Suited for performance

Fast full-scale replication of athlete with FDM

van Tubergen, Joris; Verlinden, Jouke; Stroober, Mathijs; Baldewsing, Ruben

DOI
10.1145/3083157.3092888

Publication date
2017

Document Version
Final published version

Published in
SCF'17 Proceedings of the 1st Annual ACM Symposium on Computational Fabrication

Suited for performance: fast full-scale replication of athlete with FDM

Joris van Tubergen
Jouke Verlinden
Mathijs Stroober
Ruben Baldewsing
Faculty of Industrial Design Engineering, TU Delft, Netherlands

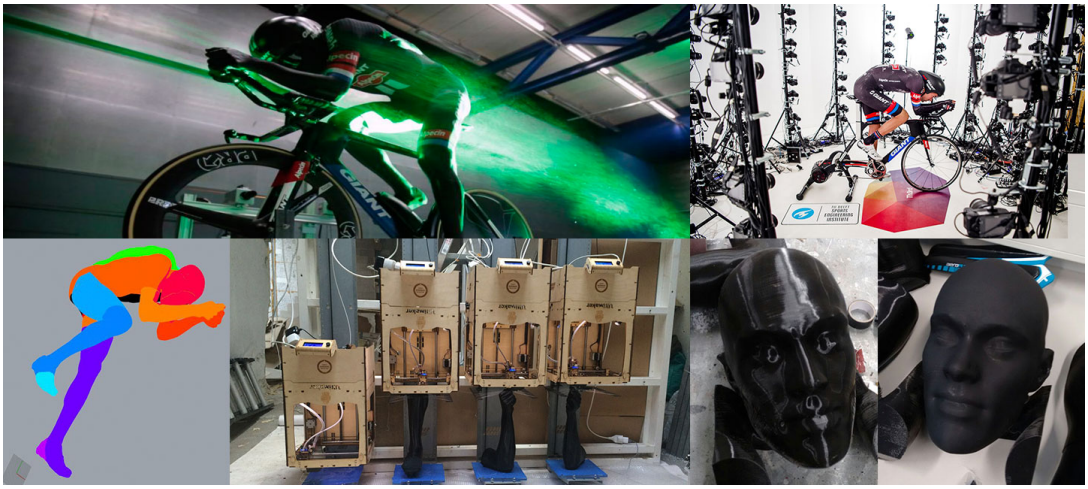

Figure 1: Workflow a) 3D printed Tom Dumoulin 2017 (photo Wessel van Keuk/Cor Vos), b) Photogrammetry 3D scan (photo Guus Schoonewille), c) Segmentation d) 3D printer setup with Z-Unlimited e) Extreme matte surface post processing.

CCS CONCEPTS

• **General and reference** → **Design**; • **Hardware** → **Design rules**; **Design rule checking**; *Process variations*; • **Software and its engineering** → *General*;

KEYWORDS

3D print, 3D scan, FDM, FFF, PIV, wind tunnel, segmenting, slicing

ACM Reference format:
Joris van Tubergen, Jouke Verlinden, Mathijs Stroober, and Ruben Baldewsing. 2017. Suited for performance: fast full-scale replication of athlete with FDM. In *Proceedings of SCF '17, Cambridge, MA, USA, June 12-13, 2017,* 2 pages.
https://doi.org/10.1145/3083157.3092888

1 INTRODUCTION

During the big Tour de France time trial on the 15th of July 2016, Tom Dumoulin was cycling in a new suit, developed jointly by Team Giant-Alpecin and TU Delft. [TUDelft 2016] The drag of different suits was optimized in the Delft wind tunnel. However, as one can't place a professional cyclist in a wind tunnel for weeks on end. For this, a 3D printed mannequin with the exact same physical measurements was made. An essential benefit using an exact replica in the wind tunnel is that it remains perfectly still, making the measurements of the airflows around the body much quicker and more accurate. Additive manufacturing was not chosen as easiest option, it lead to a collection of research opportunities. The process includes scanning, 3D segmenting, printing strategy and printing, assembling and testing. The complete process was done in less then 2,5 months.

2 SCANNING

Step 1 in this process is the accurate scanning of the cyclist. The photogrammetric 3D scan was outsourced to a specialized company (th3rd). [Bethe 2016] In short: 150 DSLR cameras took pictures of the body from different angles, all at the same time resulting in 2 Gigabytes of digital images. It is key to use the data correctly and determine where the accuracy of the scan and the resulting print is somewhat less important. On those areas you can strongly reduce the amount of necessary data.

SCF '17, June 12-13, 2017, Cambridge, MA, USA

ACM ISBN 978-1-4503-4999-4/17/06…$15.00
https://doi.org/10.1145/3083157.3092888

3 3D SEGMENTING AND PRINTING

To enable changing suits, the mannequin required to be decomposable to smaller pieces. To minimize the irregularities on the surface split lines were located under the suit. The whole mannequin was divided in 5 separable parts.

The 3D printing system consisted out of 5 extended ultimakers with a print dimension of 200mm x 200mm x 20000 mm (Z-Unlimited). [van Tubergen 2016] So the separable parts has to be segmented again to suit these dimensions.

After the 3D segmenting the parts were processed in Meshmixer for support structures and Blender to hollow certain parts to make them lighter and faster to print. The front blocks of the main body required extra attention because all the separable parts were attached to it with nuts and bolts from the inside. The 3D printing strategy was performed in Cura with custom scripts. Since printing complete with infill is too time consuming, printing without infill is not rigid enough, multiple 3D printing profiles were combined in one print file.

4 ASSEMBLING AND POST PROCESSING

To fit the requirement of extreme matte surface, the whole mannequin was first sanded and smoothed out by special soldering irons, and later painted with ultra matte latex paint.

5 TESTING

Researcher Wouter Terra [Terra et al. 2016] performed a two week investigation on race biker aerodynamics. The end result seemed to make a significant difference, although exact contribution is difficult to assess in the field.

6 ACKNOWLEDGEMENTS

This work was funded by the TU Delft Sports Engineering Institute and Giant Alpecin. We would specifically thanks Daan Bregman, Wouter Terra and Tom Dumolin.

REFERENCES

Tristan Bethe. 2016. 3D scanning Th3rd. www.th3rd.nl. (2016).

W. Terra, A. Sciacchitano, and F. Scarano. 2016. Drag analysis from PIV data in speed sports. *Procedia Engineering* 147 (2016), 50–55.

TUDelft. 2016. Video covering this process. youtu.be/TBEagWWFkuA. (2016).

Joris van Tubergen. 2016. 3D printing with Z-Unlimited. www.rooie.joris.nl/z-unlimited. (2016).