Advanced Acoustic Architectural Design through Robotic 3D Printing of Fungal Biomaterials with Parameter Optimization

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Abstract: Sustainable building practices like Additive Manufacturing of biomaterials represents a forward-thinking approach to fabricating sustainable, biodegradable structures. This method shifts the focus from material extraction to leveraging the material's biological properties. Derived from the thread-like root system of fungi, mycelium-based composites (MBC) are renewable and biodegradable biomaterials. The production of these biomaterials involves terminating the development of mycelium on organic substrates by drying or heating. Recent studies suggest that additive manufacturing (AM) of MBC enables us to fabricate complex shapes, with MBC paste formulation being key for optimal AM [1], [2], [3], [4], [5]. Moreover, these biomaterials are good acoustic sound insulators [6], [7] and have the potential to supplant standard synthetic sound absorbers.

This research is structured into four steps: (1) Firstly, extrudable mycelium paste was formulated by modifying the preparation sequences and adjustments in the admixture ratios, (2) Non-linear 3D printing parameters and extrusion rate relationship lead us to adopt an Artificial Neural Network (ANN). The training of the ANN model was done with three input features—robot speed, Δh_{layer}, and Δw_{layer}—aiming to fine-tuning the network to reflect the intricate balance of factors in the 3D printing process. (3) Taguchi L9 array was used to generate 27 acoustic samples altering key parameters including infill patterns, the proportions of layers with distinct patterns, and the infill percentage. An impedance tube was used to measure the normal incidence sound absorption coefficients at various frequencies for each sample, followed by a quantitative analysis of how the different parameters affect the acoustic absorption characteristics. (4) Lastly, built upon another study of our research team, a robotic additive manufacturing approach employing non-planar slicing and conformal 3D printing was used to fabricate geometrically complex acoustic panels [8]. This study underscores the transformative capacity of robotic 3D printing of MBC, presenting the development of biodegradable building elements with acoustic characteristics.

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