Research Focus Area:

Biomedical Design and Manufacturing

Background

Healthcare is a new frontier of manufacturing research. Biomedical manufacturing is defined as the application of manufacturing technologies to improve the safety, quality, efficiency, speed and cost of the healthcare service and biomedical science.

Goal

Foster innovation and the distribution of new biomedical technologies by working closely with clinicians, scientists, nurses, caregivers, patient focus groups, engineers and business professionals through education and research to, ultimately, transform and advance the healthcare.

Interdisciplinary Collaboration

Education: Educate a new generation of innovators with advanced technical and business skills who will be leaders in biomedical device and health technology.

Innovation: Catalyze the development of innovative biomedical devices and treatment procedures as well as broaden the manufacturing research to healthcare.

Collaboration: Create multidisciplinary teams from the Engineering, Medical, Nursing, and Business Schools that will participate in biomedical design and manufacturing education and research. Facilitate dynamic relationships with industry that will accelerate innovation.

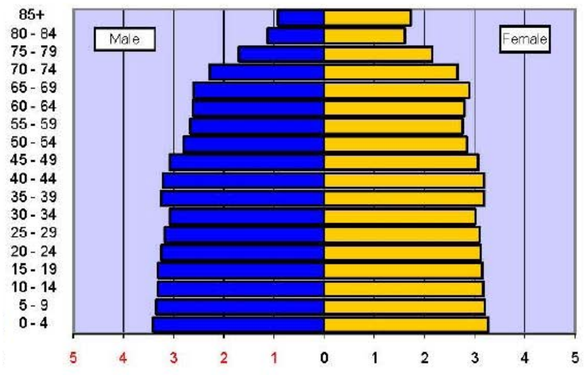
Entrepreneurship: Aimed at creating the culture and systems that can bring broad clinical access to health technology through business creation.

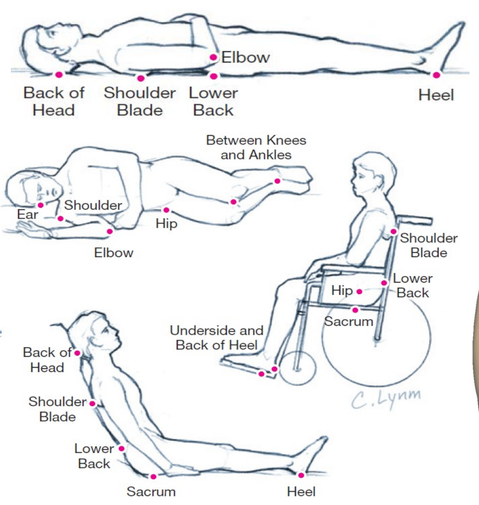
Topics of Biomedical Design and Manufacturing

Assistive Systems in Aging Society

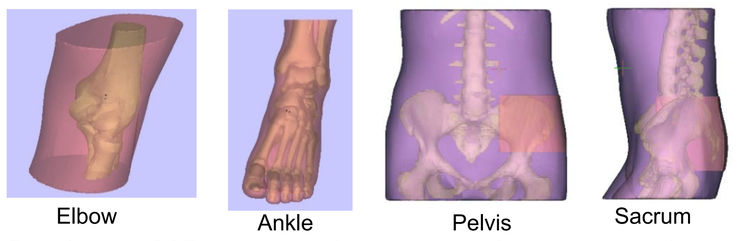
- Society is changing. By 2030, over the age of 65 will be nearly 20% of the US population.
- Challenges: Finding innovative design for people with disability to adopt assistive devices in nonobvious ways to maintain their independence, mobility and dignity.
- Projects include: (1) pressure ulcers: contact stress in bony prominence regions and patient handling, (2) 3D printing of custom orthoses and prostheses, (3) assistive and rehabilitation devices and others.

Population pyramids of US in 2030

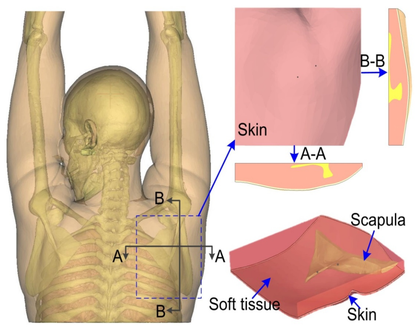




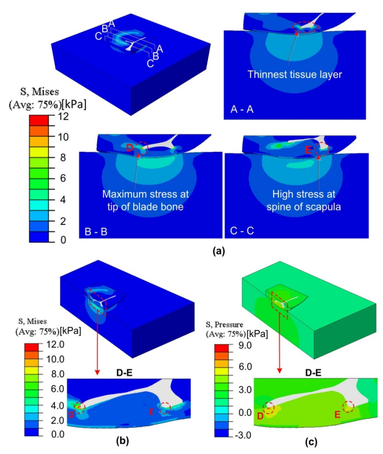
Common sites of pressure ulcers



Database of 3D geometry in pressure ulcer prone regions



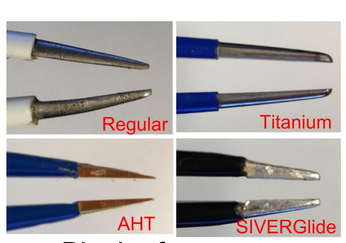
Shoulder model geometry



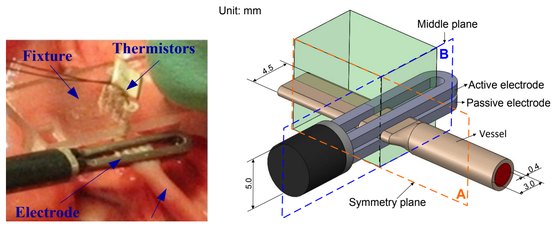
Pressure and stress in shoulder region

Innovative Medical Devices

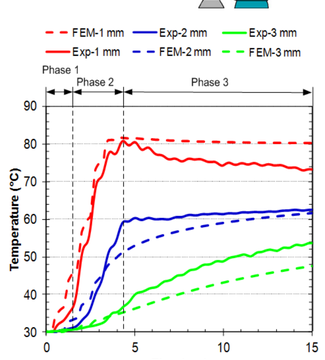
- Electrosurgical devices with thermal management to minimize nerve injury
- Mist cooling for endonasal bone grinding in minimally invasive brain surgery
- Bioimpedance sensors for whole body monitoring and diagnosis
- Ultrasound for blood flow shear measurements for aortic dissection, aneurysm, arteriovenous fistula, and other vascular diseases.

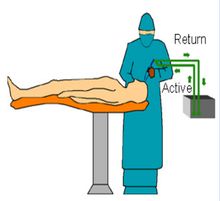


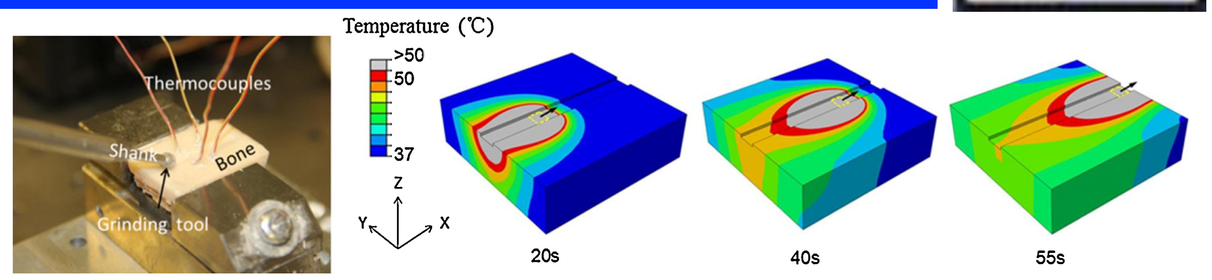
Bipolar forceps



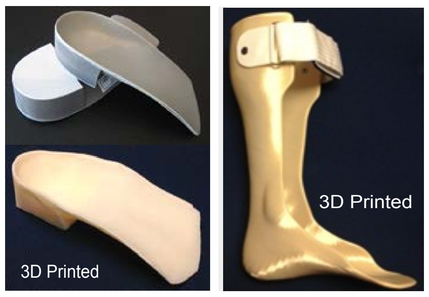
Bipolar electrosurgical vessel sealing



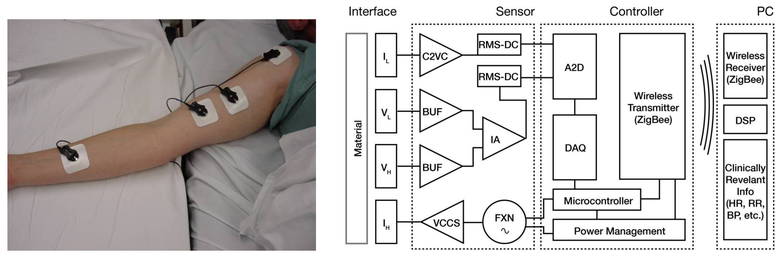




Endonasal bone grinding spatial and temporal temperature distributions



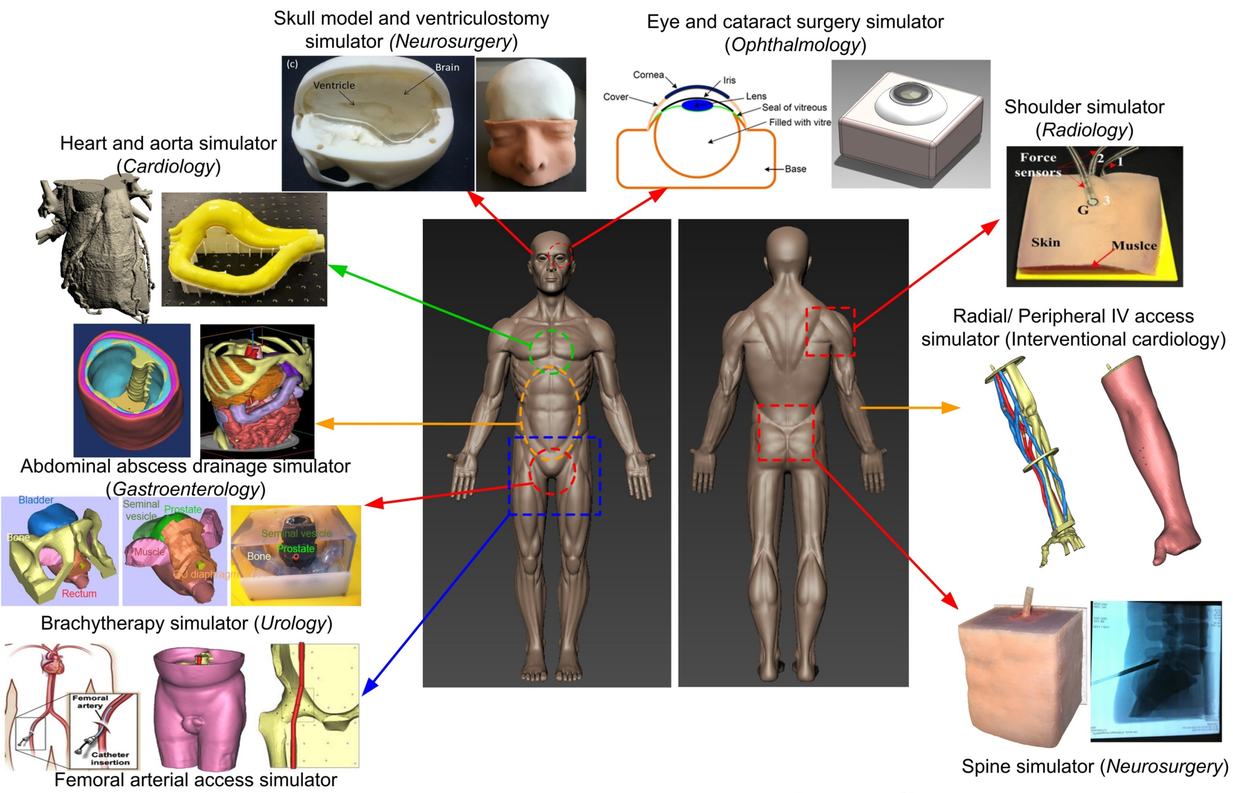
3D printed custom foot orthosis and ankle foot orthosis



Portable tetrapolar bioimpedance sensor

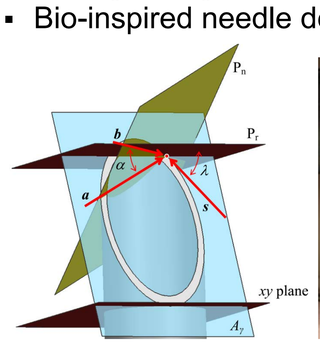
Clinical Simulators

- Transform the traditional "see one, do one, teach one" clinical education to "see one, practice many with simulator, do one, teach one" with the goal to improve patient safety
- Use 3D printing as the enabling technology for anatomically-accurate clinical simulators with novel phantom materials with the same tactile, ultrasound, mechanical and other properties
- Simulators built: Ventriculostomy, Eye and cataract surgery, Heart and aorta, Abdominal abscess access, Prostate brachytherapy, Femoral, radial and peripheral vascular access, endonasal approach to the skull base, and minimally invasive spinal surgery.

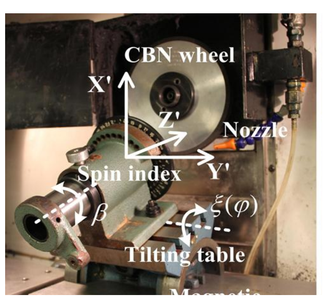


Needles and Needle Devices

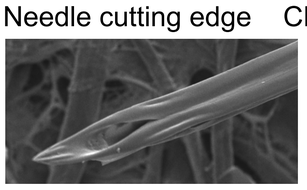
- The most common feature in medical devices
- Needle insertion is a tissue cutting process
- Model and optimal design the inclination angle and rake angle on the needle cutting edges to reduce the insertion force and core biopsy length
- CNC grinding of advanced needle tip geometry
- Bio-inspired needle designs



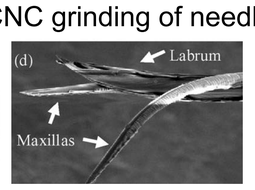
Needle cutting edge

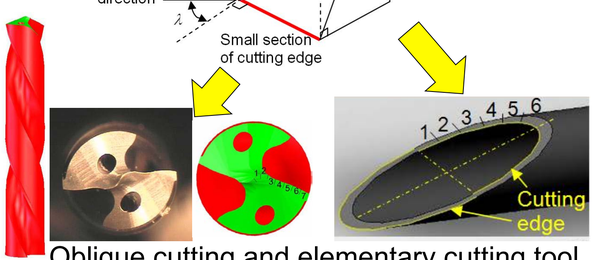


CNC grinding of needle tip

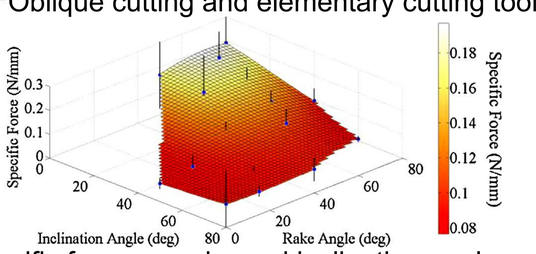


Mosquito proboscis

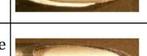




Oblique cutting and elementary cutting tool



Specific force vs. rake and inclination angles

	Needle	Angles	Bevel length (mm)	Insertion force (N)		
				Measured	Predicted	Discrepancy
Needle A		$\xi = 12^\circ$ $\varphi = 18^\circ$ $\beta = 60^\circ$	13.30	0.94	1.06	12.8%
Needle B		$\xi = 12^\circ$ $\varphi = 12^\circ$ $\beta = 15^\circ$	14.29	0.81	0.94	16.0%
Needle C		$\xi = 23^\circ$ $\varphi = 23^\circ$ $\beta = 10^\circ$	7.17	1.02	1.06	3.9%

Optimal design and manufacturing of NLPs