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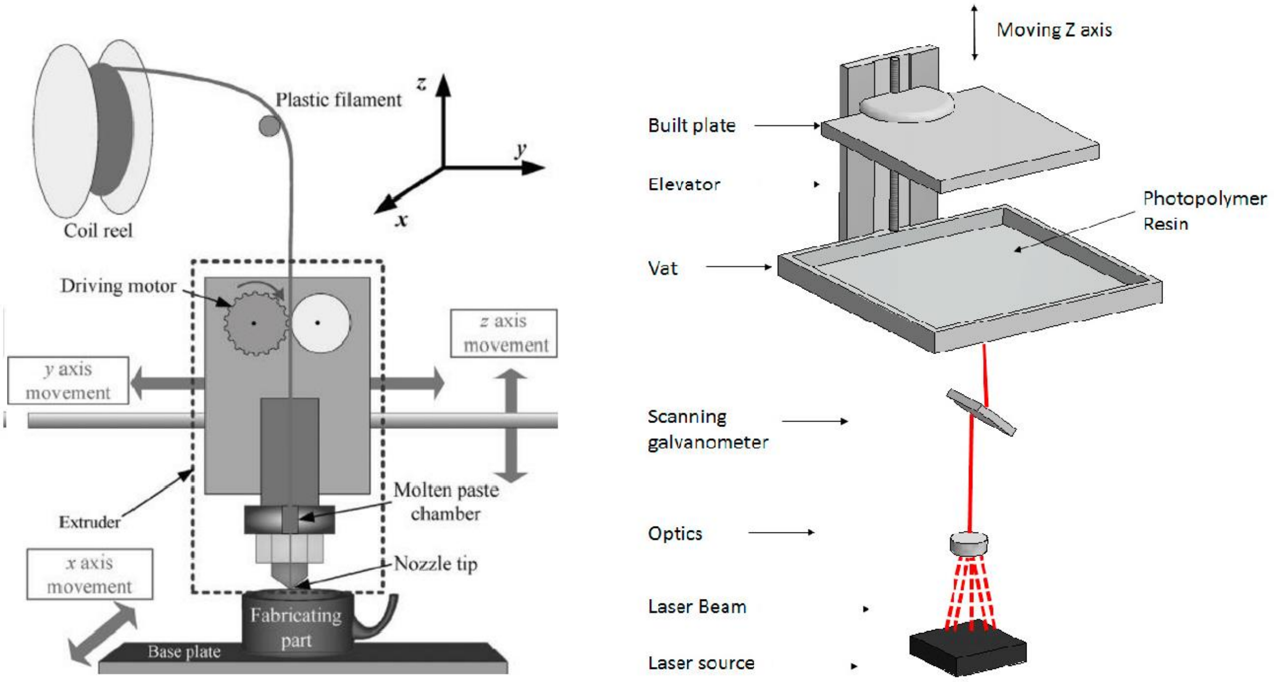
## On the issue of creating pneumatic systems using adaptive 3D printing technologies and their potential

Pneumatics – is a branch of engineering that utilize pressurized gases or air in or der to perform some motive action. Pneumatics takes its roots from the first steam engines, since steam is a sort of gas that transfers power to pistons that are basically a pneumatic cylinder. Pneumatics is very similar to Hydraulics – a similar branch in which power is transmitted through fluid rather than gas.

Nowadays pneumatic cylinders are seldom used to push large machines, while electrical engines are so much more efficient. However, in two aspects Pneumatics and Hydraulics are better than Electric solutions. Firstly, both of them provide easily achievable linear motion (cylinders and such). Secondly, they could hold applied force almost indefinitely with minimum to none expenditure of power, while electric engines must constantly maintain magnetic field flux in order to do so. Furthermore, in such work mode motors tend to overheat because of increased current flowing in coils, while some types of motors (synchronous motor) cannot maintain static load at all.



This problem is particularly evident in creation of small robotic systems, in which small electric motors are usually used. Not only such systems require complex structures in order to linearize movement, but also, they are not especially durable or strong [4]. Such problem could be solved with pneumatic (hydraulic) actuators. In the past use of small-scale pneumatics (hydraulic) was not possible because parts would be custom machined out of aluminum blocks which would have made the system too expensive. However, last 7 years have marked a gigantic leap in development and availability of 3D printers. Most of these texts' readers already know or seen Fused Deposition Modeling (FDM) Printers (fig.1a), and would say that pneumatic components couldn't be printed in such a manner. And, indeed, the surface of the part made with FDM printers would be too rough, creating too much friction and leakage. "If only there were some kind of inexpensive printer that does not make layers out of thin molten plastic sausage."



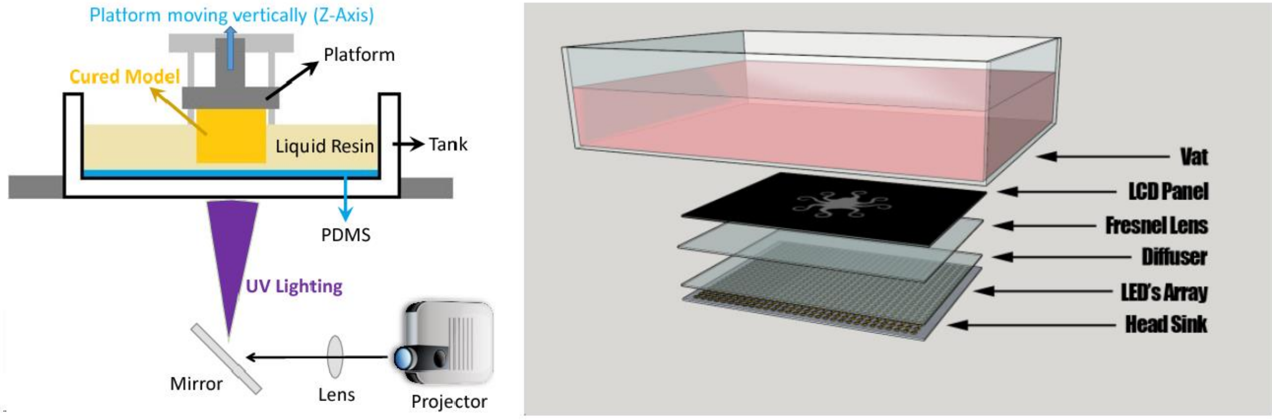

a) b)

Fig. 1. Main types of 3D printers:

a)- Fused Deposition Modeling (FDM) printer (extrudes molten plastic through the nozzle to form layers)

b)- Stereo lithography (SLA) printer (uses laser to cure liquid resin and form layers of material)






c) d)

Fig. 2. Branches of SLA based printers

c)- digital light processing (DLP) printer (a significantly cheaper than SLA due to a lack of complicated laser optics, uses UV light-projector to cure resin, an entire layer is flashed at once therefore reducing print time)

d)- mono LCD printer (same as DLP, but instead of projector, it uses 2K or 4K LCD UV panel to create a layer, even cheaper and more resent technology)

Behold, a Stereo lithography (SLA) 3d printer [1] and its cheaper counterparts the (DLP) and (LCD) 3D printers (fig.1b, fig.2). Featuring a wide variety of printable materials (from soft rubbers to hard resins), horizontal axis resolution of 25 microns and vertical layer height of 27 microns which should result in smooth mirror-like surface in finished product, which is exactly what is needed for pneumatic cylinder.



Fig. 3. Items made out of wax-like resin for metal casting [2]

If we need to make a hydraulic system, a part could be printed from special wax-like resin for metal casting (fig. 3) , and then cast in metal which would significantly cheapen manufacture of such part.

Fig. 4. 3D printed inverted screw [3]

Furthermore (SLA) (DLP) (LCD) printers could produce designs with internal cavity structure (fig.4) which would not be possible in conventional methods of manufacture, pneumatic (hydraulic) lines and fittings could be tailor customized in order to reduce size of a finished product. No more bulbous attachments, no more lines in a way of other parts, everything could be made neat and compact.

Conclusions

Therefore, (SLA), (DLP), (LCD) 3D printing has a huge potential in compact pneumatic systems and especially in high-performance robotics or other applications that require fluidity of design and custom approach. Such approach could significantly simplify existing designs both in manufacture and application.

It is true that small cylinders were made before, even from plastic, LEGO has its pneumatic line of toys since 1984 [5], but it never had been as versatile or as cheap as to design a model in CAD and have it printed or print it by yourself.



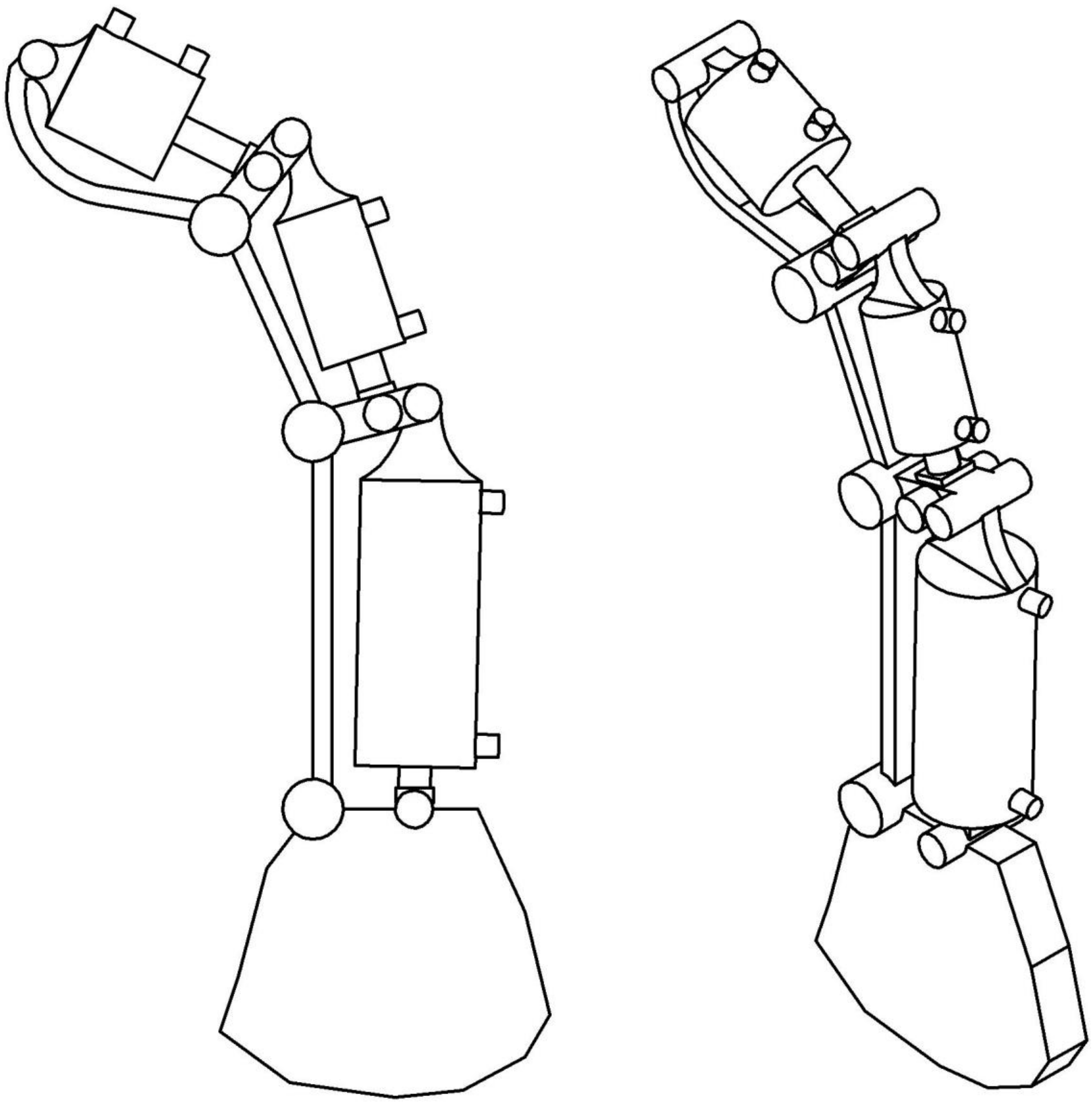


Fig. 5. Early design of our Robot hand

We think that the method of printing pneumatic devises could be directly used in development of pneumatic prosthetic arms or robotic arms [4] (fig. 5), and could be directly integrated with electric controller systems. A prototype of such a device and a semi-constructive solution scheme are currently being developed.

References

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