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A Mechanical Add-On for Multi-Resin SLA Printing: Design, Integration, and Testing

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Abstract

The ability to print multi-material structures using Masked Stereolithography Apparatus (MSLA) is a longstanding challenge in additive manufacturing. Current commercial solutions for multi-material stereolithography are limited, costly, and often require complete resin tank exchanges, making them inefficient and inaccessible to broader applications. This work presents an innovative multi-material MSLA (MMSLA) approach based on a wiper mechanism designed as an add-on to an affordable commercial printer, the ELEGOO Saturn S. The proposed system enables in-situ resin switching within a single print job without requiring complex tank replacements or external resin handling.

Our approach introduces a custom resin vat divided into two separate sections, each containing a different resin. A wiper mechanism, fabricated from thermoplastic polyurethane (TPU) and optimized through iterative testing, moves between the resin compartments, shifting the printable resin into position while maintaining an effective seal to prevent cross-contamination. The system is controlled via a Raspberry Pi, which interfaces with the printer firmware to manage layer transitions, pause printing, and execute wiper movements. Custom software modifications enable dynamic adaptation of exposure times to suit different resin properties, achieved through automated modifications of the proprietary CTB file format using UVTools.

A small test campaign was conducted to evaluate the performance of the MMSLA system. Fifteen standard specimens were printed, including solid resin parts, flexible resin parts, and hybrid structures combining both materials. The results confirmed that the system effectively enables localized material transitions without significant leakage, allowing for controlled mixing of resin properties. The hybrid parts exhibited a seamless interface between rigid and flexible sections, demonstrating the feasibility of functional multi-material prints. Mechanical testing further indicated that the expected combination of material properties was achieved, with hybrid specimens displaying intermediate characteristics in terms of flexibility and strength.

Early experimental results validate the feasibility of the wiper-based MMSLA system, with refinements in the wiper seal and movement strategy significantly improving resin transition integrity. While further work is needed to fully characterize long-term mechanical performance, optimize wiper longevity, and refine control algorithms, this approach offers a cost-effective and adaptable pathway to multi-material SLA printing. By providing an open-source, low-cost solution, this project expands the accessibility of complex resin-based manufacturing for research, prototyping, and specialized industrial applications.