

Encore: 3D Printed Augmentation of Everyday Objects with Printed-Over, Affixed and Interlocked Attachments

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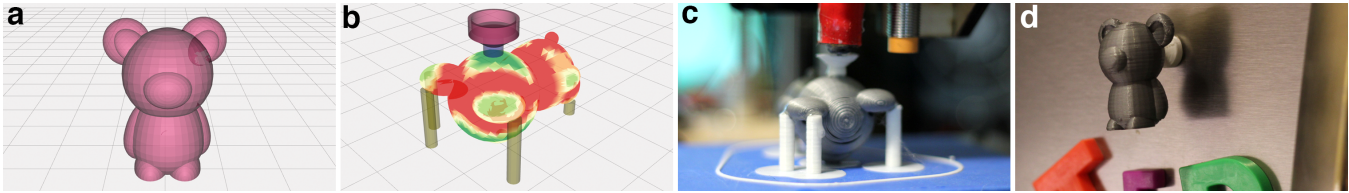


Figure 1: With the print-over technique, the user specifies where to attach to an existing object (a), the system analyzes, orients and scaffolds the object (b) and generates G-code controlling an FDM printer to directly fabricate the attachment onto the object (c), which can augment it for custom purposes, such as making a fridge magnet from an existing Teddy bear toy.

1 Introduction

One powerful aspect of 3D printing is its ability to extend, repair, or more generally modify everyday objects. However, nearly all existing work implicitly assumes that whole objects are to be printed from scratch. Designing objects as extensions or enhancements of existing ones is a laborious process in most of today’s 3D authoring tools. This paper presents a framework for 3D printing to augment existing objects that covers a wide range of attachment options. We illustrate the framework through three exemplar attachment techniques - *print-over*, *print-to-affix*, and *print-through*. We implemented these techniques in Encore, a design tool that supports a range of analysis with visualization for users to explore design options and tradeoffs among these metrics. Encore also generates 3D models for production, addressing issues such as support jigs and contact geometry between the attached part and the original object.

2 Techniques for 3D Printed Attachments

Print-Over prints an attachment directly onto an existing object. Encore analyzes the feasibility of printing a new part at different surface locations of the object (e.g., whether there is a relatively flat area, and whether the extruder will collide with the existing object while printing the new one). The result is visualized as a heat map to inform the user of her design. Once an attachment point is selected, the object is oriented and scaffolded with support structures to provide a feasible and stable configuration for direct print-over. Figure 1 shows how to make a fridge magnet from a Teddy bear toy using this technique.

Print-to-Affix uses a *connector* that matches the surface geometry of the existing object and also snug-fits to the attachment. This allows the attachment to be fabricated separately, and made to be affixable using fasteners or adhesives. Encore analyzes how the object’s surface properties afford a given affixing mechanism (e.g.,

how the convexity of a cross section affects using straps). Figure 2 shows two print-to-affix examples.

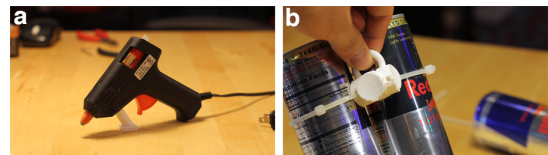


Figure 2: Examples of print-to-affix: making a glue gun stand (a) and a reusable “4 pack” holder.

Print-Through leverages the structural holes in some existing objects (e.g., keys and rings) to print the attachment through and around it. To accomplish this, the attachment is partially printed, the existing object is placed so that part of the attachment goes through the existing object, and then printing continues until the two objects are interlocked and the print is complete. Encore performs physics simulation to compute when to pause the print so that the attachment can be inserted without interfering the remainders of the print job. Figure 3 shows an exemplar print-through process.

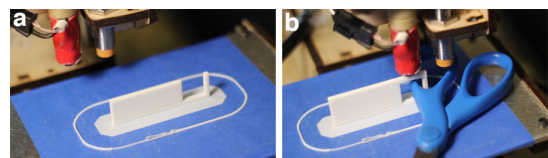


Figure 3: Example of a print-through process: the printer pauses at a point where the scissors can be dropped to interlock with the name tag, after which the print job resumes.

Various tradeoffs must be considered when using these techniques, such as viability, durability, usability and other semantics. Encore also provides an extensible set of such analysis, which is described in another of our recent submissions [Anonymous 2015].

References

ANONYMOUS. 2015. Encore: 3d printed augmentation of everyday objects with printed-over, affixed and interlocked attachments. In *Submission to the 28th annual ACM symposium on User interface software and technology*, ACM.

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