Abstract for David Dornfeld Manufacturing Blue Sky Competition

Interactive Virtual Hands-on Manufacturing

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1. Motivation

Manufacturing is not a required course in most of engineering departments in U.S., and this is partly because of lack of qualified faculty members but more importantly lack of laboratories that allow students to have hands-on experience with a variety of manufacturing processes. Good understanding in manufacturing processes and systems and design for manufacturability require sufficient hands-on experiences with manufacturing processes and systems and knowledge in principles of how each manufacturing process works. However, because there is a wide range of manufacturing processes and innovative manufacturing processes including additive manufacturing processes get developed quite frequently, it would be almost impossible to teach the process principles of these manufacturing processes let alone provide hands-on experience to students. In addition, without the knowledge of each manufacturing process, it is difficult to understand the sequence of different processes to manufacture a part design. Thus, although an engineering student may become proficient in designing with computer aided design (CAD) software, it may take years of work experience until the student become competent in designing with good manufacturability.

2. Vision

We propose to develop software that allows interactive virtual hands-on manufacturing so that a part can be designed by applying manufacturing operations. A part has been traditionally designed using CAD software and computer aided manufacturing (CAM) software is subsequently used to determine appropriate machining operations to manufacture the part. In the proposed software, manufacturing operations are virtually initiated by the user to create or cut features in the stock such that desired design can be achieved. There are enormous possibilities if a part is designed using interactive virtual manufacturing processes. Before designing a part, a user has to select a machine configuration (3-axis milling, lathe, etc.) and stock size. Then, after selecting an appropriate tool type and size, using a combination of a mouse (or any other interactive haptic device) and a keyboard, the tool and/or the stock, which are essentially solid models, are moved according to the constraints of the selected machine configuration in order to virtually cut the stock using geometric Boolean operation. After a number of operations, tool changes, machine configuration changes, etc., the final design of the part can be achieved. This part is completely manufacturable because it is designed using machining operations. As designers complete designing of the part using the software, learning in principles of manufacturing process and machine kinematics are naturally acquired. Also, characteristics of manufacturing processes, tools, machine configurations, such as rounded corners in pockets, are automatically represented in the part. Using the software, virtual sculpting can be possible as well. The software will provide virtual hands-on experiences with different machine configurations, manufacturing processes, and tool types and sizes. As each designer will eventually end up with different sequences, tools, processes, etc., machining time can be easily calculated for each designer's way, and the concept of machining efficiency or productivity can be naturally taught while designing.

3. Broader Impacts

Students of this and next generations are used to operate using human interface devices such as keyboard, mouse, touch screen, virtual reality (VR) headset, and so on. They will be able to operate virtual machines freely using these devices. Then, the software will provide a platform for them to come up with innovative ideas. For example, a new machine configuration can be imagined and tried to generate unique features. A new way of operation for conventional configurations can also be achieved. Multiple users can connect through network and operate simultaneously. The virtual software can be linked to a physical machine to generate a part. The software will be a virtual platform for manufacturing where many different users can participate and create innovations. We believe that there are tremendous possibilities.