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A METHOD FOR EFFICIENTLY ENCODING PERFORATIONS BASED ON DISPLACEMENT MAPS

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A Method for efficiently encoding perforations based on displacement maps

Abstract

Some 3D printing technologies generate 2D layers of a given thickness one on top of another. For each layer, a uniform layer of powder is placed in the whole printer's build bed, and agent fluids are selectively placed at the specific points which are to be melt to thereby form the part. One of the main advantages of these technologies is the capacity to print small features and holes in arbitrarily any position of the geometry. This enables the exploration of new applications, such as paper pulp molds. Paper pulp molds require to print really tiny holes (around 500 microns diameter) along a geometry. This presents many challenges both in FW/SW and Writing Systems such as the position of the holes determination. Furthermore, each of the holes has to be properly printed and be cleanable so that it allows the required flowability therethrough. Also, once determined the positions of the holes, it is a challenge to find a robust mechanism to send it to the printer as expanding the holes in a triangle mesh may lead to really big and computationally expensive triangle meshes which are struggle to manage. This article discloses a solution for this challenge by taking advantage of the 3MF displacement maps capabilities to encode the holes in a more compact way.

Introduction

As the industry is looking for more sustainable packaging solutions, paper pulps is getting more relevance. Some 3D Printing technologies have proven to successfully print molds for paper pulp packaging as it is capable to successfully print the holes with the required diameter. However, there are additional challenges to be addressed to enable an End to End workflow. For example, it has to be determined the best shape and disposition for the holes. Also, it is required to determine the best placement for the holes to assure the required flowability, considering flat surfaces and corners in specific cases. Furthermore, once the position of the perforations is determined, encoding them as a triangle mesh can lead to triangles meshes that are too big to be printed. This invention disclosure proposes a method to encode such perforations in a more efficient way reducing thus the overall file size to be transferred.

Proposed method

3MF displacement maps allow to efficiently encode modifications on a base geometry which, otherwise, if encoded directly as a triangle mesh, would end with a triangle mesh with much more triangles than the source model. It consists on a grayscale texture image which is mapped to the triangle vertices in which the level of gray defines the displacement of the surface, so that a white color will place the surface in the highest position possible, and a black color in the lowest position possible. The total depth of the displacement and its offset (to support negative and positive displacements with the same texture image) is encoded as metadata. Then, if the displacement is a negative value which is higher than the thickness of the part, it will produce a hole in the surface.

Encoding perforations using 3MF displacement maps

Our method starts from a part geometry which must be perforated, and a set of locations which have been pre-computed on where the perforations are to be placed. Then the method consists on the following steps:

- Select the base perforation geometry: The first configuration to be selected by the user is the type of perforation. Different shapes of perforations will lead to molds with different attributes. ***Figure 1*** shows an example of hole geometry.

Figure 1. Example of perforation base geometry

- Generate texture image based on holes locations: The next step is, based on the positions of the perforations which are an input of our algorithm, and the selection of the geometry of the hole, generated the texture image including the replicas of the hole. ***Figure 2*** shows an example of a 30x30 holes to be assigned in a test plate of 30mm x 30mm.

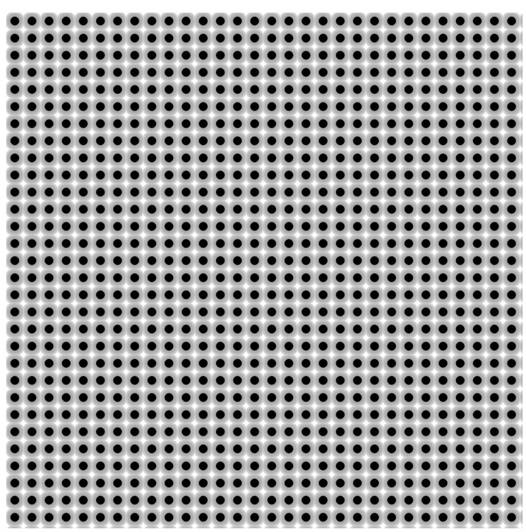

Figure 2. Example of 30x30 holes texture image for a sample plate

- The next step is to map the texture to the part geometry and encode it as a 3MF with displacement maps extension. The texture has to be mapped to just one of the sides of the part face.

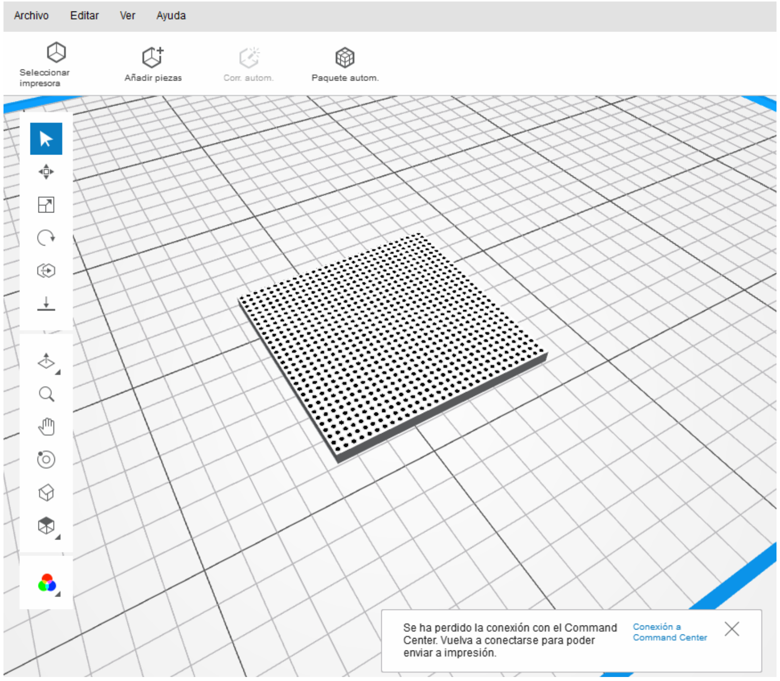

Figure 3. Example of the part mapped to the generated texture

- Finally, when the 3D printer receives the file, the 3D printer processes it to generate the print-ready content. In this process it already performs the displacements which end generating the perforations. ***Figure 4*** shows an example of a printed layer from sent job in which white pixels represent the "solid" pixels, and black pixels represent the "empty" pixels. We can see how the surface has been successfully perforated when applying the displacement map.

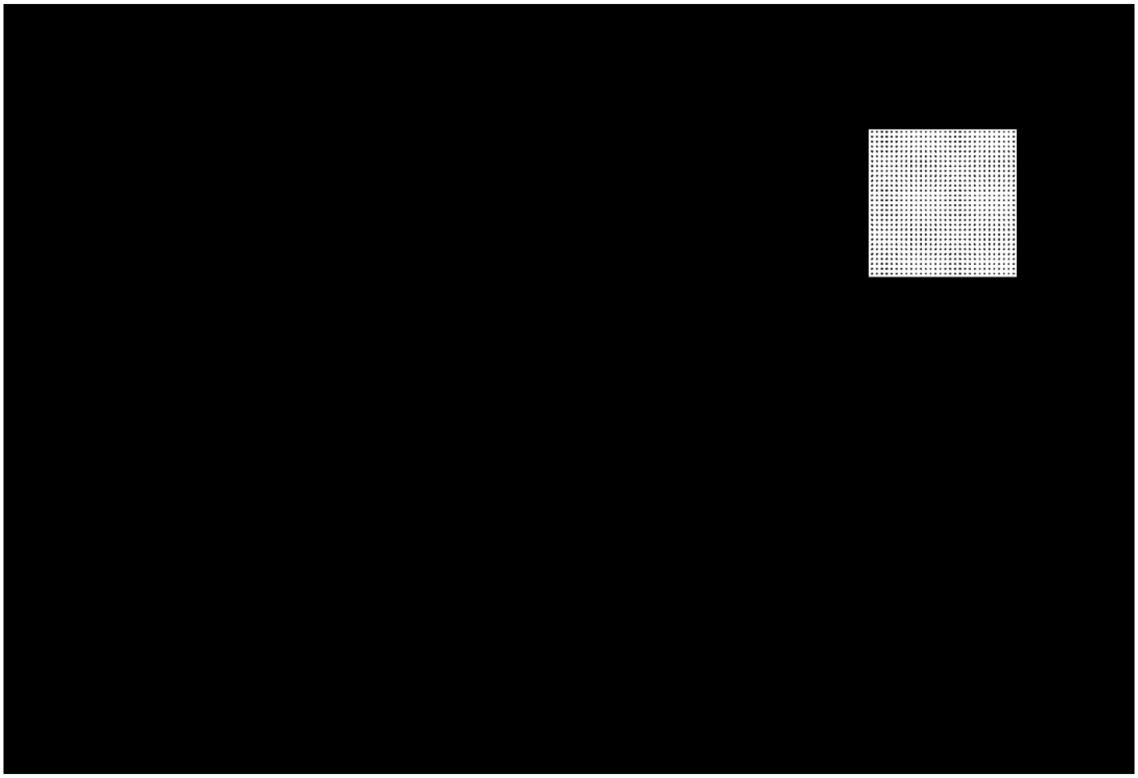

Figure 4. Printed layer of the part with the perforations applied by the FW

Having the perforations encoded as metadata allows to easily change parameters without requiring to regenerate the perforated mesh; and to properly apply the required dimensional adjustment operations before actually perforating the object. This is a clear advantage as the kind of dimensional adjustments like erosions, dilations and scaling, could end modifying the desired shape of the hole, and even completely closing the hole.

The proposed solution has the following advantages:

- It allows to efficiently encode perforation in the part surface without having to expand it to the triangle mesh.
- As the perforations are kept as "metadata", certain parameters like the depth of the perforations can be adjusted in the printer by just modifying a metadata value without requiring to recompute the equivalent triangle mesh.
- Increase the speed of the overall workflow.
- It enables to properly handle the dimensional adjustments of the object as the perforations are sent as metadata and can be applied to the mesh after applying the required dimensional compensations.

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