Department of
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Custom Nail Solutions Manufacture Process

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1. Intro/Abstract

We developed an automated system to capture high-resolution **3D scans of fingernails** and generate **custom -fit, reusable, 3D - printed cosmetic nails.** The system combines RGB-D imaging, neural-network segmentation, and geometric processing to build **subject -specific** nail geometries with **improved fit, durability, and reduced damage** compared to acrylics or press-ons. A motorized scanning enclosure collects multi-view depth images, which are fused into a clean mesh and subtracted from parametric nail templates to produce printable custom nails.

Figure 1. *Hand-scanning enclosure featuring the user hand port, motorized camera arm, and onboard touchscreen interface.*

2. Problems to Solve

Current artificial nails (acrylics, gels, press-ons) rely on pre-determined geometries, frequently cause **nail -bed damage** , rely on harsh adhesives, and are **single -use**. They generate **plastic waste** and require repeated removal and reapplication. This project aims to create a **reusable** , **custom -fitting** nail system by capturing accurate nail geometry and manufacturing durable 3D-printed nails that bond with minimal damage and can be repeatedly reapplied.

3. Key Components

Component	Metrics	Explanation
Intel Realsense D405 Camera	RGB-D camera, 1280x800 @ 30fps, sub-mm depth accuracy	Ideal for close-range (7-50cm), high resolution scans of small objects like fingernails
Servo(Miuzei Waterproof)	18-21.5 kg-cm torque, 270° range, PWM-controlled	Provides full rotational sweep and high torque
LED Light Diffuser Rails	Triangular aluminum housing, milky white cover at >120 LED/m	Softens and evens out LED light to reduce glare on fingernails
LED Light Strip	144 LED/m, RGB, 5V 100 LED/m used	Bright, adjustable white and RGB lighting, and programmable
Orange Pi 5 Plus	32GB RAM, GPIO/PWM support	Interfaces with servo, LEDs, and camera to run image processing

Table 1. *Key hardware components used in the scanning and electronics subsystems, including each component's performance metric and its selection rationale.*

4. Scanning

The scanning module captures dense **3D geometry** of all fingernails. An **Intel RealSense D405** RGB-D camera, mounted on a motorized swing arm, records multi-view depth images around the hand at a constant radius. **RGB-D odometry fuses these views** into a unified point cloud and mesh, providing **sub -millimeter - level detail** of the nail surfaces. This multi-view reconstruction enables accurate downstream geometric modeling.

Figure 2. *Point cloud capture of Jerry Saxton's (industry sponsor) fingers from the D405 camera at 90 degrees, capturing depth data and geometric features.*

5. Neural Network

A **segmentation mode** l (Meta's mobileSAM) isolates the fingernails from the rest of the hand. SAM generates **masks** for each nail, which are **applied to the corresponding depth** frames to isolate the finger nails. This produces **clean, nail -only point clouds** , improving odometry robustness and mesh quality while eliminating spurious geometry from skin and enclosure surfaces.

Figure 3. *Hand scan with the corresponding masks overlaid on top (the mask is the red area). The masks retain their position/ orientation on the original image.*

6. Results

A point cloud of a nail template is created and aligned with a real nail scan. By subtracting the scan from the template, we generate a custom -fit geometry. This result is converted into an STL file.

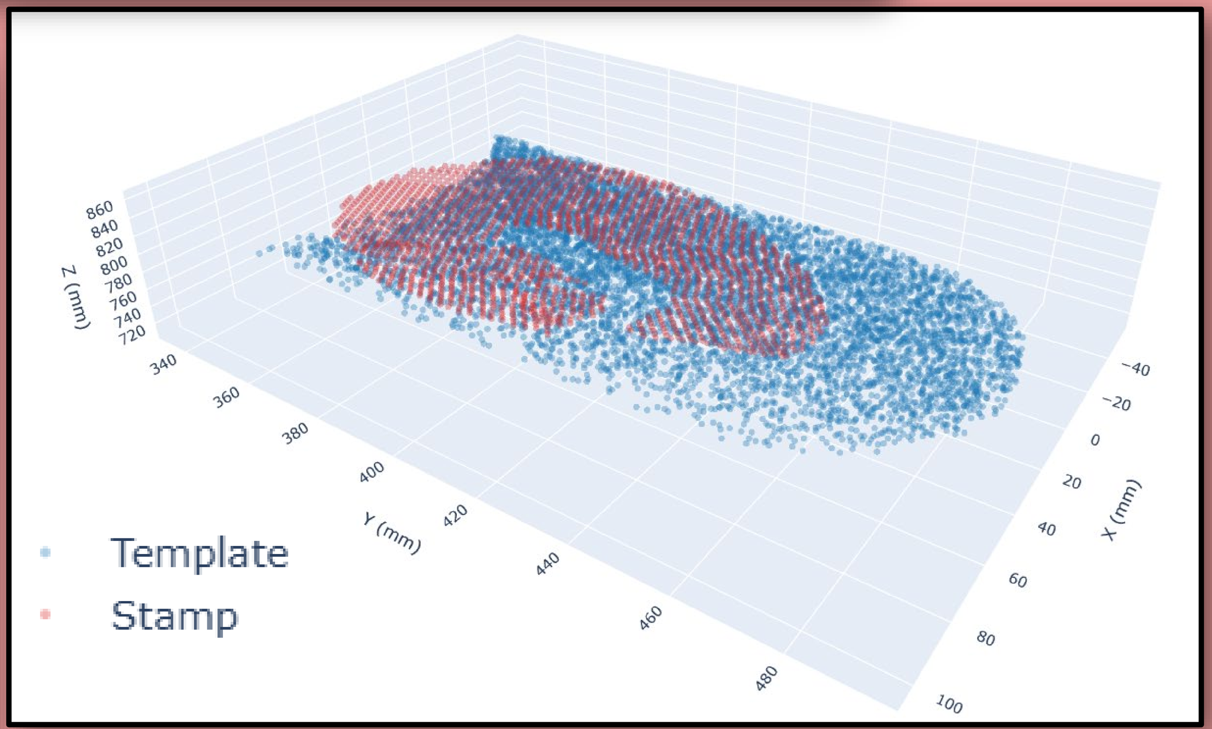

Figure 4. *An overlay of the nail template and nail scan that creates the printable nail.*

Configured STL files, derived from the nail template and nail scan, are transferred to the Form 4 Printer. There, custom nails are printed and subsequently washed and cured.

Figure 5. *Resin-printed set of 10 nails in clear resin, shown after printing, washing, and curing.*