Title

I am developing a new technology that can print 3D parts significantly faster than traditional 3D printers.

Image of overall model

Paragraph 1

This is my largest project both in scope and difficulty. The goal of this project is to create a 3D printer that uses a novel 3D printing technology. Computed Axial Lithography (CAL) is a relatively new 3D printing method that combines two existing technologies: Digital Light Processing (DLP) 3D printing and Computed Axial Tomography (CAT) scanners. I, first, started to work on this as part of my undergraduate Thesis (2020). I have continued to work on this on weekends and my time off since then. I currently have more material and work than I can showcase in this overview. As such, this form is written with the expectation that the readier has some engineering knowledge to fall back on.

Paragraph 2

CAL 3D printing works by shining a masked light source through a light sensitive resin. This resin is not standard Stereolithography (SLA) or DLP resin, as it needs to be somewhat transparent to the light that cures it. It also cures in a nonlinearly fashion. As you shine light through the container you need to dose all the resin that’s in the light path and not just the surface of the resin. Additionally, you want resin to cure only when it hits a threshold of absorbed light, making it nonlinear. Lastly, you need to create your 3D printed part by dosing the resin above the threshold in areas you want material and keep the dose below the threshold where you don’t want material. Unfortunately, I have not purchased resin yet as its expensive and I need to make it in-house, so I am missing some equipment.

Paragraph 3

There are several ways to obtain the correct dosage of light in the resin. The method I am focusing on is CAL. This method works by generating a video that plays on a ‘projector-like device’ that is then focused to have a large depth of field and projected through the resin. The resin is then rotated, and the rotating is synced to the video. The video changes as the resin is rotated, creating the correct dosage throughout the resin.

Image of object function at angles

Paragraph 4

If you are curious as to what the video looks like here is a link (<https://www.youtube.com/watch?v=xIjXOoEEyTM&t=13s>). The Video is created with an algorithm I developed which reverses the algorithm used in CAT scanners. Simply put, a CAT scanner works by taking x-ray images at different angles. These images represent the density of the person. The CAT scanner algorithm then takes these images and constructs a 3D model of the person. My algorithm takes a 3D object, an STL file, and then creates ‘density’ images for a variety of angles. These images are then stitched into a video. Unfortunately, it’s actually more complicated than that. Here are just some of the other factors that need to be taken into account:

Paragraph 5 (list)

* The geometry of the container
* Over/under sampling edges and surfaces
* The inability to un-absorb dose (this means an approximation of the object must be made)
* Gravity (cured resin tends to sink)

Paragraph 6

For those interested in how I try and account for some of these factors see the slide below that shows the math used in filtering the images.

Image of math for filter

Paragraph 7

Resin absorption follows Beer’s Law. One must adjust the concentration of the curing agent in the resin. Ideally you would have the same amount of light being absorbed at every depth of the resin. However, a percentage of the light is absorbed per unit of length. A way to get around this is to have less light being absorbed, meaning most of the light passes through the resin and is never used. This is inefficient and requires a larger light source. The plan is to test different concentrations of curing agent to see what the optimal absorbance rate is. Below is a slide showing Beer’s Law and the linear approximation made.

Image of beers law

Paragraph 8

A high-power light source is required. Due to my budget constraints, I decided to build my own ‘projector’. I designed the light path with a 30W 405nm LED COB. The UV light passes through a fresnel lens and a LCD screen that is designed for UV light. This LCD screen is also monochromatic which means each pixel doesn’t need to be split into 3 channels (RGB), allowing more light through. This is important with UV screens as they are much less efficient with light transmission. An optical simulation was used to see the distortion due to the light passing through different media. This simulation does not account for the fact that the LED COB is not a point-source and has non-collimated light. I believe this is actually a problem that may make this design non-functional for any detailed features. This is because the width of the COB is large, as it needs to be high power, but you cannot collimate the light from a large LED. This was known before purchasing the LED and was going to be compensated by focusing the light in the center of the resin. However, after doing this, the depth of field was found to be too shallow for any detailed objects to be printed. I actually have an idea for solving this problem that will be implemented in a future iteration, once I learn more from this current iteration.

Image of Optical Path

Image of optical simulations

Paragraph 9

The first iteration is made using a rail system that allows me to try different depths for the light path. While I calculated the theoretical optimal distances needed, I wanted this flexibility to be able to change the lens and light sources. I 3D printed most of the components for this project with my personal FDM printer. The CPU cooler is used to dissipate the heat from the LED COB, which is attached with thermally conductive, double-sided tape. A Large CPU cooler is required because UV LED are substantially less efficient than a ‘white’ LED. As a result, I can only keep the UV light on for a couple minutes (long enough for a 3D printer, theoretically).