, making it a non-regularized Boolean. Although the method obviates the need for complete boundary evaluation, it can provide exact point classification, which is as accurate as B-rep and as fast as voxel representation of solids. b) The slice representation not only enables easy multi-Boolean. It also enables a "core and crust" model to partition a tessellated solid with an arbitrary topology into a set of disjoint convex pieces. The core comprises a set of prismatic solids of identical square sections contained in the solid and represents an approximate convex decomposition (ACD). The crust comprises a set of convex solids of arbitrary form and supplements the (ACD) to make it exact. It is fast and robust to handle defective solids such as solids with missing patches and self-intersections. It also provides a unique capability of selective convex decomposition of any specific domain of interest. c) Efficient and exact union of the hundreds of pairwise Minkowski sums of the combination of the convex components is enabled through the slice representation without the loss of the essential lower-dimensional features. A graph of the available motion space in individual grid-cells in the slice representation is then analyzed to construct all the paths with heterogeneous degrees of freedom. i.e. each disassembly path is multilinear, multi-ways and multi-dimensional. d) The method developed for disassembling two components is shown to be general enough for analysis of assemblies with an arbitrary number of components where each target sub-assembly and its complement are treated as the two components.

ABOUT THE SPEAKER

Chandra Sekhar Sathua is a PhD student in the Department of Mechanical Engineering, IISc Bangalore. He holds a bachelor's degree in Mechanical Engineering from Jalpaiguri Govt. Engineering College, West Bengal, and master's degree in Mechanical Engineering from IIT Kanpur. His research interests include Geometric Modelling, Spatial Reasoning, Computational Geometry, and Manufacturing Planning.