**Venipuncture**

Venipuncture is the most common invasive medical procedure performed in the United States for the purpose of collecting blood samples or delivering vital fluids to the peripheral circulation. It also happens to be the number one cause of hospital injury to both patients and practitioners. Failure rates are particularly high in obese and dark-skinned patients where locating a vein can be difficult, as well as in pediatric and elderly populations where veins are often small and weak.

To improve venipuncture accuracy in challenging patient populations, our team at VascuLogic has developed a portable device that autonomously servos a needle into a suitable vein under image guidance. The device operates in real-time, combining near-infrared and ultrasound imaging, computer vision software, and a robotic end-effector that servos the needle.

**VeinViewer**

One of the main challenges of performing venipuncture in dificult patients is the inability to visualize vessels underneath the skin. Imaging devices, based on near-infrared or visible light, do exist to help clinicians in locating otherwise occluded vessles; however, there are numerous limitations with the current devices on the market. These include: (1) high cost ($15 - $20K), (2) lack of depth perception, and (3) minimal image processing to guidet the puncture.

Our team at VascuLogic, has developed a vein viewer mobile application that utilizes near-infrared light to assist clinicians in visualizing veins. The app is compatible with Android and iOS smartphones and tablets, and features computationally efficient image analysis software such as segmentation and tracking for real-time vein visualization.

**Diagnostics**

Blood testing is the most common medical routine performed in the world and in many ways, forms the cornerstone of modern medicine. In the United States, blood tests influence 80% of medical decisions made in hospital and primary care settings. However, diagnostic results are generated almost exclusively in centralized labs from large-volume blood samples. This approach requires the transport of samples to a centralized facility and highly trained personnel to run the analyses on bench-top instruments, resulting in long turnaround times on the order of hours to days.

Point-of-care testing has shown the potential to reduce turnaround times and expedite the clinical decision making process.4 Yet despite the commercialization of a wide range of analyzers, these devices are used for less than 10% of all blood tests.5 One limitation with these devices is that they only perform a narrow set of assays. However, oftentimes diagnostic tests are nearly always ordered in combination with other panels. In order to perform these tests, multiple instruments and blood samples would be required. This lack of integration with different assays is a major drawback for current systems.

Our team at Rutgers is developing a portable analyzer using centrifugal microfluidics and fluorescence microscopy for the detection of cells, chemistries, and proteins on one disc. Much of the work so far, as seen in the figures above, has focused on the detection of white blood cells---a ubiquitous assay when diagnosing the common flu or bacterial infection.

**Laryngoscope**

Collaborating with an anesthesiologist at Rutgers Medical School, I designed and built a custom video laryngoscope for pediatric populations. A video laryngoscope is an intubation device, designed to assist in difficult airway management by providing an indirect view of the upper airway on a video display.

The device consisted of a unique blade geometry and ergonomic handle that contained the video display. A 3 mm diameter endoscope was embedded in the blade to provide a wide-angle view of the upper airway.

**Prey Simulator**

Collaborating with a team of engineers and biologists, my colleagues and I designed, fabricated, and programmed a machine to aid in the investigation of the neuronal control of flying prey interception in dragonflies. The task involved constructing an apparatus to simulate the complex motions of a flying insect.

In this fashion, the 3D motion device can mimic a flying insect by moving a small bead accurately up to speeds of 1 m/s in any direction. Dragonflies are efficient aerial predators that can intercept and capture small insects in flight. The stimulus device is still in use to investigate the way in which dragonfly neurons encode information about object movement in 3D. In a broader context, this work could lead to the development of more effective guidance mechanisms for military or civilian use.

**Dart Robot**

For my senior capstone project in design of mechanical systems at Union College, I was part of a team that designed and built a dart-throwing robot. At the end of the course, our robot competed (and surprisingly beat) several human players in a game of darts. My specific role was developing the base positioning system to align the dart with the bulls-eye, as well as the open-loop control scheme.

The positioner consisted of 2-DOF (revolute and prismatic joints) to align the throwing arm with the target – both actuated via DC-brushed motors and hobby motor drivers. A wireless remote control was programmed to position and throw the dart at various speeds and trajectories.

**Putt Boat**

For one of my projects in the design of thermal/fluids systems senior capstone class at Union College, I was part of a team that optimized the design of a putt-putt steam boat engine. The task was to design a boat that could carry the most payload, while at the same time, fast enough to beat our competitors in a race.

The hull and associated tail fins were 3D printed, and the steam engine was adapted from a toy boat. Ice cubes were added to the engine design to enhance the thermal efficiency and increase thrust.

**Gorilla Mandibles**

As a sophomore at Union College, I worked with Professor Andrew Rapoff of the mechanical engineering department, evaluating bone material property variation in cercopithecoid mandibles. The purpose of this work was to establish functional and mechanical linkages between mandibular morphology, masticatory biomechanics, feeding behavior, and food mechanical properties. Working alongside engineers and anthropologists, we analyzed the relative contributions of internal reaction forces to stresses in the great ape mandibular symphysis.

My contribution involved examining mandibular stresses on symphyseal cross sections of gorillas and orangutans through Matlab simulations. By developing models of stress distribution in cercopithecoid mandibles, my research provided a foundation for the identification of biomechanical variables responsible for initiating and maintaining metabolic activity of bone tissue.