Daniel Felix Ritchie School
of Engineering & Computer Science
UNIVERSITY OF DENVER

Ritchie School Senior Design Showcase

Friday, May 17, 2024

Daniel Felix Ritchie School of Engineering and Computer Science

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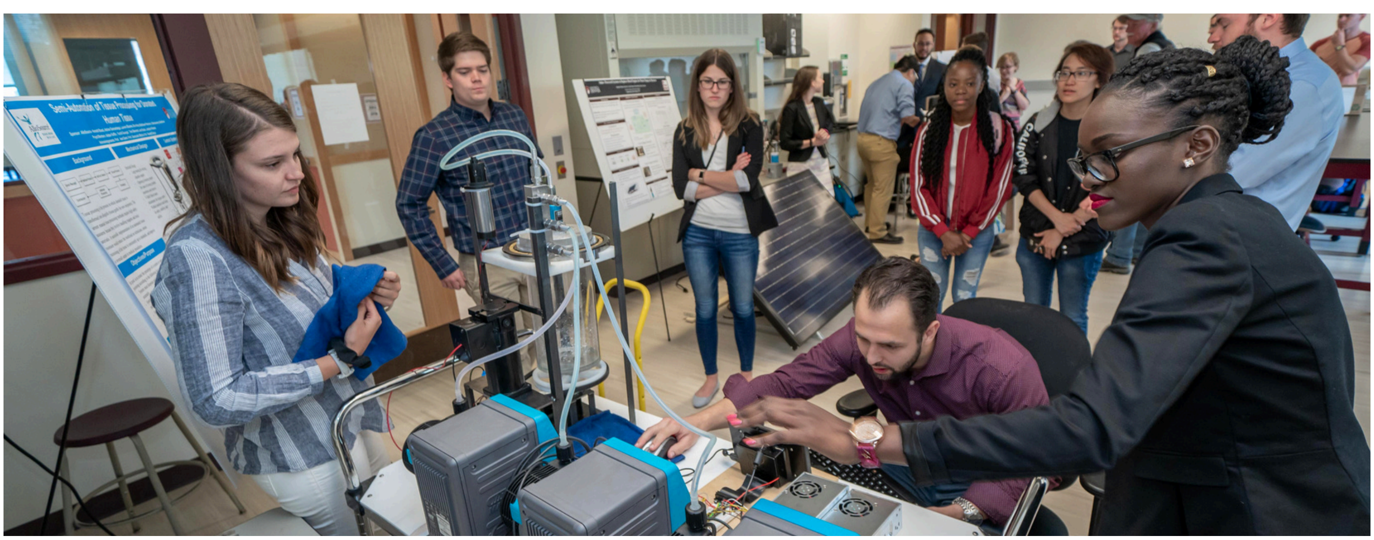
MAKE YOUR DISCOVERY

SENIOR DESIGN

Interdisciplinary Teams + Industry Projects = A Powerful Senior Capstone Experience

The Senior Design Project provides undergraduate students with an integrated, mentored, requirements-based design project, giving students the opportunity to serve on self-directed teams. Each project team will conceive, design, prototype, verify and validate a system to solve a specific customer problem. Through teamwork, critical thinking and thorough systems engineering procedures, senior design projects allow students to apply the fundamentals learned in their first three years in a research and development project.

Senior Design is a year-long course required for all engineering seniors to graduate. Each team of 4-5 seniors is mentored by both the Engineering faculty and their project sponsor. Sponsors gain the first-hand experience of working with potential future employees to see their project to fruition. Our seniors hone their collaborative team skills while fulfilling their commitment of creating real-life deliverables for their sponsors.



SCHEDULE

Senior Design Pitches and Q+A

9:00 a.m. - 11:00 a.m. ››› *MAGLIONE HALL, SIE COMPLEX*

Senior Design Demonstrations

11:15 a.m. - 1:00 p.m. ››› *ENGINEERING & COMPUTER SCIENCE BUILDING*

Senior Design Presenters Pizza Lunch

1:00 p.m. - 1:45 p.m. ››› *ENGINEERING & COMPUTER SCIENCE BUILDING*

Industry Advisors and Senior Design Sponsors' Lunch

1:00 p.m. - 2:00 p.m. ››› *ENGINEERING & COMPUTER SCIENCE BUILDING, 510*

Industry Advisory Board & Industry Advisory Council Meetings

2:00 p.m. - 4:00 p.m. ››› *INDUSTRY ADVISORY COUNCIL, ECS 357*
INDUSTRY ADVISORY BOARD - MME, ECS 400
INDUSTRY ADVISORY BOARD - ECE, ECS 401

SENIOR DESIGN PROJECT DEMONSTRATION LOCATIONS

Engineering & Computer Science Building (ECS) Room Locations

1st Floor

ECS 103 Team Lockheed Martin

ECS 110 Team B-BRAUN
Team Blind Institute of Technology
Team Craig Hospital

ECS 143 Team Agile Orthopedics
Team DU-Biosensing
Team Design Outreach
Team Eventum Orthopaedics
Team Paragon 28

2nd Floor

ECS 200 Team daqscribe

ECS 200 Team DU-Surf

ECS LOBBY Team DU-Cyclorotor
Team Highridge Medical
Team DU-UAV

Providing Accessible, In-Home Care with Parallel Bars

Sponsor: Agile Orthopedics

Our Sponsor, Agile Orthopedics strives to bring accessible in-home care to recovering amputees and other physical therapy patients. Parallel bars are one of the many medical devices that are used in physical therapy to provide stable support for walking. However, parallel bars take up a lot of space and are not easily transported. Because of this, parallel bars often have to be permanently installed which can cost a lot of money and places additional restrictions on where they can be installed. Additionally, it is difficult to gauge how a patient is performing when using parallel bars without the use of external sensors or probes. To address this problem, we have aimed to design parallel bars that collapse in size, provide stable support, and provide data and performance metrics to the patient and/or physical therapist.

Our parallel bars adjust in both width and height to accommodate a wide variety of people while also being able separate in half to collapse in length for storage in a trunk. On top of that, the legs of the bars swivel in order to reduce the bars down to just two dimensions which facilitates the storage and transport of the bars. When assembled, the bars utilize pins to lock at certain heights which improves stability. Moreover, the base plates for the bars extend past the legs of the bars to provide additional stability and combat horizontal wobbling or tipping. In order to provide the patient and/or therapist with performance metrics, the parallel bars are equipped with a force sensor in each leg which are connected to an Arduino microcontroller.

The microcontroller is responsible for reading and converting the raw sensor data to weight and weight distribution values and displaying them on a user interface. The user interface allows the therapist to create a new patient by entering their name and date of birth. The session data for each patient is downloadable to a text file. These parallel bars would allow physical therapists to transport a portable set of bars in their personal vehicle to wherever they need and would also allow patients to purchase their own set of bars. Additionally, the sensors within the bars would provide valuable information to the physical therapist and patient which would help determine progress.

Student Team Members

Shooq Alasousi
Eric Jacobs
Oliver Nickel
Ana Vences

Peripheral IV Catheter Needle Tracking with Vein Visualization Technology

Sponsor: B-BRAUN

The accurate placement of peripheral IV catheters is important in healthcare settings to ensure optimal patient care and minimize procedural complications. Traditional methods of catheter insertion often rely on the skill and experience of healthcare practitioners, leading to variation in success rates and potential risks to patient safety. In response to this challenge, our project aimed to develop an innovative solution for precise needle tip localization during IV catheterization procedures, leveraging advanced artificial intelligence (AI) and computer vision technologies.

Our objective was twofold: firstly, to address the need for real-time tracking of the needle tip during catheter insertion even after it is inside the patient's arm, and secondly, to provide clinicians with a visual projection of the needle tip location relative to reference markers on the catheter attachment. To achieve this, we developed a complex design integrating cutting-edge hardware components and an AI custom model.

Central to our design is the utilization of the ZED 2 Stereo Camera for high-definition depth sensing, coupled with the powerful computational capabilities of the Nvidia Jetson Orin Nano platform. This combination enables advanced real-time tracking of the needle tip, facilitating precise catheter insertion with minimal margin for error. Additionally, we incorporated the DLPDLCR4710EVM, a digital light processing (DLP) projector, to project the needle tip's position onto the patient's skin surface.

The core innovation lies in our custom AI model, developed using computer vision techniques, to detect and analyze reference markers on the catheter attachment. By accurately identifying these markers, the AI system can take the precise coordinates of the needle tip relative to the reference points. This information is then seamlessly integrated with the projector coordinates, enabling clinicians to visualize the needle tip's location in real time, thereby enhancing procedural accuracy and efficiency.

The anticipated impact of our contribution is significant. By harnessing the synergy of AI, computer vision, and advanced imaging technologies, our solution promises to revolutionize IV catheterization procedures. Clinicians will benefit from improved accuracy and confidence during catheter insertion, leading to reduced procedure times, decreased patient discomfort, and mitigated risks of complications such as vessel puncture or infiltration. Moreover, our approach promotes greater standardization in catheterization techniques, irrespective of operator experience, thereby enhancing overall patient care quality and safety.

In conclusion, our project represents a pioneering endeavor in the realm of medical device innovation, offering a comprehensive solution for IV catheter needle tracking and visualization. Through the seamless integration of hardware and AI technologies, we aspire to empower healthcare practitioners with the tools they need to deliver superior patient outcomes and redefine the standards of procedural excellence in intravenous therapy.

Student Team Members

Abdihalim Bihi

David Ki

Johnathan McHorse

Toby Werthan

Building Opportunities with Tactile Geometry

BLIND INSTITUTE OF TECHNOLOGY

Sponsor: Blind Institute of Technology

The Blind Institute of Technology aims to increase accessibility and awareness for professionals with disabilities. Developing professionalism begins in the classroom, which is why our team has been working to make 7th and 8th-grade geometry more accessible for visually impaired students. Mathematics is a subject that many people struggle with, and it can be especially frustrating for those who cannot use visual cues typically associated with math. To make geometry more accessible, we have created a product that employs tactile graphics using 3D-printed shapes and flashcards, as well as auxiliary outputs via an iOS application.

The components of this design can be used at home and school from a kit that organizes and carries the individual pieces. Our final product will help build opportunities for students to develop and continue their STEM education. This learning tool will also be uniquely accessible due to its scalability, as it can be 3D printed at home, school, or even at the public library, and assembled with the simple construction steps provided.

Student Team Members

Hannah Bosak

Ryan Choi

Savannah Palmer

Bryce Swearington

DU Mobility Solutions

CRAIG

NEUROREHABILITATION
& RESEARCH HOSPITAL

Sponsor: Craig Hospital

Craig Hospital, a neurorehabilitation and research center in Englewood, specializes in the treatment of patients with spinal cord and brain injuries. These patients are often tetraplegic and require sip and puff wheelchairs to move independently. These wheelchairs are controlled through pressure alterations from breathing. However, transitioning to these wheelchairs presents challenges, primarily due to the non-intuitive controls, lack of availability, and minimal time to practice before release from the hospital.

This project's main objective is to streamline the transition to sip and puff wheelchairs by designing a learning tool. The device developed for this purpose is based upon the four essential inputs: soft sip, hard sip, soft puff, and hard puff. It takes solely these inputs to fully maneuver the wheelchair in all directions.

The sip and puff device offers different mounting capabilities to fit the patient's preference. The compact and lightweight structure with a magnetic connection system enables a secure attachment on a patient's headband, shirt, or a custom mechanical arm clamped to the hospital bed. A dental straw extends to the patient's mouth from the sip and puff and is connected to a pressure sensor via pneumatic tubing. This tubing incorporates an in-line filter to prevent the sensor from splash back.

The device is comprised of a PCB with an attached pressure sensor, a battery controlled by an on-off switch, and a filter. These components are housed within 3D printings. All parts of the sip and puff are easily detachable for replacement or cleaning. Bluetooth connection enables communication with computers which feature a custom GUI. The GUI offers trainings modules for patients, administrative interfaces for nurses, and raw data screens for diagnostic purposes. Additionally, a selection of JavaScript games with controls mapped to the sip and puff device enhances patient engagement.

By introducing patients to sip and puff technology early on and providing easily accessible practice, the device aims to enhance their comfort using the device to ultimately ensure a smooth integration into their daily lives.

Student Team Members

Ethan Burnett

Kevin Fuentes

Evan Hill

Clay Mosher

Evan Snell

Rugged and Ready: Data Recording in Extreme Environments

daqscribe
The Ethernet Recorder Company™

Sponsor: daqscribe

In the aerospace and defense industry, the demand for rugged products is ever increasing. Operating environments are becoming more hostile as they include autonomous underwater, airborne, and space missions. Daqscribe is a leader in building data recording products for companies like NASA, Sierra Nevada Corporation, The Boeing Company, and more. Daqscribe has partnered with the University of Denver Senior Engineering Students to take their existing computing system, and design a robust, mechanically sealed enclosure system that allows it to survive extreme vibration, temperature, altitude, humidity, and underwater submersion environments, all while providing 100% accuracy in the data recordings. Aside from the basic electronic components in the system, the rest of the design was up in the air, giving the freedom to design a custom, durable case to house Daqscribe's electronics. Without an effective protective chassis, the internal hardware cannot function since environmental conditions are the enemy of all data recording systems.

To tackle this problem, the project was divided into several subsystems: Thermal Management, Drive Bay Enclosure, Chassis Integration, User Input Printed Circuit Board, and Back-Plane Printed Circuit Board. During the poster session, more details about each unique solution will be displayed as well as a live data recording demonstration of the final design.

Due to limitations of time and resources, the vibration and altitude requirements were not met this year. Therefore, development in these areas will be continued next year. The final solution of this project has a tremendous impact as it allows Daqscribe's products to go farther than ever before. It can now be deployed in aircrafts, submarines, Humvees, and more, which expands the applications of their devices beyond Telecommunications, National Security, Research and Development, AI, and Autonomous Vehicles.

Student Team Members

Brooke Bernier
Phillip Chiem
Reagan Hardy
Brian Lee
Mason Niccoli

Beyond Electricity: A Peristaltic Wound Pump for Global Health Challenges

Sponsor: Design Outreach

Approximately 1 billion people residing in low-resource regions around the world receive healthcare from facilities with an unreliable supply of electricity. Existing wound vacuum systems rely on electricity to function, creating a lack of access to critical wound care technology for these patients. Our team collaborated with Design Outreach, a non-profit based in Columbus, Ohio, to develop a mechanically powered wound vacuum pump, addressing the need for non-electric wound care in low-resource regions.

A wound vacuum uses negative pressure to remove fluid from a wound, which reduces swelling and keeps the wound area clean. These devices significantly reduce the risk of infection and speed up the healing process. In facilities with reliable electricity, wound vacuum pumps are implemented routinely for open wounds such as burns, ulcers, open fractures, infected wounds, and other related traumas of the fascia. The ability to employ this technology in regions without reliable electricity would improve patient health and alleviate resource and personnel-based stress on healthcare systems.

By harnessing the kinetic energy from a constant force spring and employing a gear train equipped with a braking system to regulate the rate of spring retraction, the team was able to power a peristaltic pump and remove fluid from the wound site. The product initiation process begins with the healthcare provider turning a crank to load the constant force spring onto the drum of a pulling winch. From there, a gear is inserted onto the drum's shaft and the lock is disengaged. The spring begins to retract, causing the winch's drum and attached gear to turn. The energy is transferred through the gear train, where it ends with a gear attached to a peristaltic pump. As the gear turns, the pump shaft is spun, drawing negative pressure through the pump and successfully removing exudate material from the patient.

The introduction of a non-electric wound cleaning device enables healthcare providers in underserved regions to deliver life-saving services, contributing to a greater goal of making healthcare more accessible globally. This design can be adapted to a variety of medical devices, but it also has impacts beyond healthcare. The mechanical power source our team developed could be applied to sanitation and household energy systems in resource-constrained settings. Our design represents a transformative step towards mitigating health disparities and fostering practical development in underserved communities.

Student Team Members

Joseph Pham

Charles Podiak

Bryan Sharp

Lucy Ward

Optical Biosensor

Daniel Felix Ritchie School of Engineering & Computer Science
UNIVERSITY OF DENVER

Sponsor: Dr. Sangho Bok

Biosensors are common and used every day to help millions of people around the world. Despite this, they are expensive and bulky. Many cannot be obtained easily and places that need them the most are usually not readily available. This project involves creating a device that can detect biomarkers from a biofluorescent sample excited by light of specific wavelengths. More specifically, the device will detect the angle of reflection of light being emitted by the excited biofluorescent sample. The device makes use of precision movement and trigonometry to calculate the angle of reflection.

The design involves the use of a precision vertical linear stage to move the sample up and down. The stepper motor can be configured to run at various steps per rotation. The vertical motion is tracked by an integrated rotary encoder. For sensing and emitting light, a custom fiber core is implemented. This fiber core has a central optical fiber cable to emit light onto the sample and is surrounded by smaller optical cables. The central fiber cable is coupled with a standard laser diode which emits light at a specified wavelength onto a sample. The emissions will be detected by the smaller optical cables which direct the light into a triad spectroscopy sensor. These sensors can pick up wavelengths that vary from UV to NIR light.

The device is controlled by an Arduino R4. The Arduino is programmed to respond to basic commands over UART such as telling the motor to step or getting the motor's position. This means any PC can fully control the Biosensor using the UART commands. Currently this is done via a text interface written in Python. The interface can perform low level commands and even complex sequences of commands such as autonomously locating and calculating the angle of reflection from the emitted light.

With this design, Dr. Bok and his team in the biosensing lab can continue their research into biofluorescent light emission and detecting biomarkers from reflection angle. If successful, the biomarkers detected by this device can be used to identify several diseases including COVID-19. With successful detection of biomarkers, this device, or something similar, may be implemented around the world for rapid diagnosis of potentially serious disease, forgoing the slow and expensive process of placing samples on testing strips.

Student Team Members

Hiroto Bauer

Alex Kondracki

Raul Medina-Estrada

DU Cyclorotor

Sponsor: Ritchie School of Engineering & Computer Science (Electrical and Computer Engineering)

This Senior Design Project is the Cycloidal Rotor – Cross domain design, testing, and analysis and is sponsored by the University of Denver and monitored by Dr. Valavanis and PhD. candidate Chris Ramos. A cyclo-rotor is a unique type of rotary-wing propulsion system that generates vertical thrust from a horizontal axis of rotation, and offers omnidirectional thrust vectoring, enabling exceptional maneuverability, and hover capability. Research is underway to explore the use of cyclo-rotors in creating 4-in-1 unmanned aerial vehicles (UAVs) capable of traversing air, land, water surface, and underwater environments. This project is structured around continuing studies on cycloidal rotors and a format in which they can be tested to analyze the effectiveness of different designs. Our team was tasked with designing and manufacturing a functional test rig and a cycloidal rotor design. The test rig has to be capable of testing multiple different cycloidal rotor designs and be able to receive and collect data on the lift and thrust generated during test phases. The approach taken was one in which the test frames initial design is made out of wood with the dimensions being efficient for the exchange and testing of different dimensioned cycloidal rotors.

In order to receive data from testing a total of three tension/compression load cells are mounted on the bottom of the test rig which then connects to a separate frame that sits under the test bed. The cycloidal rotor that was designed is based on research on efficient airfoils and aspect ratios found. The pitch of the airfoils is what allows for the modification of lift forces and directionality. This is controlled by a servo motor that is incharge of rotating the center shaft to adjust the angle in which the airfoils sit.The cycloidal rotor is powered by a brushless motor, which spins a gear that transfers rotational motion through the meshing of another gear fixed to the cycloidal rotor housing. The data collected from testing will help optimize cyclorotor designs, potentially leading to innovative transportation solutions and advancements in VTOL (Vertical Takeoff and Landing) technology. This project could contribute to more efficient and sustainable vehicles, benefiting industries such as aviation, marine transport, and ground transportation.

Student Team Members

Anthony Delgado

Will Howhannesian

Michael Kahler

Eyobel Kahsay

Cade Thorton

Surfing into Sustainability

UNIVERSITY OF DENVER

Sponsor: Matthew Taylor

Our sponsor Matthew Taylor is a geography professor at DU who researches human-environment relationships in Latin America. He teaches and does field-based research in Latin America where he has become familiar with the culture, community, and the people. There is a growing surfing community in Nicaragua which has become close to Professor Taylor's heart. He noticed that within the surfing community there are not many options for sustainable or environmentally friendly surfboards.

Professor Taylor tasked us with designing a more environmentally friendly surfboard that is attainable in Nicaragua. Current materials are made from plastics and harmful chemicals that do not breakdown easily and are harmful to the individuals making the surfboards. Long exposure and inhalation of these chemicals can cause cancer. In addition to this, they pollute the environment not only during the manufacturing processes but also after use.

Our design aims to minimize the carbon footprint of materials while maintaining performance standards. Extensive research was conducted on current surfboard materials, possible alternatives and their ability to be implemented in Nicaragua. Materials were tested to ensure properties meet or exceed those of traditional materials.

We have settled on two environmentally friendly options, a recycled foam core and a cardboard core. Both are covered with the traditional fiberglass cloth for strength and sealed with bio resin. Our final designs optimize environmental impact, cost efficiency, board performance, and community engagement.

With our surfboard designs, we hope to offer surfing communities an alternative to current models by providing a more sustainable, cost-effective option. Cardboard and recycled EPS reduce the overall carbon footprint of boards significantly while bio-carbon based resins ensure the safety of the shapers. Our boards can be produced and customized to the shaper's discretion which values and upholds the craftsmanship of these individuals. We hope that our investigation into these alternative materials catalyzes a shift in the surfboard industry, one that prioritizes the well-being of our surfing communities and the natural environment. All in all, our boards provide surfers with an option to go green and feel good while doing the thing they love most.

Student Team Members

Milana Diaz

Lukas Fisher

Ryan Pineda

Underwater Autonomous Vehicle

Sponsor: DU SRI, Unmanned Systems Research Institute

Technological advancements are known to have little bounds, there is still one area that continues to constantly challenge researchers: water. Our vast oceans, numerous lakes, and winding rivers remain the most unexplored part of our world. With our many unexplored bodies of water, it's clear that there is an urge to find ways to explore and navigate these bodies of water. Water is a very difficult medium to work in. It presents unique challenges due to its inherent properties. We know electronics and other systems are not fond of the properties of water, along with this, buoyancy and pressure cause many obstacles when trying to navigate accurately in this space. Given that in the modern day, all our advanced data collection systems are now electronically powered and navigating the water can also provide a challenge without electronic assistance, this project aims to create a system capable of running multiple missions in small bodies of water. The idea is to create a semi-autonomous system that can navigate above and below the water without having to return to shore so that these unexplored areas can be uncovered, explored, and navigated.

The resulting prototype design utilizes the system's tight space to integrate a package of controllers and sensors which provide real-time orientation data to enhance our navigational precision. Moreover, the incorporation of motors in our ballast tanks enables a reusable ballast tank system, optimizing operational efficiency and resource utilization. The system, being semi-autonomous, also allows for a wireless connection to the system and allows for the system to move freely without being tethered. This feature enhances maneuverability and expands the scope of exploration by eliminating the need for constant return to shore. This prototype design is just a version one which proves this concept could work and provides a robust solution to underwater exploration and navigation. However, our vision extends beyond mere validation; the vision extends to creating an even larger unmanned system.

By deploying this prototype, we aim to provide essential understanding in two of the four mediums which will be studied by the DU2SRI lab in efforts to create a larger 4-in-1 unmanned system design. This larger system will be capable of Land, Air, Water Surface and Underwater maneuverability. The adaptability of the system allows the lab to tailor the platform to their specific needs, which then maximizes its utility and effectiveness. Ultimately, our prototype's deployment aims to advance the idea of underwater exploration while inspiring and guiding the DU2SRI lab to continue in their efforts of creating a larger system. Not only can the system be used for exploration, but the versatility allows for many realms to be explored. Whether its rescue missions, water sampling, or cartography, the potential applications of our system are endless. In navigating and exploring the waters, we seek to provide DU2SRI with some guidance in two of the four mediums that they are trying to achieve with their 4-in-1unmanned system design.

Student Team Members

Avery Doss
Charlie Hancock
Eliot Howell
John Leseur
Ella Ross
Cole Schweitzer

Skin Mounted Sensors for Total Hip Replacement Cup Alignment

eventum orthopaedics

Sponsor: Eventum Orthopaedics

Total Hip Arthroplasty (THA) stands as one of the most transformative surgical procedures in modern medicine. Its goal is to alleviate pain from worn or misaligned hip joints and restore mobility for individuals suffering from hip joint degeneration. Despite its widespread success, challenges continue to persist, notably in achieving consistent surgical outcomes, costing the United States $300 million per year in additional healthcare costs due to poor outcomes (rheumatology.org). This is often due to inaccuracies in current methodologies and the prohibitive costs associated with more precise techniques. Hence, this project endeavors to explore a novel approach to THA surgery, aiming to provide a cost-effective and accessible method to enhance cup alignment for each patient's unique anatomy.

The conventional methods employed in THA surgeries often result in inaccuracies, leading to variable outcomes or requiring substantial financial investment. To mitigate these issues, this project investigates a system comprising a network of sensors strategically placed on the patient's skin that wirelessly interfaces with a data visualization. These sensors provide real-time data transmission of angles depicting the patient's orientation, guiding the surgeon towards precise positioning of surgical tools relative to the patient's reference frame to place the cup. By integrating this sensory guidance, the system aims to improve the accuracy of cup alignment for each unique patient, thereby enhancing the overall procedure success rate.

The proposed system goes beyond surgical guidance by laying the groundwork for development of a patient-specific plan. By leveraging machine learning algorithms and the sensor system, this product has the potential to perform pre-operation analysis based on individual patient data. The resulting patient-specific plan would then be used in surgery to actively guide the surgeon through placing the cup. This innovative approach optimizes surgical plans to suit the unique anatomical characteristics of each patient and aims to enhance surgical precision thereby improving post-operative outcomes further.

This project focuses on the development and evaluation of a proof-of-concept prototype, demonstrating the feasibility of the proposed system. This project showcases the reliable function of the proposed technology in a simulated surgical environment. This was proven by conducting testing on all components including the construction and implementation of a mechanical testing rig to mimic the hip and surrounding areas and by integrating validation procedures throughout the development process. The study explores the system's potential impact on THA surgeries with guaranteed satisfaction, envisioning a future where advanced technologies are more available to patients and surgeons.

In summation, this project highlights the transformative potential of integrating real-time sensory guidance into THA procedures through the development of innovative technologies. This project aims to address the existing limitations of current methodologies, with hopes to usher in a new era of precision and consistency in orthopedic surgery. This investigation looks to advance orthopedics and demonstrates the importance of continuous innovation in medical technology aimed at improving healthcare reliability and affordability.

Student Team Members

Samuel Adams
Zach Bayler
Madeline Bohn
Connor McCoy
Josh Mejia

Quantifying Tension During Vertebral Body Tethering

HIGHRIDGE MEDICAL

Sponsor: Highridge Medical (ZimVie)

Student Team Members

- Mattie Hyde
- Adam Page
- Noe Sheridan
- Dylan Yapp

LARRS – Lunar Astronaut & Rover Recovery System

LOCKHEED MARTIN

Sponsor: Lockheed Martin

Lockheed Martin has tasked the team with constructing a recovery kit for a prototype lunar terrain vehicle that also can recover incapacitated astronauts. The objective of the recovery kit is to allow a 5th percentile female astronaut, standing about 4' 11" and weighing 115lb, to recover a lunar terrain vehicle that has become stuck in lunar regolith, along with the recovery of an incapacitated astronaut removed from the vehicle. The vehicle recovery kit is also designed to be stored in a storage container that may be mounted to the lunar vehicle. Furthermore, the solution is to be deployable in under 10 minutes to not risk astronauts running out of oxygen and to avoid straining other life support systems. Of note, for this project's purposes, the solution is not required to be ready for function on the lunar surface. Rather, the prototype shall be functional on Earth and a plan for designing a lunar-ready prototype shall be formulated. The reason behind this design choice is because constructing a lunar-ready prototype would require highly expensive material and take significantly longer to manufacture.

The team's process for formulating the project requirements involved working with Lockheed Martin's engineers, researching information regarding the lunar regolith, NASA's standards, and the team's own design and testing process to develop an encompassing list of requirements for this project.

The solution that the team fabricated involves six subsystems: a winch, winch control system, ramp, harness, anchors, and storage container. The winch is designed to be portable and be able to pull both the vehicle and astronaut out of problematic situations. The winch control system allows for the winch to be controlled via wireless remote and monitoring of the battery conditions. The harness is used to secure the astronaut as they are pulled back to the vehicle by the winch. The anchors are to be fixed into the lunar regolith to give the winch a counteracting force when pulling the vehicle. The storage container is designed to house the entire solution as well as secure each subsystem, so they are not damaged in transit from Earth. Each subsystem can be used together with the rest as needed and conveniently stored in the storage container. Future work for this project includes looking at the outgassing values for all materials used the weight and size as well needs to be optimized to the minimum values.

Design testing involved testing each subsystem separately to ensure their individual function and, once each subsystem was tested, the completed design solution. Overall, each test was a success, and the prototype met the prescribed requirements.

Student Team Members

Ryan Considine

John Denfeld

Leonel Gomez Flores

Kelby Modene

Adam Nobs

Daniel Silva Rios

Charcot Reconstruction Surgery: Osteotomy Guide

Sponsor: Paragon 28

Paragon 28 is a company that creates mechanical systems for surgical foot and ankle procedures. Their goal is to produce systems that streamline these surgical procedures and make them more easily reproducible. By achieving this goal, Paragon 28 is able to develop products that solve or mitigate many real issues surrounding the world of foot and ankle surgery. Examples include issues related to the level of invasiveness of the procedures, the amount of control the surgeon has when performing osteotomies and replacements, and the lack of reproducibility associated with some of the procedures due to variations in patient anatomy.

One procedure that Paragon 28 has taken an interest in is Charcot reconstructive surgery. Charcot neuroarthropathy (CN) is a destructive complication of the joints, which is often found in people with diabetes with peripheral neuropathy. CN can cause the decay of bones in the foot, leading to bowing of the foot arch and the presence of sores. If left untreated, CN has the potential to cause significant deformities or even death. As such, CN requires either the amputation of the affected foot or a reconstructive surgery to remove the decayed bone in the foot. While reconstructive surgery is preferred over amputation, surgeons who aim to perform it are faced with many challenges.

In the Charcot reconstructive surgery, a surgeon removes a wedge of decaying bone from the foot, allowing the arch of the foot to be reconstructed and preventing the need for future amputation of the foot. However, there is a lot of variability in the size of the osteotomy performed due to how much bone has decayed in each specific patient. On top of this, the rate of bone decay may cause bone positioning to shift between the time at which x-rays are taken and the procedure is performed. This forces surgeons to use a guess and check method when performing Charcot reconstructive surgery and can intimidate surgeons that do not have a lot of experience with this procedure. In response to this issue, Paragon 28 aimed to create a product that addresses the need for a more reliable and reproducible method for performing the surgery. The aim of the product was to guide surgeons of all skills levels through the reconstructive surgery, regardless of the differences between each patient's case. To achieve this, the product needed to facilitate the adjustment and guidance of biplanar saw blade cuts and allow for guidance of the procedure for medial, lateral, and plantar surgical approaches.

Tasked with designing this product, a Mountain Top Engineering team at the University of Denver created a series of mechanical systems to serve as a cut guide for Charcot reconstructive surgery. These systems include a proximal frame and distal frame, cylindrical cut slot inserts, and an external guidance system. The frames and cut slot inserts allow for rotation of the cut guide in both the sagittal and A/P plane of the foot, whereas the external guidance system allows for the adjustments of these components to be visualized through fluoroscopic imaging before the procedure is performed. Cut slots were designed to be used with a reciprocating saw blade and were dimensioned to confine saw blade movement to specific degrees of freedom. The frames were built with angled mounting holes to ensure the product does not move after being set, while set screws were built into the frame to allow for locking of the cut slot inserts. The external guidance system was constructed with a plastic body and set of parallel rods, allowing the cut planes to be projected onto the foot in fluoroscopic imaging. When combined, these systems facilitate the removal of a wedge of bone from the foot through biplanar saw blade cuts.

As a result of this product being used, Charcot reconstructive surgery becomes more reproducible for surgeons using this device and surgeons can be trained for this specific type of surgery. As such, the product allows foot and ankle surgeons of all skill levels to perform this surgery, increasing patients' accessibility to Charcot reconstruction.

Student Team Members

Stormy Hegg

Elliott Ische

Steven Said

ACKNOWLEDGEMENTS

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Thank you, friends, family, and support systems who contributed to the success of our students who are showcasing multiple years of hard work and dedication to their studies.

For more information, visit ritichieschool.du.edu

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UNIVERSITY OF DENVER