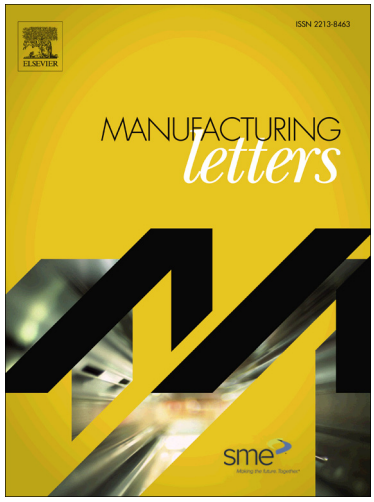

Algorithm for remanufacturing of damaged parts with hybrid 3D printing and machining process

Yufan Zheng, A.J. Qureshi, Rafiq Ahmad

PII: S2213-8463(18)30026-9
DOI: https://doi.org/10.1016/j.mfglet.2018.02.010
Reference: MFGLET 139

To appear in: *Manufacturing Letters*

Received Date: 11 February 2018
Accepted Date: 11 February 2018

Please cite this article as: Y. Zheng, A.J. Qureshi, R. Ahmad, Algorithm for remanufacturing of damaged parts with hybrid 3D printing and machining process, *Manufacturing Letters* (2018), doi: https://doi.org/10.1016/j.mfglet.2018.02.010

Algorithm for remanufacturing of damaged parts with hybrid 3D printing and machining process

Yufan Zheng
Laboratory of Intelligent Manufacturing, Design and Automation (LIMDA), Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta Canada
+1 (587) 982 6105
yufan6@ualberta.ca

A.J. Qureshi
Department of Mechanical Engineering, University of Alberta Edmonton, Alberta Canada
+1 (780) 492 3609
ahmed.qureshi@ualberta.ca

Rafiq Ahmad
Laboratory of Intelligent Manufacturing, Design and Automation (LIMDA), Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta Canada
+1 (780) 492 7180
Rafiq.Ahmad@ualberta.ca

ABSTRACT

In industry, damaged parts are difficult to be replaced. Remanufacturing is a technique that gives a new life to a product. However, remanufacturing of a complex damaged part with various defects is not easy to develop and mostly a single process. In this paper, a hybrid method is proposed which integrates coordinate measuring machine (CMM) data collection, defective model regeneration, and decision making for process selection for the repair, such as materials addition with 3D printing or material removal with machining. The proposed method is demonstrated to repair a turbine blade virtual model to test its efficiency and reliability.

Keywords

Remanufacturing; Reverse engineering; Decision making; 3D-printing; CNC machining

1. INTRODUCTION

Remanufacturing is considered as an environmentally conscious manufacturing. Traditional remanufacturing steps include: 1. Inspection by technician; 2. Manual welding; 3. CNC milling or manual grinding; 4. Manual polishing [1]. Manual remanufacturing could keep high quality of remanufacturing because welding is a mature technology to control the microstructures and mechanical properties of metal. However, it costs a lot of time, requires serial labor intensive and operator skill sensitive processes [2]. Therefore, the demand of automatic process for remanufacturing is increasing during real production and virtual simulations to address these problems [3].

In the past, researchers developed some methods to repair engineering components by additive manufacturing techniques including laser direct deposition [4], three axis controlled welding [2] and laser cladding [5]. However, the complicated damaged surface requires additive manufacturing repair and subtractive repair at the same time. Researchers have introduced integrated methods combining reverse engineering, machining and additive manufacturing to repair worn parts [2][1]. In their methods, optical scanning devices were involved in their remanufacturing systems. However, optical scanning devices are not popular in factories and the prices of them are very high. Furthermore, the preprocessing after data collection is a bigger challenge. DMG has developed a hybrid machine that combines laser-cladding additive manufacturing with milling subtractive manufacturing. However, this machine is limited by automatic remanufacturing because there is no intelligent decision-making system [6][7].

Coordinate measuring machines (CMMs) are comparatively cheaper, more commonly already available in workshops and much accurate than the expensive 3D scanners. This paper aims to develop an automatic and hybrid manufacturing system, which combines CMMs techniques, reverse engineering, additive manufacturing and subtractive manufacturing.

2. METHODOLOGY

In the proposed method, a reverse engineering process is used for digitization of the physical damaged part into 3D CAD model. Then repair volume can be extracted by registration of nominal model and defective model. Based on the repair volume, different repair strategies could be used to repair the damaged part and bring the part back to a like-new condition. Figure 1, shows the flowchart of the proposed method. The following sections explain a step-wise approach to the methodology.

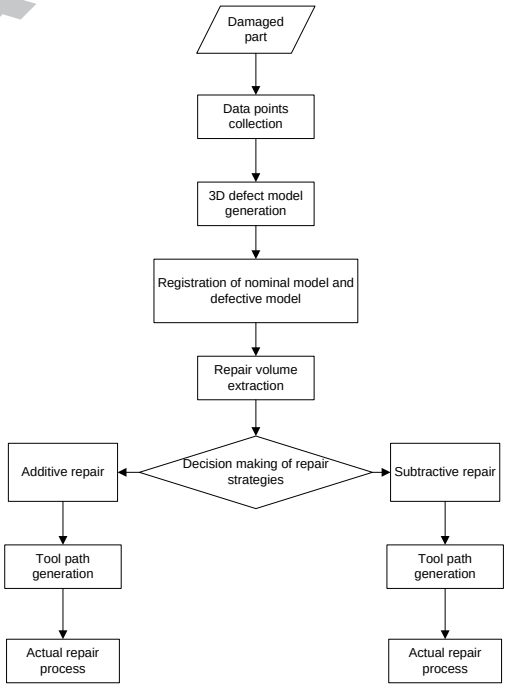

Figure 1. The framework of remanufacturing of damaged parts with hybrid 3D printing and machining process

2.1 Data points collection

Over past three decades, there are several different technologies for data points collection which include coordinate measurement machine (CMM), laser scanning, structured light scanning, stereo scanning [8]. CMM is the most popular equipment in data points acquisition in reverse engineering [9]. Although CMM