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AUTOMATIC WHITE TEMPERATURE PARAMETERS CHARACTERIZATION FOR NEW MATERIALS IN ADDITIVE MANUFACTURING

HP INC

Automatic White Temperature Parameters Characterization for New Materials in Additive Manufacturing

Abstract: A standardized procedure makes the characterization of new materials used in additive manufacturing / 3D printing by automatically calculating white control parameters suitable for the materials and print modes.

This disclosure relates to the field of additive manufacturing / 3D printing.

A technique is disclosed that provides a standardized procedure to make the characterization of new materials used in additive manufacturing / 3D printing easier, faster and less expensive, while ensuring good part quality and uniformity of the fabricated parts.

3D printers are powerful tools for companies involved in prototyping since they can iterate physical designs much faster than other technologies. Some 3D printers implement a new concept, where the process is highly sensitive to temperature stability. In order to control the temperature of the process, several high energy lamps are placed above the printing bed. These lamps (called "top lamps") deliver the energy needed to maintain the powder temperature between the working ranges necessary for the process. These lamps are continuously controlled with a closed loop cycle directly related to the temperature of the layer's white pixels. The accuracy of this calculation is key for the stability, uniformity and the precision of the machine. To ensure this stability, the 3D printer is given a range of values and certain constraints, which allow it to determine if this calculation is correct for each layer, and find another solution if it is incorrect for a layer.

This parametrization is important because less-well calculated white parameters can cause the energy from the top lamps to be improperly delivered, resulting in non-uniformity of object dimensions, poor visual appearance and feel properties, and/or undesirable artifacts, or raised parts, requiring that the machine be stopped. Moreover, these values and constraints are different for each material and each print mode of the printer, so they must be calculated for every newly-developed material. Until now, a knowledgeable engineer of this field has been required to print and manually analyze various plots in order to properly calculate these parameters.

According to the present disclosure, and as understood with reference to the Figure, a standardized method of characterizing white control parameters suitable for all the materials and print modes is presented. The method is as follows:

1. Print a determined symmetrical plot using the desired print mode and material. The plot provides useful data in all the zones from the bed. In some examples, each top lamp is associated with a corresponding zone. This plot can provide black (hot temperature), white (cold temperature) and different tonalities of gray pixels in all the zones for the best fit of the model.

2. Extract thermal data from the printer and the printed plot:
   a. Theoretical heat calculation for each layer extracted from the pipeline (a.k.a. categories)
   b. Real temperature images extracted for Temperature camera sensor

3. Process these data to calculate the final values (initial, min, max), according to the algorithm presented below.

4. Introduce these values to the 3D printer as the media properties for each material and print mode.

The above method provides the material developer an easy workflow to find the best heat calculation slopes and focus more on other properties.

The algorithm of step 3 (above) has 3 main blocks:

3A. Data gathering: obtain, from the print job, the data to be used for the calculation. The data comes from the session for the print job and is of 2 types. The first is Theoretical Heat calculation (categories). These images are the result from the theoretical heat calculation of the pipeline. They are 8-bit images where contone 23 means white pixel, less than that means temperature colder than white temperature, and bigger means hotter temperatures until reaching the maximum black temperature. The second is Real Temperature images which are directly extracted from the temperature sensors of the printer. Each pixel represents the real temperature that the sensor is detecting.

3B. Data processing: the core of the algorithm is a for-loop which analyzes all the slopes (Theoretical Heat vs. Real Temperature) of all the layers of the plot and zones of the bed. This is a similar procedure to calculating the white temperature from the bed when there is some data on the plot. This calculation is repeated for all the layers found in the print job, and for all of the zones of the bed, giving a result like the following figure:

3C. Data output: using the above data, the algorithm calculates the boundaries from the material (minimum and maximum slope) and the median between them, which is the initial slope that the machine will use if there is no white since the beginning. What is given to the material developer is a readme file (see Figure) with the slope values (initial, min, max) from all the segments that are to be input to the printer for printing with the desired material.

The disclosed technique advantageously solves the problem of introducing new materials to the additive manufacturing / 3D printer by automatically calibrating the parameters for top lamps energy delivery. As such, these parameters ensure that the fabricated parts produced by the printer will be of high quality.

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Log_Test2_PA12_TestCardsOnly_Z2100.txt - Notepad

File Edit Format View Help

```
Test name:  Test2_PA12_TestCardsOnly_Z2100

Initial Z layer:  2100
Final Z layer:  2201

Axis:  RAX-B

Results for R>0.8
  > Slope average: 0.1622
  > Slope max tolerance: 0.1887
  > Slope min tolerace: 0.1224

Axis:  RAX-F

Results for R>0.8
  > Slope average: 0.1582
  > Slope max tolerance: 0.1801
  > Slope min tolerace: 0.1221
```

```
Axis:  RAX-F

Results for R>0.8
  > Slope average: 0.1582
  > Slope max tolerance: 0.1801
  > Slope min tolerace: 0.1221

Axis:  SAX-B

Results for R>0.8
  > Slope average: 0.1257
  > Slope max tolerance: 0.1418
  > Slope min tolerace: 0.0685

Axis:  SAX-F

Results for R>0.8
  > Slope average: 0.0946
  > Slope max tolerance: 0.1130
  > Slope min tolerace: 0.0694
```