3D Bioprinter: Design and Mechanisms

Mechanical Engineering

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Abstract

The 3D Bioprinter will aid tissue engineering researchers in advancing medical practices by providing a more readily available opportunity to create regenerative organs, tissue scaffolds, and organ models. This product will reduce the amount of patients requiring transplants and will create an ability to perform clinical trials on patient models before actual patients try the. The proposed printer contains two syringe pump extrusion heads that move horizontally (x direction) and along the depth of the printer (y direction). The extruded object can be printed onto a few select surfaces (glass plane and petri dish) that are placed on a platform that moves vertically (z direction). The motion of both the extruder and platform will be driven by motors attached to lead screws and balanced by shafts with linear bearings. To maintain the proper environment for cell doped hydrogels to thrive in, the two syringes in the extrusion system be heated and cooled independently. The air circulating in the environment will be filtered by a Hepa filter. To make the product more appealing and user friendly, a touch screen interface will be used in conjunction with USB, SD, or MicroSD connectivity. This printer has the ability to become an important part in medical research in labs across the country

Cover and Frame

Figure 1: The Cover is made of an aluminum frame and acrylic panels, while the main frame of the printer is made of aluminum panels.. The acrylic allows the user to look into the printer during printing to ensure a quality print is being made. Panels keep contaminants out of the printer while a Hepa filter allows only clean air into the printer.

Platform and Vertical Motion System

Figure 4: The Platform is an aluminum plate with a small cut-out for a glass surface or petri dish. This allows the user to print directly on to the proper surface for use. The platform is actuated vertically allowing the user to print an object up to 6 in tall. This 8 in. by 8 in. by 6in print volumes is one of the largest on the bioprinting market today.

Background

Tissue engineering is the development of producing cells and cell scaffolds to restore functioning tissue where it has been damaged [1]. 3D printing has the potential to improve patient outcomes by providing precision printed scaffolds [2]. In addition to meeting patient needs, 3D bioprinting will be able to enhance drug testing by producing organ models [2]. As these improvements will lead to life saving technologies the future of medicine, engineers, chemists, and biologists are coming together to produce 3D bioprinters [3]. Bioprinters feature an ability to print multiple materials to match the complexity of biological tissues [4]. This detail is what makes 3D bioprinters so different from traditional 3D printers that print polymers. To meet this complexity, printers use hydrogels to produce geometric accuracy and keep cells viable from the time the bio-ink is printed till when the tissue is implanted in the patient's body [5]. Different biocompatible hydrogels are used to support bio-ink while creating the architectural elements of the objective tissue while also providing support as a mechanical mimic of the tissues surrounding the printed cells [6]. The hydrogels keep the printed tissue soft to enhance compatibility with the body resulting in a patient specific tissue graft [2,4].

Extrusion Mechanism

Figure 2: The Extrusion mechanism contains a 3D printed syringe holder with an imbedded heating element. The holder and the motor that drives the syringe plunger slides up and down on a seesaw mechanism with the plunging mechanism to prevent interference by the unused extruder. The whole system rests on a part that is moved from left to right by the planar motion system.

Conclusions

This product has been developed to begin work towards a more affordable bioprinter for the tissue engineering research market. This advancement improves access to bioprinters and allows more researchers to begin developing the fundamental science and understanding necessary to make bioprinting more accessible in the modern world and ultimately as a viable Federal Drug Administration approved treatment. These treatments would change the face of medicine as transplant patients could 3D print their own organs and large area burn victims could print their own skin.

Market Need

Current bioprinter options include the printers by Envisiontech ($200,000+), Organovo (not for sale), RengenHU ($200,000+), BioBots ($10,000+), and Cellink ($25,000+), as well as Aether, and 3D Printing solutions. As noted, the cheapest bioprinter on the market is currently $10,000 for a base unit and most cost an excess of $100,000 [7]. While some of these printers can be bought for fundamental research, providing a printer at a low cost is needed by the research community to advance the fundamental science of tissue engineering. By providing greater access to bioprinters, the development of tissue engineering research increases. This creates opportunities to research the design and testing of tissue scaffolding while also allowing pharmaceutical researchers to test drugs on organ models before animal testing to reduce the costs of pharmaceutical testing and the cost of pharmaceuticals as well. Additional drug testing can be performed by producing miniature models of patient's organs and then applying the drug to the model to determine first if it will meet the patient's needs before giving the dose to the patient. This will save medical doctors from needing to perform trial and error runs of medications with patients that prolong medical care while also helping patients heal faster.

Planar Motion System

Figure 3: The Planar Motion System is composed of two lead screws with anti-backlash nuts to reduce vibrations. The extruder is moved from left to right by one motor and lead screw while that mechanism is moved front to back by a second motor. The planar motion system allows tissue to be printed over an 8 in. by 8 in. region.

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