

Blog

Mixed Integer Linear Programming

The typical flow of thought undergoing in a human mind is constantly planning the things to be done: within a certain time-frame, before the deadline, increasing profits, minimizing the travel redundancies along-with routine survival chores. Such parallel processing and/or planning are not yet mastered by robots. The field of mathematics which deals with this situation is Mathematical Optimization a.k.a. Linear Programming.

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A Look Into 3D Printing

3D printing has been around in some form or another since the early 80's. Until recently, it was too expensive to be used by anything other than corporations or other locations with large funding. Now you can buy quality printers for a few hundred dollars, and they are continually improving in both quality and price. This post will seek to give a brief overview into why 3D printing is so popular and useful, as well as different methods and types of printers.

So what is 3D printing, and why is it so useful? Let's use an example. Say you have a complicated part you need to create for a robot. Previously, if you wanted this part made, you had two main options. You could bring your designs to a machinist, and talk to them about how best to mill or lathe it from a piece of metal or wood stock. This could be time consuming, and expensive depending on the rate the machinist charges. There's the added complexity that certain shapes cannot be milled properly, even on a 6 axis milling machine. Machinists also usually only work with metal, some will do wood. If those materials do not work for the object (too heavy or too flammable, for example), your other method would be to contract a company to start an injection molding process. Here, molds are made of your object and hot plastic is forcibly injected into the mold to make your object. This process requires making the mold, which means milling the negative out of metal which is again hard if the object is irregularly shaped. Most molding companies require a minimum number of objects ordered, usually in the tens to hundreds, problematic when you only need one and a spare or two.

Enter the 3D printer. 3D printers work by extruding a thin layer of plastic through a nozzle onto the printing bed. When that layer is completed, the head moves up a little higher (usually in the range of a 0.5 - 0.05 mm) and prints another layer of plastic onto the first one. It does this layer by layer until the resultant part is created. This allows you to create incredibly random and complex shapes and print them with (relative) ease. Where the layer would be printed over free air (called bridging), printers can do a few different tricks to keep the plastic from falling. They can rapidly cool the plastic as it's extruded in order to firm up the plastic before it falls. They can also build their own 'supports'. This is plastic extruded in such a way that it forms a temporary scaffolding to hold up the more

delicate sections of the part. These are easily removable, and in some cases, use a separate type of plastic that is dissolvable.

The other benefit of 3D printing is that it's cheap. Once you spend the money upfront to buy the printer itself, your only operating cost is more plastic. As of the date of publication, you can get a kilogram of PLA plastic (the most commonly used type) for roughly \$20 dollars on Amazon, and that will last you quite a while.

Up until now I have been talking about extrusion-based 3D printing, as it is the most popular method. There does exist a few other types, with their own benefits and drawbacks. The first one I will talk about is Stereolithography (SLA) printing. This involves using a liquid resin that cures under intense heat. These printers have a tub of this liquid, and hit parts of it over time with a laser to build the part up. These printers are more complex and generally more expensive than the extrusion-based printers. They can create even more complex shapes than their extrusion-based brethren as they create their own latticework of supports that is more intricate than extrusion-based can use. They're useful for small, complex shapes, and can use types of materials not possible with extrusion-based printers.

In a similar vein the SLA type printing is the Metal Sintering method. These are very similar to SLA printers, but use metal powder instead of resin. These printers have a bed of metal powder that then gets hit with a high powered laser to solidify the powder. Then, another layer of powder is added on top and the process repeats. This method is more complex and more expensive than the others, but allows your resultant pieces to be made out of pure metal. This is useful for mass producing complex machined parts.

The last type of printing is more of a variation of extrusion-based printing versus a whole new method. This method allows you to extrude fibers into the plastic being placed down. For example, you can extrude nylon or carbon fibres and embed them into your part, adding incredible strength to what would normally be a plastic part. This gives a good in-between of normal extrusion-based printing and the more complex laser sintering.

As extrusion-based printing is the cheapest and most common method of printing, I'm going to delve a little deeper into it and explain the benefits and drawbacks of different types of plastics. First, we'll look at PLA. PLA stands for polylactic acid, and is the most common type of plastic used in 3D printing. It is cheap, rigid, and does not shrink when cooled. That last trait makes it useful for use in printers without a heated print bed, as other plastics can cool and pop off the bed before the part is fully printed. One drawback of PLA is it's brittleness. Under stress, it tends to break after only a little bit of bending. Still, it is useful in many different scenarios, and is a wonderful plastic to use for fitment tests or other mock ups.

The next is ABS, Acrylonitrile butadiene styrene. This is another common plastic, but has some drawbacks, which is why PLA is the most common. ABS tends to shrink when cooled, leading to the part pulling off the bed. You can get around this by using a heated print bed, or by spraying the bed with abs plastic dissolved in acetone, which will also help adhesion. ABS also tends to have a strong smell to it when printing. This can be bothersome if there is a lot of printers going at once, or if it's a confined space.

Finally, we'll look at PETG. Polyethylene terephthalate (I don't know where the G came from either), is similar to PLA in that it doesn't shrink, nor does it have a smell. However, it is springier than PLA, and has a more glossy, shiny finish. This is useful if your parts needs to have some bend to them.

As a final section, we'll do a brief overview of the process of 3D printing. From idea onto physical

product. For a 3D printer to work, it needs to know what to print. To tell it that, you need to generate an STL file. An STL file is a program-agnostic file that defines the shape of a CAD'ed object. I personally like to design my parts in Autodesk Inventor, but you can also use Solidworks, TinkerCAD, and numerous other programs to generate your part. Alternatively, websites like Thingiverse.com have tons of premade STLs submitted by users to share with one another.

The STL defines WHAT you're making, but now we need to tell the printer HOW to make it. This method changes from printer to printer. Some printers have proprietary software that you have to use. Other's are open source and you have many options to choose from. I personally own a Prusa i3 Mk3, so I use Slic3r PE, which is a fork of an open source program with additional configuration for the Prusa line of printers. These programs as a whole can be referred to as 'slicers' as they slice the stl into the layers that the printer will lay down. This is also where you can adjust any settings related to supports, bridges, or any of the myriad of other settings you can tinker with. Once the STL is 'sliced', you then get a GCode file. GCode is used to tell machines how to move and is primarily used in CNC machines. This GCode then gets loaded onto the machine, then you can sit back and watch it print!

This was a very basic overview on how 3D printers work, their different types, and the general process on how to use them. This is absolutely not an in depth look, and I highly recommend you go find youtube reviews and other articles before you decide to make a purchase. I hope this at least piqued your interest! Please comment below with any questions and I'd be happy to try and find some answers.

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