UNIFIED SOFTWARE FOR MULTI-FUNCTIONAL G-CODE: A METHOD FOR IMPLEMENTING MULTI-TECHNOLOGY ADDITIVE MANUFACTURING

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Abstract

Additive manufacturing (AM) began a manufacturing revolution moving industrial production into consumer homes. With interest shifting toward multi-functional parts fabricated through AM technologies, multi-functional fabrication systems are now being developed. Merging different manufacturing technologies into a single machine is a challenge, but ongoing research in the development of multi-technology systems has shown promise. The software and automation aspects of multi-technology systems are being developed in unison. This paper explores the challenges and approaches to developing software that interfaces with multifunctional CADs and creates files for direct use in multi-technology AM machines.

1 Introduction

In recent years, Additive Manufacturing (AM) has taken a prominent role in the manufacturing industry. Commonly referred to as 3D printing, AM is a process which takes a Computer Aided Design (CAD) file and creates a 3D-printed part in a layer-by-layer fashion. AM capitalizes on design freedom and quick turnaround time relative to traditional manufacturing methods [1]. With these advancements in AM technology, there is an interest and an ambition to fabricate multifunctional parts using AM. Until now, fabrication of most multifunctional parts consisted of a stepwise, process-interrupt approach that used multiple machines and processes [2]. Along with hardware and process improvements, software is being developed to simplify and aid the user in creating multifunctional parts with minimal human intervention.

2 Interface and Assimilation

2.1 Background

Additive manufacturing has recently surged in popularity and although the CAD industry is supportive of the new market, it can also be slow to fulfil the needs of multi-technology advanced manufacturing. One of the first hurdles to overcome when automating and developing multi-functional G-code is the extraction of information. Most AM files are exported in Standard Tessellation Language (STL) which includes vertex data, which describe triangles that tessellate to define a part. Much of the information contained in a CAD is lost when converted into STL format. In response, the industry has evolved and is promoting the Additive Manufacturing Format (AMF) file extension, as well as the Microsoft 3MF extension. AMF is written in EXtensible Markup Language (XML), allowing the file to evolve with the technology by making it simple to add or remove information in an organized manner. Although the file type (AMF) allows more information to be saved, the additional information required is not well-defined. There has been a wide acceptance of AMF or 3MF by slicing software that prepares CAD files to be processed by

the AM machine. Although specific processing algorithms are yet to be developed, there is a foundation for support of multi-functional G-code in the future.

2.2 Strategy

Currently, there isn't a clear method for extracting additional information from CAD files to construct a multi-process part. While there exists a multitude of CAD software applications, SolidWorks is currently being used for its wide acceptance in industry and is ready availability to students. Although SolidWorks does not support data extraction for multi-functional parts, it does support Visual Basic (VB) macros and has a built in Application Program Interface (API). The support of an API allows the development of VB macros that can directly interface with the part that is being designed in SolidWorks. The use of a macro grants access to most of the additional information needed to compose the multi-functional G-code. Defining the type of information and structure is dependent on the process that one is seeking to accomplish. One way to create multi-functionality is to add electronics to AM parts. As such, automation of a wire-embedding process [3] was the first software challenge tackled. The first step in defining a circuit in CAD is understating how the machine interprets the process. Simple sketch lines can be used to describe circuit paths and connections. Basic electronics can be hand drawn line by line, yet this is not an effective way of designing intricate electronics. Electrical engineering programs used for designing Printed Circuit Boards (PCB) are very effective at automatically routing complex paths. The paths are then imported into SolidWorks and aligned with the polymer-printed part. This makes adding complex electronics simple and straightforward as seen in Fig 1 and Fig 2.
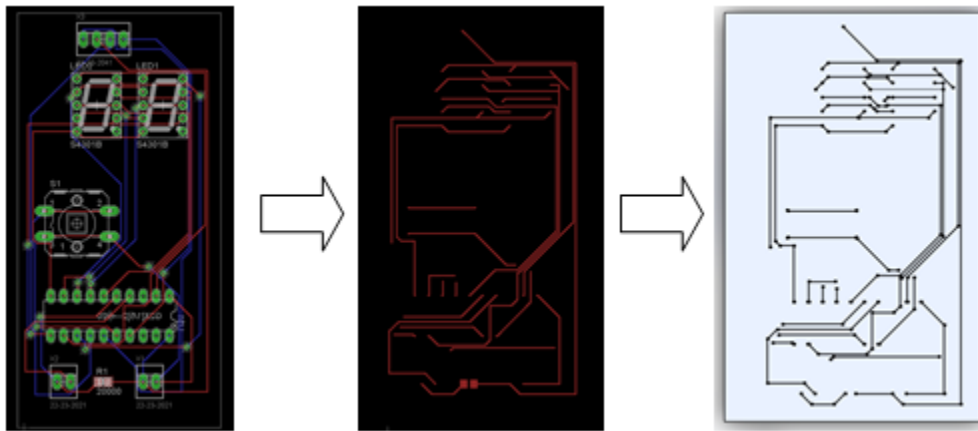

Fig.1. PCB design to DXF layers that can be exported into SolidWorks

Furthermore, every layer that includes a circuit is comprised of a sketch with a name that signifies it is a circuit, with a numeric value to individually identify it (e.g. "circuit1", "circuit2", etc.). This naming convention allows the macro to identify the circuits and their respective heights and export them separately as DXF files that define the circuit on that plane. A text file with a list of all the circuits and their corresponding heights can then be created. Similar approaches can be applied to other processes to extract data and create multi-functional G-code.

3 Integration

Just as multiple hardware technologies can be integrated into a unified system, multiple software processes can also be merged together. The basic slicing software used is Cura (an open source AM slicing software that accepts both STL and AMF files). The software supports post-

processing plugins within its Graphical User Interface (GUI) making it simple to run and implement post processing for multi-functional parts. Once the exported STL or AMF file is opened in Cura, the part can be oriented and placed appropriately on the build plate. A simple click of a post processing plugin initiates a post processing program that uses all of the additional information extracted from the CAD to generate the multi-functional G-code file. Extracting data through macros and instead of an AMF file results in the loss of much of the reference information. As the user has the ability to change the position and rotation of the part arbitrarily, the current plugin has to do more than simply merge multiple processes: it has to find every part and circuit, orient them, and super impose them. Ultimately, a design from CAD is generated without any human intervention. Fig 2 shows a test piece (wire embedding is still under development) in which a simple drawing was created in CAD and subsequently processed, generating final G-code to realize the design, simply from tool offset information from the drawing pen tool, without any additional user post-processing of the G-code file, thus creating a multi-processed part from a single CAD file.
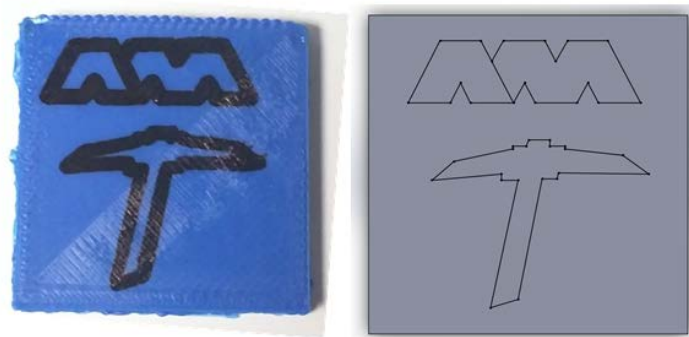

Fig. 2. Image shows the multi-process AM part automatically generated from a single CAD file without human post-processing.

4 Conclusion

An algorithm for generating multi-functional G-code files for use in multi-technology AM machines has been successfully demonstrated. With the large industry use of CAD, but limited support of multi-process manufacturing, there is a great need for software packages to generate multi-functional G-code. Identifying the required information and processing are vital steps to determining a cohesive strategy.

References

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