

## A technology for embedding data in printed objects

January 16 2020



Embedding information in a printed object. Credit: Optical Media Interface Lab, NAIST

A team from Nara Institute of Science and Technology (NAIST), composed of Ph.D. Student Arnaud Delmotte, Professor Yasuhiro Mukaigawa, Associate Professor Takuya Funatomi, Assistant Professor Hiroyuki Kubo, and Assistant Professor Kenichiro Tanaka, has developed a new method to embed information in a 3-D printed object and retrieve it using a consumer document scanner. Information such as a serial ID can be embedded without modifying the shape of the object, and be simply extracted from a single image of a commercially available document scanner.

There are several technologies for 3-D printing, but the most commonly



used consists of deposing layers of molten plastic on top of each other. This method is known as Fused Deposition Modeling (FDM). Generally, plastic deposition is performed with layers of constant thickness. However, in the proposed method, pairs of vertically adjacent layers are selected, and their thickness balance is modified according to the information to be embedded. This thickness balance modification has little effect on the external shape of the object.

Additionally, the thickness of the printed layers can be measured precisely by scanning the object with a document scanner. The developed method allows for the detection of changes in <u>layer</u> thickness and the extraction of the embedded information.

The results of this research were published in the international academic journal *IEEE Transactions on Multimedia* (TMM) on December 25, 2019.

## **Background and purpose:**

"Digital Watermarking" is a technology that embeds information inside digital content such as images, audio, video, and 3-D models. Some methods, such as barcode and QR code, embed information in a visible way. Other methods embed it covertly, with the additional information hidden in the content and not perceivable by the user. Since 2010, 3-D printing technology has increasingly gained popularity, leading to a growing interest in watermarking technology for 3-D printed objects. In this research, we proposed a new method to embed a watermark during the printing of an object, and we focused on minimizing distortion on the outer shape to prevent perturbation on the original function of the object.





3D printed object (FDM) with embedded information using our method. Credit: Optical Media Interface Lab, NAIST





Comparison of normal and our method.Left: normal print. Right: print with modified layer thickness using our method. Top: printed object. Bottom: scanned image with a document scanner. Credit: Optical Media Interface Lab, NAIST

## **Characteristics:**

There are several technologies for 3-D printing. Among them, Fused Deposition Modeling (FDM) is the most commonly used. It consists of deposing layers of molten plastic on top of each other. The desired shape is obtained by precisely controlling the position and flow of a printing nozzle such that the deposed plastic layers have a controlled path and thickness. Generally, the plastic flow is controlled to produce a constant layer thickness. However, in our method, the plastic flow is modified during the print to locally change the layer thickness to embed some additional information. In order to prevent the degradation of the external surface of the object, pairs of vertically adjacent layers are selected and the ratio of their respective thicknesses. Since a standard layer thickness is about 0.2 mm, information can be embedded in a relatively small area ranging from several millimeters to a few centimeters.

To retrieve the embedded information, it is necessary to measure the thickness of the layers. However, our method can do this measurement using only a common document scanner, and does not require any special equipment. The FDM printing process naturally produce some layering artifacts that are visible in the images obtained by a document scanner. These artifacts allow us to measure the thickness of the layers and extract the information.



## **Future perspective**

With this method, it is possible to embed various types of information such as a URL that can be linked to Web services; a unique ID that can be used for product tracing; and the printer ID and printing date for batch quality management.

**More information:** Arnaud Delmotte et al, Blind Watermarking for 3D Printed Objects by Locally Modifying Layer Thickness, *IEEE Transactions on Multimedia* (2019). DOI: 10.1109/TMM.2019.2962306

Provided by Nara Institute of Science and Technology

Citation: A technology for embedding data in printed objects (2020, January 16) retrieved 1 May 2024 from <u>https://techxplore.com/news/2020-01-technology-embedding.html</u>

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