# A 3-D printout for your health

June 10 2013, by Angela Herring

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The field of 3-D printing technology is revolutionizing industries across the spectrum, from the arts to electronics. We asked Constantinos Mavroidis, Distinguished Professor of Engineering, to explain how the approach, which is capable of rapidly producing low-cost three-dimensional structures the same way an ink-jet printer creates a two-dimensional image, is beginning to do the same for the biomedical field.

## Why is the biomedical field ripe for 3-D printing?

Customization, personalized treatment, ease of fabrication for complex geometries, and short fabrication times are some of the advantages of 3-D printing that are greatly needed in medicine and biology. Recent amazing progress in 3-D printing technology makes the use of 3-D printing in medicine very appealing and in many cases is the only solution in several problems; this progress includes a larger number of improved materials that are biocompatible, better fabrication accuracy, possibility for multi-material fabrication, reduced cost of 3-D printing, and a large variety of fabrication processes that can meet many different demands. I believe that the recent "boom" in the use of 3-D printing everywhere will also expand to medicine and biology.

## How will 3-D printing revolutionize the biomedical field?

There are many different applications of 3-D printing in medicine and biology, including pre-surgical planning, prosthetics, orthotics, dentistry, implants, and tissue and organ generation. This list of applications will expand every year, and new applications will be added as 3-D printing technology improves. I distinguish these applications in two large types: tissues and organs, and devices. Although in some cases, it will be hard to distinguish one from the other.

In tissue and organ generation, 3-D printing will be used to "print" synthetic biocompatible materials that are exact replicas of human tissue and organs that need to be replaced due to malfunction or because they have been removed. A good example is 3-D printing of artificial skin for wound healing. The technical challenge here is the material to use and the manufacturing process, as each material will usually require a different manufacturing process and a different 3-D printer. In devices like tools and assistive objects, 3-D printing is used as a way for customization, personalized treatment, and reduced fabrication cost and

time. Examples are prostheses in which the socket has been customized to fit the missing limb's anatomy. In this case, 3-D printing is used in conjunction with 3-D laser scanning that is used to "reverse engineer" human anatomy so that is then used to customize the device to be 3-D printed.

## What areas of the field have you and your students explored already, and where are you setting your sights in the future?

My team at Northeastern's Biomedical Mechatronics Laboratory has for many years focused on developing patient-specific customized orthotic devices. Using funding from the National Science Foundation and CIMIT and in collaboration with Spaulding Rehabilitation Hospital, we were one of the first groups worldwide that developed customized 3-D printed orthotics that fit the patient's anatomy. The benefit is that we are converting the orthotics business into a fully digital process. Using 3-D laser scanning, CAD software, and 3-D printing, the orthotist is turning from a craftsman into a digital designer.

We are now embedding sensors into the 3-D printed orthoses, create to smart, patient-specific medical devices.

Provided by Northeastern University