Influence of the printing direction on the surface appearance in multi-material fused filament fabrication

R. Tonello[1], M. T. Mollah[1], K. Weiss[1], J. Spangenberg[1], A. Strandlie[2], D. B. Pedersen[1] and J. R. Frisvad[1]
[1]Technical University of Denmark. [2]Norwegian University of Science and Technology
Email: rict@dtu.dk, jerf@dtu.dk

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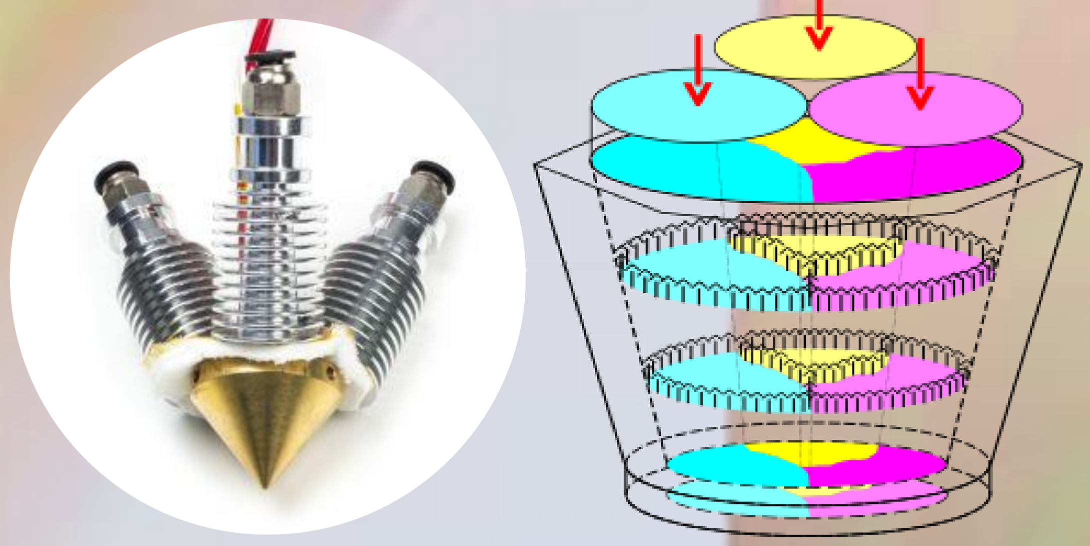
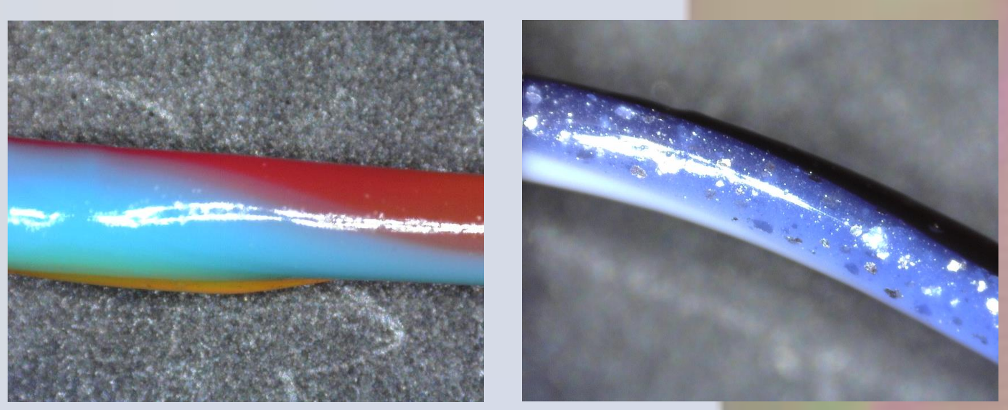
Abstract

Multi-material fused filament fabrication (FFF) offers the ability to print 3D objects with very diverse surface appearances. When multiple materials are fused into one filament in a diamond hotend extruder but do not blend, the resulting surface appearance depends on the printing direction. We explore how this leads to milli-scale colourations as a function of the printing direction. We present a framework based on both experimental and computational fluid dynamics analysis for controlling the extrusion process and the colouration of the surface according to preferable printing directions and mixing ratios with the aim of enabling fused filament fabrication of intricate surface appearances, such as goniochromatism.

Machine and evidence

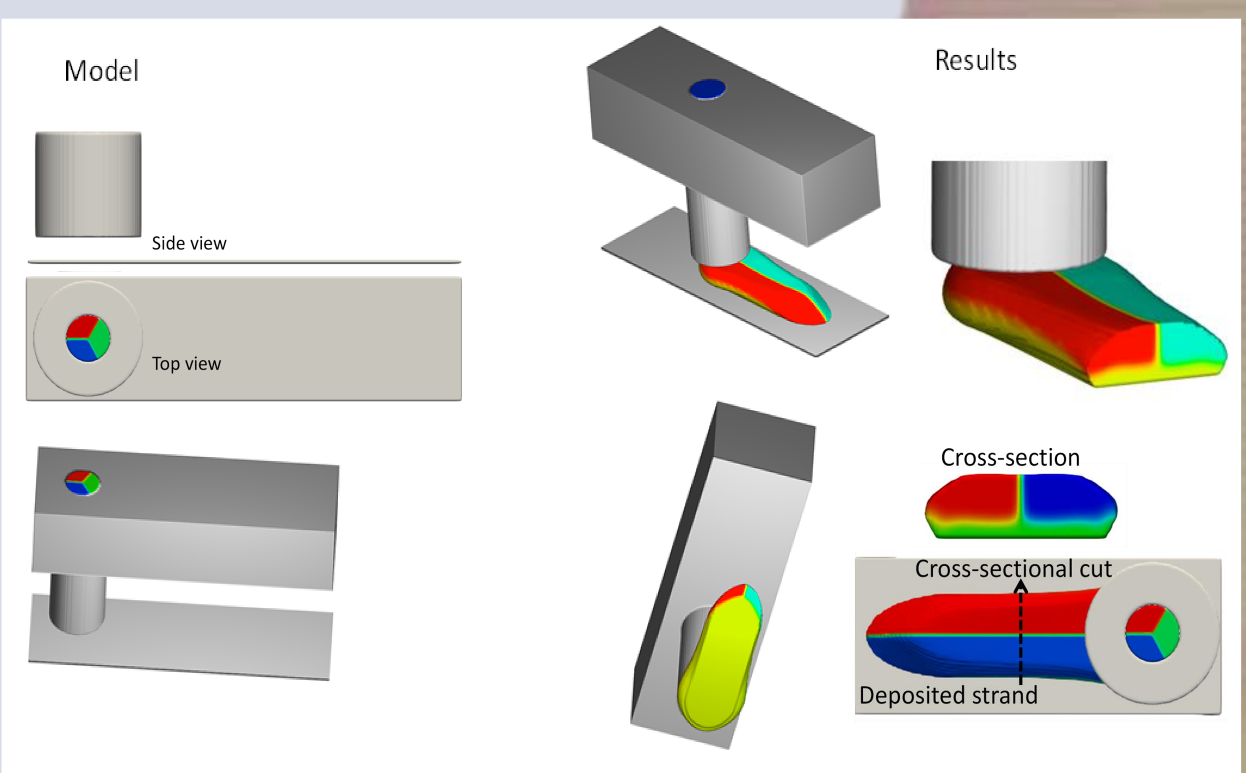


The diamond hotend extruder uses the concept of a Fused Filament Fabrication (FFF) 3D printing technology combining three input filaments fuse into one output.

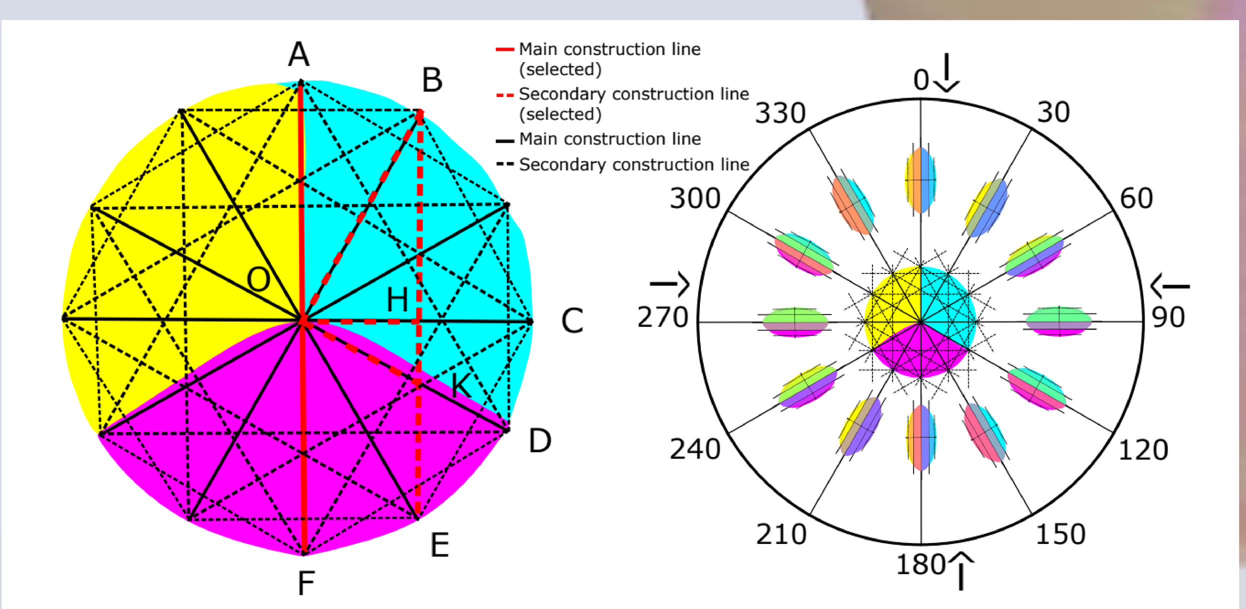


When the output filament is a mix (separate discernable materials) instead of a blend of the inputs.

Simulation of the extrusion process and geometric distribution model

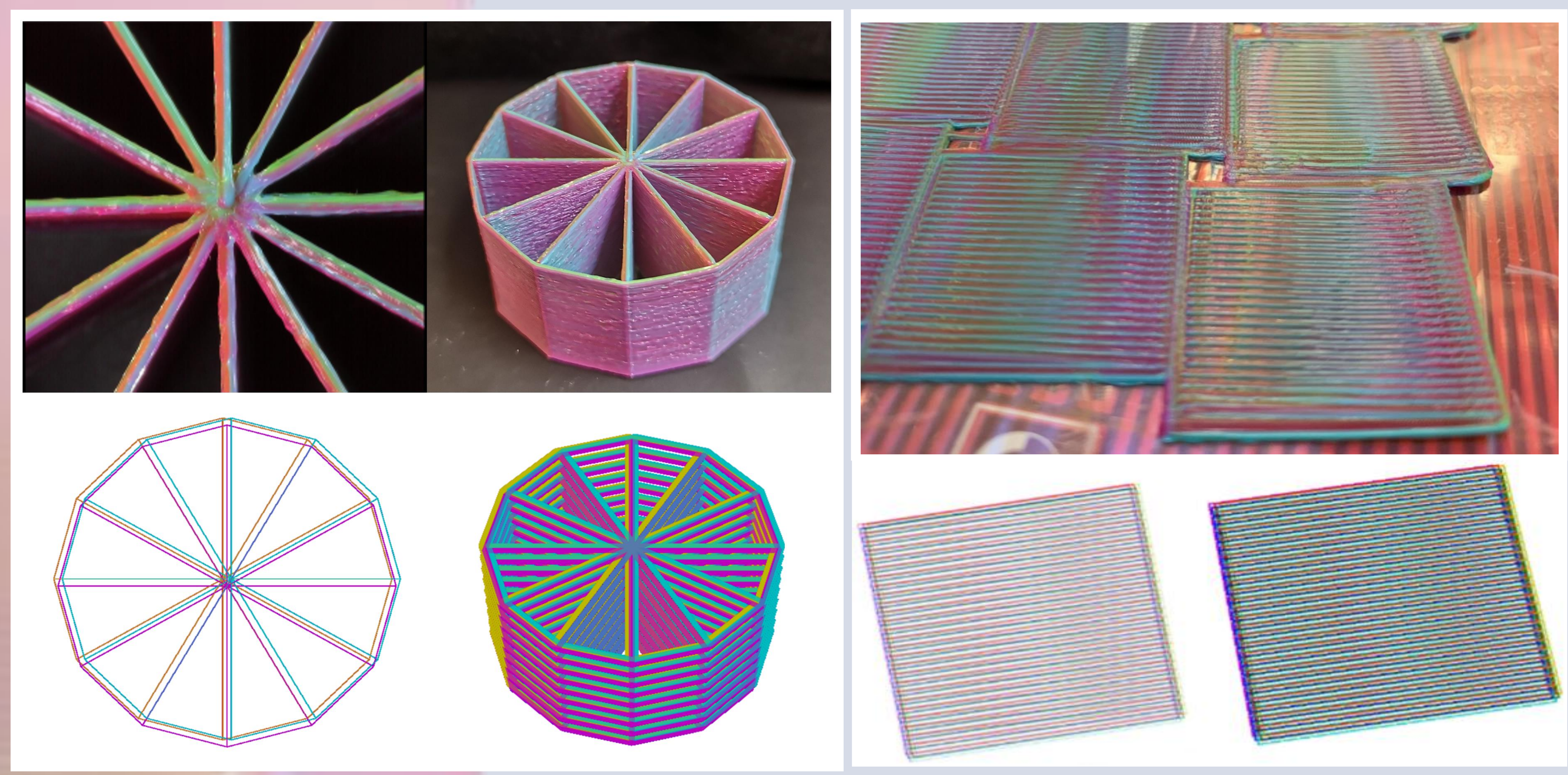


Computational fluid dynamics (CFD) simulation of the multiple extrusion process.



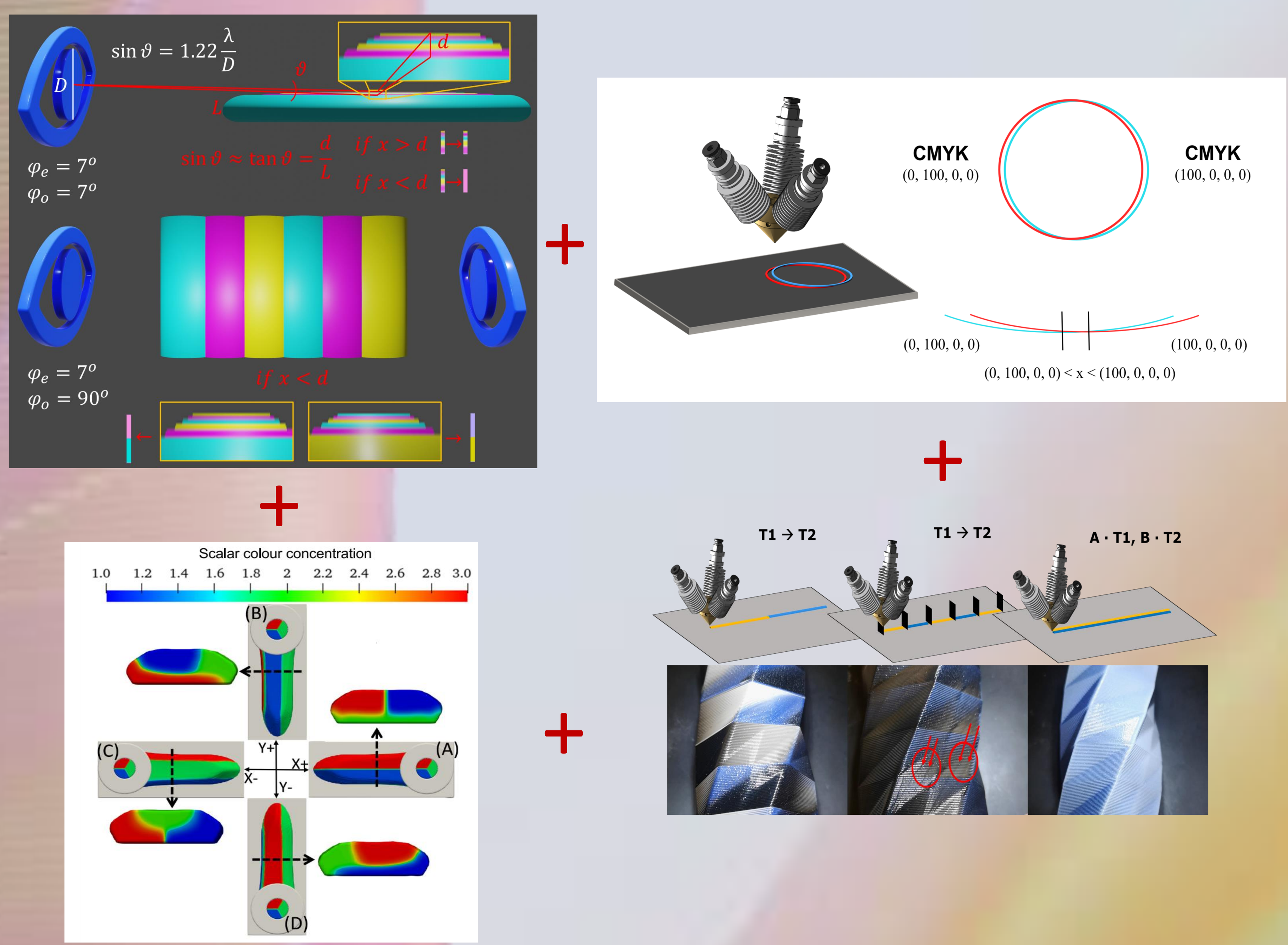
Geometric model for computing the dependence of the output filament color distribution as a function of the printing direction.

Visualization tool for multi-colour structures

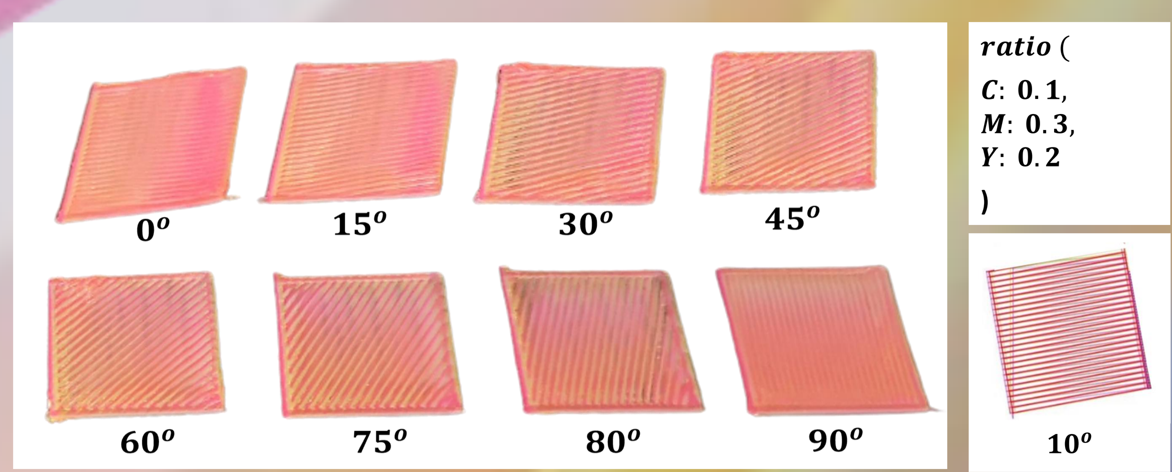


Printed results and expectation plotted using the G-code and our color distribution model (left).
Flat samples printed with spacing between filaments to exhibit goniochromatic color effects (right).

Discussion



The CFD simulation confirms the geometric model and predicts the material distribution in a multiple-in-one filament extrusion. At the same time, selecting the option with different mixing ratios offers an advantage in the multiple-in-one extrusion technology. These two tools and the limitation of the acuity can provide optical effects, such as gonichromatism.



Printed squares with different printing directions. The visualization system correlates well with the printed tests.

Conclusions

The CFD method is hence useful for predicting the influence of printing direction on the distribution of materials and our proposed geometric model helps to describe the colour distribution in a printed filament as a function of the printing direction. Moreover, it is the derivation of our visualization tool.

References

Fig.1 (left): Nozzle Diamond Hot End (RepRap World) - https://reprapworld.dk/extruder/hot-end/multi-extrusion/diamond-hotend/

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