Development of In Situ Diameter Measuring Device of 3D Printing Filament in Extruder Using Image Analysis

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Abstract

Nowadays, Fused Deposition Modeling (FDM) technology is experiencing a surge in popularity. To ensure compatibility with 3D printer nozzles, precise filament diameter is crucial. While large-scale manufacturing requires expensive and reliable sensors to maintain this precision, smaller-scale operations such as laboratories often utilize DIY filament extruders for material research and plastic recycling. In this situation, the focus is on creating an affordable tool that can accurately measure and control filament diameter to consistency. Whereas there are several ways to measure a filament diameter such as using a digital vernier caliper, the traditional way, or a hall effect sensor (Piotr et al., 2022), our team decided to use the non-contact image analyzing method, by using a Raspberry Pi camera module 3 coupled to OpenCV and NumPy libraries for grayscale picture analysis (Petsiuk & Pearce, 2021b) and filament diameter numerical calculation. This method provides a cost-effective and adaptable substitute, especially for DIY extruders. Moreover, since the filament is initially semi-solid when extruded, unlike a vernier caliper and a hall sensor, the device eliminates contact with the filament to reduce measurement errors. Additionally, our device provides users with real-time feedback by displaying the estimated filament diameter as the calibration process adjusts the filament winder speed—one of the filament diameter's factors— processed through Raspberry Pi 4. Therefore, this work aims to establish an automated, low-cost method of detecting and calibrating filament diameter to revolutionize filament production in smaller-scale settings. The accuracy and performance of the device are tested by comparing the exact output filament size measured by the digital vernier caliper with our image-processing device, along with the consistency of extruded filament. The device delivers precision, efficiency, and user-friendliness through image analysis technology and dynamic calibration capabilities. This allows for increased productivity and experimentation in filament extrusion operations.

Keywords: Fused Deposition Modeling, Extruder, Filament Diameter, Grayscale