# Novel Process Planning approach for support-free Additive Manufacturing using Multi-Axis Deposition systems

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The support structures used in Additive Manufacturing (AM) processes cause poor surface quality in the contact areas of the support with the part surface. Hence, the usage of the support structure is a critical issue, which needs to be minimised for reducing the printing time and post-processing challenges associated with AM parts. One of the solutions to address this problem is building the parts in a multi-direction using multi-axis deposition systems. Direct Energy Deposition (DED) is can be used to print near-net shapes and repair volumes using five-axis Computer Numerical Control (CNC) or six-axis serial manipulator-based robotic systems. For such a system, robust algorithms are needed to decompose faceted solid models into programmable tool paths for multi-directional printing using multi-axis systems. In the past, many algorithms for volume decomposition have been developed for nesting parts inside the building envelope, improving the mechanical properties, and maintaining the printed part surface quality.

A volume decomposition strategy involving the identification of overhang features in faceted models, and build directions than can be used to build the decomposed volumes using multi-axis DED systems is presented in this seminar. The Improved Convex Volume Decomposition (ICVD) algorithm presented in this seminar makes use of the down-facing surface normal in the tessellated model as a reference for decomposing the overhang features, and also provides an opportunity to identify and decompose the presence of overhang features in the particular build directions. This methodology could eliminate the need for intrinsic mass property evaluations such as centroids, and silhouette edges for simple overhanging features.

A test part was built using a multi-axis DED system to verify the benefits of overhang-angle-driven volume decomposition, which decomposes the overhang features in the decomposed Overhang Sub-Volumes (OSV). Moreover, the post-processing time of multi-directional printed parts is reduced. The work presented may help process planning systems to automatically identify Multi-Directional Sub-Volumes (MDSV) and carry out effective part deposition with minimum or no support structures. The ICVD algorithm overcomes some of the issues associated with previous decomposition approaches such as decomposition-regrouping, model simplification, open-loop concave models and binary tree construction, which features cumulative decomposition of overhang features in a particular build direction. The proposed algorithm will be helpful for Computer-Aided Process Planning (CAPP) software developers for AM applications, similar to process planning software developed for STEP-NC-based manufacturing applications.