Characterization and Improvement of 3D Printed Surfaces

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Materials of Cultural Heritage: Appearance Acquisition and Reproduction


Materials of Cultural Heritage: Appearance Acquisition and Reproduction

Direct light


Raking light

A visual assessment: cracked
General Context

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How to measure the change?
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How to measure the change?

How to keep the information in an easy way for the restorer?

Surfaces reproduction

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- Measurement devices
  - Texture
  - Gloss

How to measure the change?

How to keep the information in a easy way for the restorer?

Surfaces reproduction

2.5D printing
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2.5D printing: an additive process where layers of UV inks are placed on top of each other, creating a colored and glossy relief.

Printing parameters can vary and their influence is unknown.
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- Acquisition
- Reproduction
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Acquisition

- Wood
- Paper
- Ink
- Brass

Reproduction

Characterization of the 2.5D printing technique

Texture and Gloss response?
Contents

• Model of the system
• Protocol and Results
• Decompensation Process
• Perspectives
We want to **characterize** and to **compensate** the abilities of the texture printing process.
We choose to work with a Height Modulation Transfer Function (HMTF) such as:

\[ HMTF(f) = \frac{\text{Output Height Modulation (f)}}{\text{Input Height Modulation (f)}} \]

where

\[ \text{Height Modulation (f)} = \frac{\text{Height}_{\text{max}} - \text{Height}_{\text{min}}}{\text{Height}_{\text{max}} + \text{Height}_{\text{min}}} \]

For a given frequency \( f \).
3 variables in input:
- 8 frequencies
- 9 pairs of heights
- 3 droplet sizes

<table>
<thead>
<tr>
<th>Frequencies (cycles / inch)</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>25</th>
<th>30</th>
<th>50</th>
<th>75</th>
<th>90</th>
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</thead>
<tbody>
<tr>
<td>Heights (µm)</td>
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<td></td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Droplet sizes (µm)</th>
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<th>3</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1.8</td>
<td>5.4</td>
<td>8.8</td>
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</tbody>
</table>
3 variables in input:
- 8 frequencies
- 9 pairs of heights
- 3 droplet sizes
Measurements
confocal microscope with chromatic coding

Model
Protocol and results
Compensation process

Modelling
2nd point
Relief Adapted Method

Source – white light
Beam splitter
Chromatic objective
Object

Filtering hole

Spectrometer
Computer

\[ \lambda_a \]
\[ \lambda_b \]
\[ \lambda_c \]
Output response after micro-topographic measurement

Ex: giga_b_lv3_C_3_p1
An example of results

Heights Modulation Transfer Functions for the heights pair [107 µm; 140 µm]
Droplet levels 1, 3 and 5

\[
HMTF(w) = \frac{H_0}{\sqrt{1 + \left(\frac{w}{w_0}\right)^n}}
\]

with
- \(H_0\) the gain
- \(w_0\) the cut-off frequency
- \(n\) the order of the system

\(H_{\text{max}} - H_{\text{min}} = 32.94 \mu m\)
Protocol and Results

One model

<table>
<thead>
<tr>
<th>Model</th>
<th>Protocol and results</th>
<th>Compensation process</th>
</tr>
</thead>
</table>

<table>
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<th>Droplet level</th>
<th>Droplet size (µm)</th>
<th>Cut off frequency (cycles/inch)</th>
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<td>58.53</td>
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<td>52.92</td>
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<tr>
<td>5</td>
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<td>46.11</td>
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\[
HMTF(w) = \frac{0.55}{\sqrt{1 + \left(\frac{w}{w_0}\right)^{5.2}}}
\]

with

\[w_0 = -1.7 \times \text{droplet level} + 61.8\]

Hmax − Hmin = 32.94 µm
Compensation Process

Wiener filtering

\[ \text{Input}_{\text{comp}} = \mathcal{F}^{-1}\left( \frac{\mathcal{F}(\text{input})}{HMTF} \times \frac{HMTF \times HMTF^*}{HMTF \times HMTF^* + SNR} \right) \]
An example of results

Heights Modulation Transfer Function for the heights pair [107 µm ; 140 µm] Droplet levels 1. Regular (red) and compensated (black) curves
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Acquisition

Reproduction

Characterization of the 2.5D printing technique

Texture and Gloss response?

Limited texture possibilities, enlarged thanks to the Wiener filter.
Nevertheless, despite all changes in frequencies, no change in gloss seems to be perceivable to a human eye.

How to go « towards the mat »
Thank you for your attention!