White Paper - UAB Grand Challenge

Title: Birmingham Manufacturing Initiative for Personalized Implants/devices (BMI4PID)

BMI4PID Team: Engineering, Medicine, Computer Science (submitted by: Brian Pillay; pillay@uab.edu, 205 9965797)

In accordance with the "Convergence", Facilitating Transdisciplinary Integration of Materials and Manufacturing Engineering, Physical science and Medicine and beyond, the roadmap published by the National Academy of Science and NSF Ideas for future investment (*10 Big Ideas*) - Shaping the New Human – Technology Frontier, this concept paper envision an approach to problem solving that cut across disciplinary boundaries and impact healthcare, economic and education sectors of Alabama.

The advent of the field of precision medicine is an exciting opportunity that provides new opportunities in diagnosing and treating patients based on their personal genetic makeup. New opportunities for treatment of diseases like cancer, diabetes, etc. are rapidly being developed. However, there are standard of care treatments for most patients needing implants and/or devices that have not been modernized and could be significantly improved through engineering technology and manufacturing advancement. It is common knowledge that individuals are unique with respect to their size, shape and function of organs, appendages, cavities, etc. However, most implants and devices are mass manufactured in distinct sizes, most times small, medium and large, with a possibility of a few more options in between.

The advent and proliferation of additive manufacturing has revolutionized the manufacturing world with regards to the scope of possibilities and intricacies of products. Components that were previously inconceivable to manufacture can now be built from the ground up, mimicking nature. This has excited the medical industry and several researchers are working on 3D printing of live culture, organs, tissue, etc. to aid healing and treatment regimens for patients.

3D printing is also being used in some cases for personalized prosthetics, implants and devices. Most of these are still at the early stage of development and quite expensive. There is also a long waiting period from patient diagnosis to final receipt of the device and subsequent treatment of the patient. Diagnosis is at the medical practitioners' facilities, the practitioner then sends digital data of the patient to an offsite facility where the device is designed and will probably then go to another facility for manufacture, either additive or subtractive. Most times modification are needed when the device gets back to the doctor and it's sent back to the manufacturing site. The process is time consuming and inefficient. Owing to the increases in need of organs for younger patients, a 3D printing of "growing organs or tissues" – integration of transforming information in structural design could be visualized with shape memory polymers and 'smart and intelligent materials" having responsiveness to external or internal stimuli.

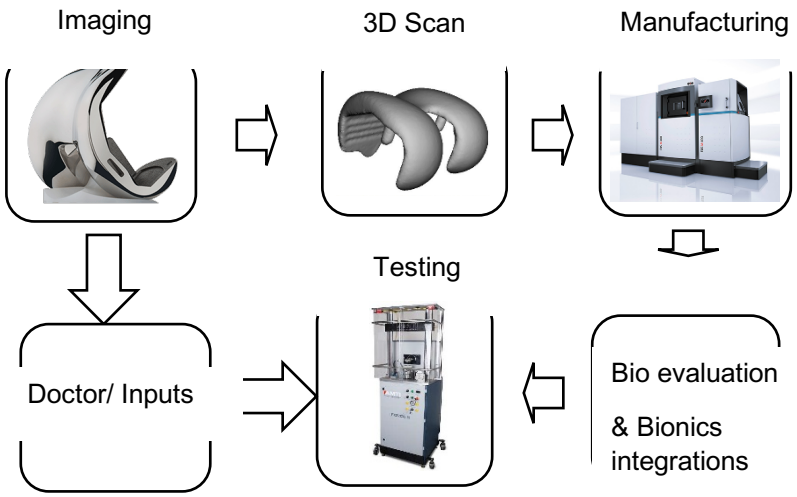
Sensor deign and artificial intelligence is another area that has revolutionized many industries like cellphones, gaming, etc. These technologies has enabled large amounts data generation, capture, and sophisticated analysis through machine learning. Human machine interaction, adaptability, versatility and repeatability is being developed for advanced manufacturing in agile environments through embedded 3D printing methodologies, where sensors and computational mediums can be added during the additive manufacturing process This has the capability to 3D print complete autonomous systems.

The same process can be used to build the proposed personalized devices and implants which can dynamically adapt to any given individual.

The above technologies and research areas are developed in silos. This white paper aims to integrate the above technologies to develop a proposal that provides personalized implants/devices at the site of the medical practitioner on demand and automated in concert with the doctor/surgeon. The following will be addressed:

1. Imaging automated computing technology used to generate live 3 dimensional models of the patients body/organs/affected areas.
2. Doctor/Surgeon input of device needed for correction/rectification
3. Automated design of device/implant including sensors, power generation, storage, etc.
4. 3 D printing (onsite) using multi material platforms including inorganic, organic and biological material from the patient to promote bio-integration faster healing. The surgeon will work in concert with automated manufacturing systems to integrate the patients biological material including cells (iPSCs) for organ printing.
5. Sensors integrated in the device/implant will collect data and activate mechanisms for device react to the needs of the patient.

A schematic of such example is shown here



Customized parts with specifications for a patient can be more easily and economically made using the additive manufacturing method. This is particularly important in the medical device sector because of the surgical trend towards minimally invasive surgery and the need to decrease healthcare costs. Utilizing the myriads of manufacturing capability from Biologics and Polymers to composites and metals, the plan is to modify and transform the medical implant components and devices with system integrated “bionics” for 3D printed parts and for sensing and functioning.

BMI4PID in Alabama and beyond Impacts: We see a three-in-one impact for this investments- (1) Economic and business sector of Alabama, (2) A manufacturing brand for UAB and (3) Next generation workforce development and STEM education.

Team

The team will comprise researchers from:

Engineering

Medicine

Computer Science

Southern Research

Possible industrial partners, example Evonik, Swigro (Alabama based Additive Manufacturing machine supplier)