Digital Printing on 3D Printed Surfaces

29.09.2016


Add+it 2016, Steyr

LEADING
INNOVATIONS

WWW.PROFACTOR.AT

Content

- Background
- Motivation – Why inkjet printing on 3D printed surfaces
- What is necessary to do so?
  - Rough surfaces
  - Curved surfaces
  - Finding the right spot
- What else could be done?
- Outlook and Vision
Our Research Topics – Research for Industries

Industrial Assistive Systems

Additive Micro/Nano Manufacturing

Additive Micro/Nano-Manufacturing

Application

Material

Equipment (HW/SW)
Surface Finishing of Additively Manufactured Objects?

- Surface finishing is almost always necessary in additive manufacturing
  - Layer-by-layer buildup
  - Wires
- Sand blasting
- Solvent treatment
- Polishing
- Painting, ...

- Why not add functionality in the same step?

**Why not inkjet print on such a 3D printed object?**

What Could be the Benefits?

- 3D Printing provides individualized objects
- Surface finishing should also have the possibility of be individualized
  - Digital inkjet printing
- Put different materials on different positions of the objects
  - Chemical properties
  - Mechanical properties
  - ...
- Include additional functionality!
Additional Functionality ??

- Inkjet Printing of functional materials

Multimaterial, Multilayer Inkjet Printing

- Inkjet printed modified OrmoComp
- Silver nanoparticle inkjet ink
What is necessary to be able to inkjet print on 3D prints?

- Inkjet Printing on rough surfaces
- Inkjet Printing on curved surfaces
  - Local distance variation between printhead and surface due to finite size of printhead
- Finding the right spot on the curved surface i.e. on the 3D printed object, where to perform the Inkjet Printing
  - Moving the printhead over the 3D object
    - Has something to do with finding the object, knowing where the surface is
Inkjet printing on the rough and curved surface

- Rough surface: capillary effects
- Fast UV-curing
- Optimize surface tension and viscosity for substrate
- However: Inkjet restrictions

variation of distance between printhead and surface

- Jetting voltage
- Puls shape
Inkjet Printing on curved surfaces

- Watch glass
- 200µm drop spacing
- 20V

Inkjet Printing on curved surfaces

- Watch glass
- 200µm drop spacing
- 40V
Inkjet Printing Challenges

3 challenges:

- Rough surface

- Local distance variation between printhead and surface due to finite size of printhead

- Moving the printhead over the 3D object
  - Has something to do with finding the object, knowing where the surface is

Inkjet Printing on Curved Surfaces
Influence of Robot Movement?

Acceleration phase  
Non-constant speed  
Dot density variation

Increased distance

So ... inkjet printing can do nice things

- On rough surfaces
- On curved surfaces
- Printhead moved by robot

We are working on it

But ... 3D printed objects are individualized ... each one is different

Where to print??
Finding the Objects

Finding the Objects – 3D vision
Object to be found

http://candelor.com
Moving over a scanned 3D surface

continuous surface scanning of carbon fibres
Coverage Planning

- Known, or acquired 3D geometry →
- Evaluate, which area can be reached with the
- Accuracy of acquired 3D geometry ??

Reactive path planning

- Reality … different from the plan
- Visual Servoing
The objects can be found

- Using machine vision, it is possible to find known objects in 3D space and move a robot in close vicinity of the surface

Conclusions

- Inkjet printing on curved and rough surfaces
- Getting the ink to the right spot on this curved surface (3D object) → Inkjet Printing + Robotics
- Finding the right spot on the curved surface i.e. on the 3D printed object, where to perform the Nanoimprint → 3D Machine Vision
- Basic technology building blocks for Inkjet Printing on arbitrary 3D printed objects are available
- …. more things can be done
Inkjet and NIL combined

Step 1 – Inkjet printing
Step 2 – Apply stamp
Step 3 – UV illumination
Step 4 – Remove stamp

Nanoimprinting on the rough and curved surface
Pattern deformation on small objects

- Sphere 160µm diameter
- Hole pattern:
  - P = 2.75 µm Ø 2.2 µm

Stamp

Substrate

Pattern deformation on small objects

- Sphere 160µm diameter
- Extension in x- and y-direction
- Compression in z-direction

Structure on Top: Period 4.4 µm D = 2.96 µm

Top view

Side view

Bottom: Period 2.75 µm D = 2.27 µm

Top view

Side view
Nanoimprint on curved surfaces

- Single layer imprint using different resins
- FDM samples of PLA (R = 20 mm)

OrmoComp®

OrmoStamp®

3D printed by Stratasys on a Connex 3 printer

Designed by Sebastian Schuster
Outlook and Vision

- Combine all these technologies
- Lots of interesting challenges !!
- Lots of challenging applications !!

Multifunctional individualized curved surfaces

- Nanoimprint combined with inkjet
- Functional materials
- On 3D printed and conventional surfaces
Multifunctional individualized curved surfaces

- Nanoimprint combined with inkjet
- Combination of Functional Materials
- On 3D printed and conventional surfaces

Hybride Additive Manufacturing of Multifunctional Products
Acknowledgements

- A. Fuchsbauer, M. Ikeda, N. Chitturi Chowdary, T. Köpplmayr, H. Außerhuber … Inkjet on curved surfaces
- M. Haslinger, T. Köpplmayr … NIL on curved surfaces
- L. Häusler, H. Außerhuber, M. Haslinger … NIL in general
- T. Voglhuber … NIL and inkjet test-setups
- A. Walch, P. Meyer-Heye … reactive path planning, quality skill
- M. Ankerl … candelor
- S. Zambal … fibremap
- C. Wögerer, C. Eitzinger, H. Fachberger, T. Lederer

Acknowledgements

- Funding

© PROFACTOR GmbH
Thank you for your attention

Dr. Michael Mühlberger
- Tel: +43 (0)7252 / 885-253
- Mail: michael.muehlberger@profactor.at

Dr. Anita Fuchsbauer
- Tel: +43 (0)7252 / 885-407
- Mail: anita.fuchsbauer@profactor.at

Further information
- Web: www.profactor.at
- Xing: https://www.xing.com/companies/profactor
- Twitter: www.twitter.com/profactor
- YouTube: http://www.youtube.com/user/profactorgroup
- Facebook.com: PROFACTOR_Leading Innovations