"Digital Volumetric Processing Ushering in the Age of the Digital Twin for Manufacturing"
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Biography:

Thomas R. Kurfess received his S.B., S.M. and Ph.D. degrees in mechanical engineering from M.I.T. in 1986, 1987 and 1989, respectively. He also received an S.M. degree from M.I.T. in electrical engineering and computer science in 1988. Following graduation, he joined Carnegie Mellon University where he rose to the rank of Associate Professor. In 1994 he moved to the Georgia Institute of Technology where he rose to the rank of Professor in the George W. Woodruff School of Mechanical Engineering. In 2005 he was named Professor and BMW Chair of Manufacturing in the Department of Mechanical Engineering at Clemson University’s International Center for Automotive Research. In 2012 he returned to Georgia Tech where he was appointed the HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control and Professor of Mechanical Engineering. During 2012-2013 he was on leave serving as the Assistant Director for Advanced Manufacturing at the Office of Science and Technology Policy in the Executive Office of the President of the United States of America. In this position he had responsibility for engaging the Federal sector and the greater scientific community to identify possible areas for policy actions related to manufacturing. He was responsible for coordinating Federal advanced manufacturing R&D, addressing issues related to technology commercialization, identifying gaps in current Federal R&D in advanced manufacturing, and developing strategies to address these gaps. He has served as a special consultant of the United Nations to the Government of Malaysia in the area of applied mechatronics and manufacturing, and as a participating guest at the Lawrence Livermore National Laboratory in their Precision Engineering Program. He currently serves on the Board of Directors, the National Center for Defense Manufacturing and Machining, and the National Center for Manufacturing Sciences, and on the Board of Trustees for the MT Connect Institute. He is also the 2017 and the President Elect for the Society of Manufacturing Engineers. His research focuses on the design and development of advanced manufacturing systems targeting digital manufacturing, additive and subtractive processes, and large scale production enterprises. He has significant experience in high precision manufacturing and metrology systems. He has received numerous awards including a National Science Foundation (NSF) Young Investigator Award, an NSF Presidential Faculty Fellowship Award, the ASME Pi Tau Sigma Award, SME Young Manufacturing Engineer of the Year Award, the ASME Gustus L. Larson Award, an ASME Swanson Federal Award, and the SME Education Award. He is a Fellow of ASME, AAAS, and SME.

Abstract:

Historically, analog representations have been converted to the digital domain to enable the use of digital computing, yielding substantial improvements in performance. For example, 1D signals such as sound are digitized and analyzed via digital signal processing (DSP). Furthermore, compression and connectivity enabled new business models, such as cloud-based music management, delivery...
and marketing systems (e.g., iTunes). Although it required more time due to memory and computational power constraints, digitization progressed to 2D data (e.g., images and video). Once again, this shift from the analog to the digital world enabled new technologies and business models. As with 1D signals and DSP, most image processing today is done via digital image processing. The premise of this lecture is that digitization will transition from 2D to 3D resulting in digital volumetric processing (DVP). The initial instantiation of DVP is the voxel, which can be considered a 3D version of the pixel. DVP in combination with data compression, high-speed connectivity, and parallel operation formulation will enable next generation opportunities in manufacturing from a variety of perspectives including analytic, business and education.

Processing of digitized 3D models is not a new concept; it is used regularly in CAD/CAM/CAE applications with finite element meshes and STL-type representations. A voxel model provides a simple 3D structure for a part that is readily parallelizable, much in the same sense that the pixels on displays are processed in parallel using a graphics processing unit (GPU). Consequently, many of the parallel high performance computing (HPC) techniques used to accelerate graphics on a GPU can also be used on voxel models. Current research in the Precision Machining Research Consortium (PMRC) at Georgia Tech has leveraged such capabilities to both process 3D metrology data and program CNC machine tools at rates well over 1000 times faster than was previously viable. Additionally, as new cloud-based computing services purport another 1000-fold increase in speed using next-generation GPU platforms, the potential for a reduction in processing time by a factor of 1 million is quickly becoming a reality. Such capabilities, currently implemented at incremental cost on cloud services platforms, have enabled next-generation programming systems that include video game-like interfaces for programming 3-, 4- and 5-axis machine tools. As the engineer is designing a part with this game-like interface, a real-time analysis of the part’s manufacturability provides instant feedback to the designer regarding the cost, quality, and viability of the design. Extension of these DVP concepts into the realm of additive manufacturing, which already relies on digital models (e.g., STL), enables natural extensions of machine tool programming, metrology, and additive/subtractive design for manufacturability into fully integrated hybrid manufacturing operations. Furthermore, DVP is starting to gain traction in many types of finite element analyses (e.g., thermal, solid mechanics, fluid flow, etc.), moving DVP into a more ubiquitous state in manufacturing, design, and analysis. Integration of DVP with digital twins that rely on empirical data for complete model definition enables a fully unified approach to process monitoring and control using discrete geometry.