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DELIVERABLE REPORT

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Deliverable: D5.4 – Generation of micro- and nano-textured surfaces

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1. Description of the Deliverables

Additive manufacturing (AM), also known as 3D printing, is one promising method to generate textures resulting in a different surface appearance. Texture can be generated by concentrating on the nanoscale or microscale.

At the nanoscale, some inherent attributes of the appearance of materials, such as color, can be various. For instance, gold nanoparticles of different sizes less than 100 nm have different colors. However, working at dimensions between approximately 1 and 100 nanometers, where unique phenomena can result in new properties and applications, requires different levels of equipment and considerations. Embedding nanoparticles in the substrate and controlling appearance attributes based on nano-substances dispersed in the feedstock materials requires on-demand access to a wide range of laboratory facilities. Due to COVID-19, planned access to nano-labs, nano-contained feedstocks, and related equipment in other selected partners in the project has been hugely restricted. Therefore, the surface textures have been generated in-situ at the microscale, and appearance is mainly investigated based on the microscale phenomena at the nanoscale spectral measurements.

Microscale repetitive layers in the 3D printed surface texture are intrinsic features of AM technology. The layer pattern plays a vital role in the appearance attributes of the surface, including color, gloss, and translucency. The wedge angle in the design process, as well as processing parameters including infill density, the feedstock material, layer thickness, and the slicing method, affect the formation of the layers. It results in the generation of different textures.

The main work at microscale study described a method to modify the color appearance of the 3D printed surface by controlling surface texture focusing on the pre-processing stage for PLA filaments. It is revealed that optimizing pre-processing parameters can generate surfaces at specific wedge angles with a minimal color difference compared to flat surfaces.

This report provides a brief explanation of the generation of the surveyed surfaces according to the main work. A paper has been submitted based on the findings of this study [1]. For more information regarding the results, please contact the ApPEARS consortium.

2. Implementation of Work

Fused deposition modeling (FDM) is a simple technique that can manufacture complex geometries by determining surface texture through positioning the layers differently. It is the most economical technique among other AM methods due to advantages such as the high strength of its materials, cost-effectiveness, ease of printing, multicolor and glossiness appearance, and environmentally friendly nature [2].

While FDM 3D printing developments have been remarkable thus far, the manufactured objects tend to suffer from inferior surface texture quality, including undesirable color variation, pronounced striations, high roughness, and voids [3]. For many applications, manufacturers use coating and painting methods to reach the desired surface finish. However, these techniques present several challenges that must be overcome to form the printing process. For instance, there is a problem of material accumulation alongside the edge of the object and then inside the part at the start of the FDM process. This issue cannot be resolved by coating or painting since it requires a specific number of outlines to pack the part per the required response [4].

Knowledge of color science is essential for generating successful 3D-printed textures with the desired appearance and surface quality. Although the color stability and appearance of 3D surfaces have been reported before [5], studies of the color difference based on the printing process are lacking. Therefore, this work aimed to evaluate the influence of the design and the slicing parameters in the pre-processing stage on the color difference of FDM objects. Fig. 1 shows the workflow of this study to produce textured surfaces using AM to improve their color appearance.

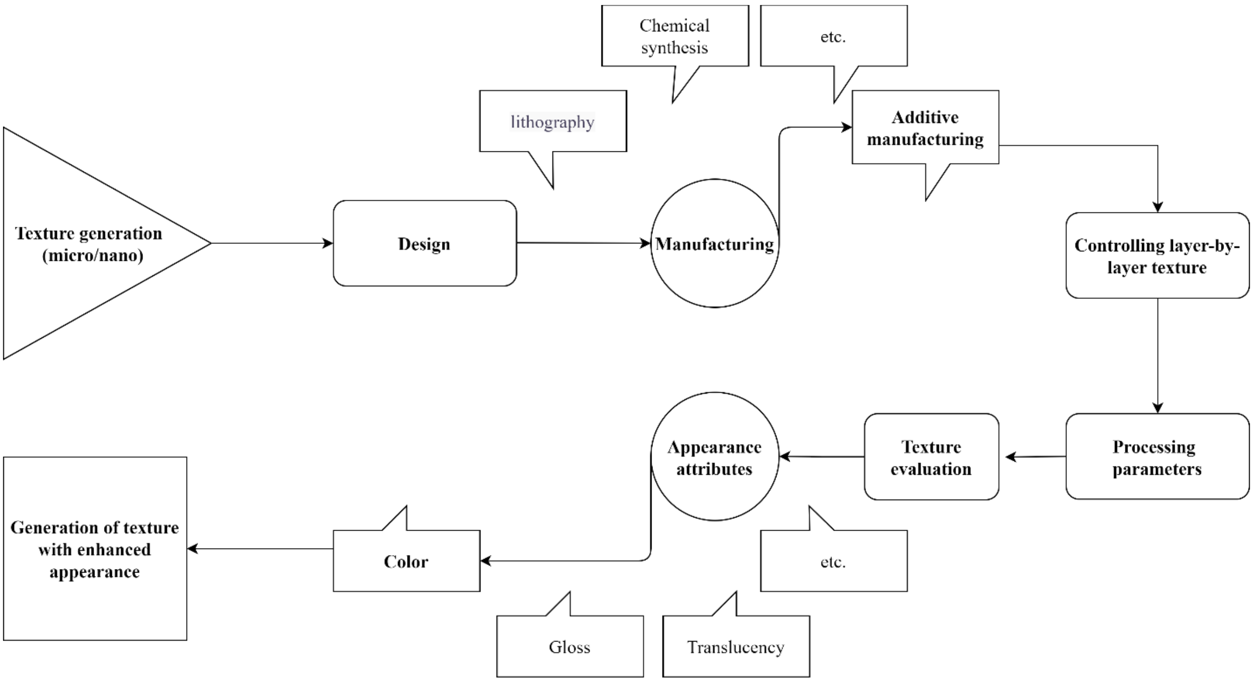

Figure 1. The workflow of texture generation with enhanced appearance.

For this purpose, a set of 3D-printed samples, according to Fig. 2, has been printed and analyzed (see next page).

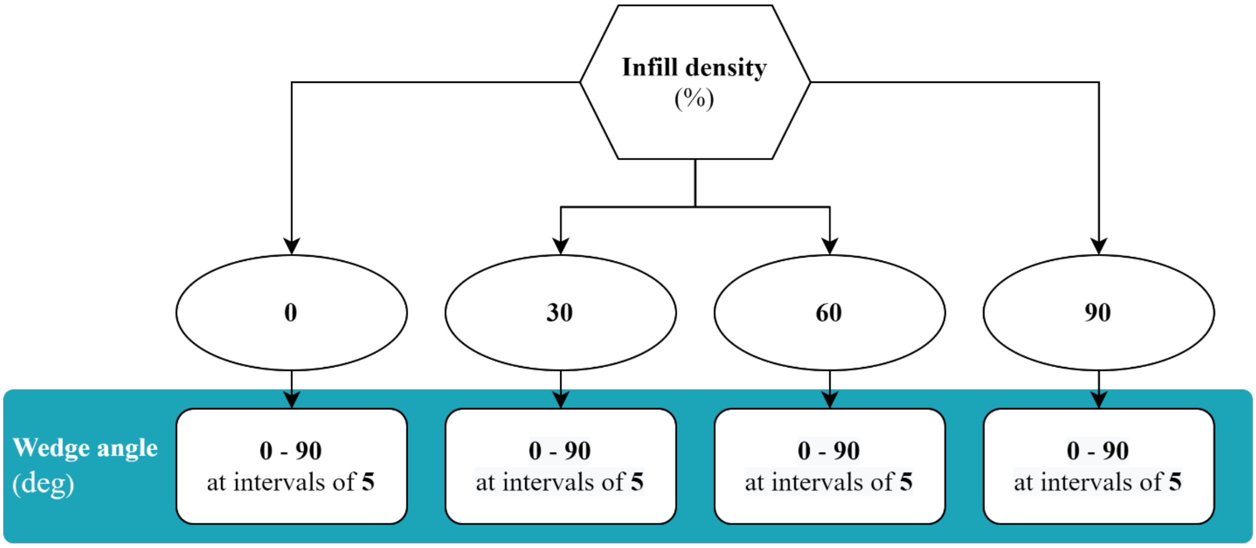

Figure 2. An overview of the AM model features of each printed sample.

The general design and one of the printed specimens in red color can be seen in Fig. 3. The spectral results of the printed samples were measured by a spectrophotometer (X-Rite i1 Pro, Switzerland) represented in Fig. 4.

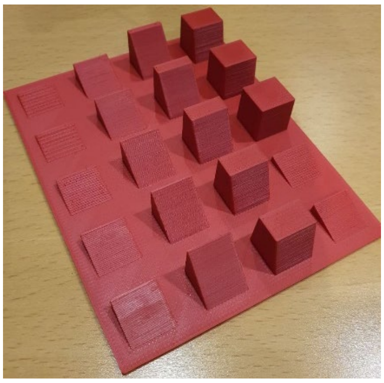

Figure 3. 3D printed samples using an FDM machine.

Figure 4. The measurement device and color palette of the i1 Pro spectrophotometer.

Results showed that design algorithm and avoiding specific angles could influence the layers positioning sequence, allowing us to optimize the topology of printed parts. Besides, feedstock material and infill density also affect the texture generation depending on the design. By controlling these layers, we can deliberately generate textures with improved appearance and superior surface quality.

The enhancement of the appearance at different illumination and viewing angles can be exploited in various applications, such as civil engineering, aeronautics, medical fields, and art. The results of this study can be considered as a general recommendation for generating micro textures at certain wedge angles and infill densities for PLA filaments in order to enhance the appearance of the FDM printed parts. It is a basis for future studies on applying generative design and topology optimization for surface texture and appearance of AM objects.

Reference

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