ASSISTIVE PADDLE MOUNTING SYSTEM FOR PARA-KAYAKING SPORTS

Betsabe Hernandez, Dinh Le,
Rin Ray, Weston Randall
Embry-Riddle Aeronautical University
Daytona Beach, FL, 32114
hernanb7@my.erau.edu

ABSTRACT

According to the Americans with Disabilities Act (ADA), a person with a disability is one who has a physical or mental impairment that substantially limits one or more major life activities [1]. In the United States, sixty-one million adults live with a disability [2]. Consequently, parasports—sports designed to accommodate the limitations of the disabled—have increased in popularity in the US. Assistive devices for kayaking specifically benefit those that are unable to participate in traditional kayaking sports. The extra support helps compensate for their inability to handle a paddle. A previous design, the Gamut Hinged Mount by Angle Oar, allowed for users to handle a paddle by holding it in place by a static bar, however, this design has poor structural stability and a short product life span due to fatigue. Considering these shortcomings, the team developed a new paddle holder that mimics the motions that a regular paddler would experience. The new device's key characteristics includes a ball & socket within a 20° angled arched rail allowing for natural figure-8 motion profile. Additionally, the team focused on using lightweight and strong marine grade materials to increase the expected life span of the paddle mount. After creating the adaptive device in SolidWorks, a motion-path simulation was performed on the model. And after overlaying the motion-profile of a regular paddler over the simulation, the results showed that they were nearly identical. This is a step towards the team's goal of creating a device that could help those with a mobility disability that want to kayak again.

Background

In collaboration with the *Oceans of Hope Foundation* (OOHF), an IRC 501©(3) non-profit organization that offers para-kayaking events in North-East Florida, our team has created an assistive device prototype for a para-kayaking sports. The team has based the model of this prototype off the *Gamut Hinged Mount* by *Angle Oar* (the assistive device used by the OOHF) and have made major modifications based on both client requirements and the feedback from the OOHF members who have used this assistive device. The problems experienced by users at OOHF is the susceptibility to deformation by bending and failure when the kayakers exert too great a force thereby, increasing the risk to users in their need to compensate for the force required to paddle—and the motion path of the paddle does not mimic that of an unassisted forward stroke made by a non-disabled person. Taking into consideration of these shortcomings, the team designed a slotted arc that has a ball and shaft inserted into it which is attached to an oar.

Test procedure

The initial design was created within SolidWorks to allow for a pseudo-physical and computational analysis to be performed before building the prototype. Next, a motion simulation function within SolidWorks was used to track the motion of two endpoints on the model to obtain theoretical data of the paddle's ranges of motion as it goes through the slotted arc. The motion path was then compared to existing research on kayaking motion to assess the validity of the design [3][4]. After validation, the SolidWorks model was 3D printed for testing. The 3D printed part would be used for motion capture testing to measure the range of motion used when using our device. Further testing was done using ANSYS with a mesh size of 8mm to determine the total displacement of the slotted arch when under a load of 150-lbf.

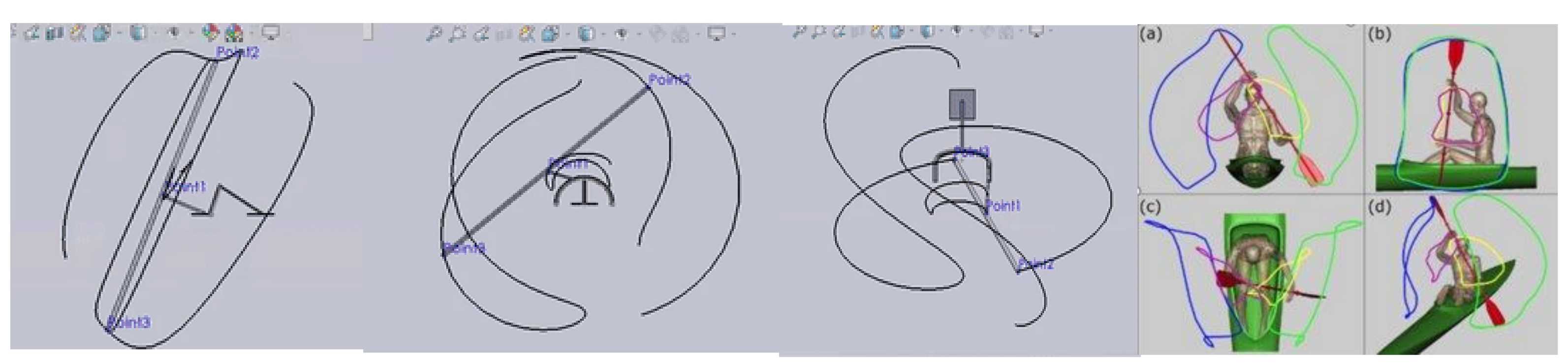


Figure 1: SolidWorks motion profile of the adaptive kayak device in comparison to the average Motion Path of Athlete Kayaker from (a) front, (b) side, (c) top and (d) oblique views. [2]

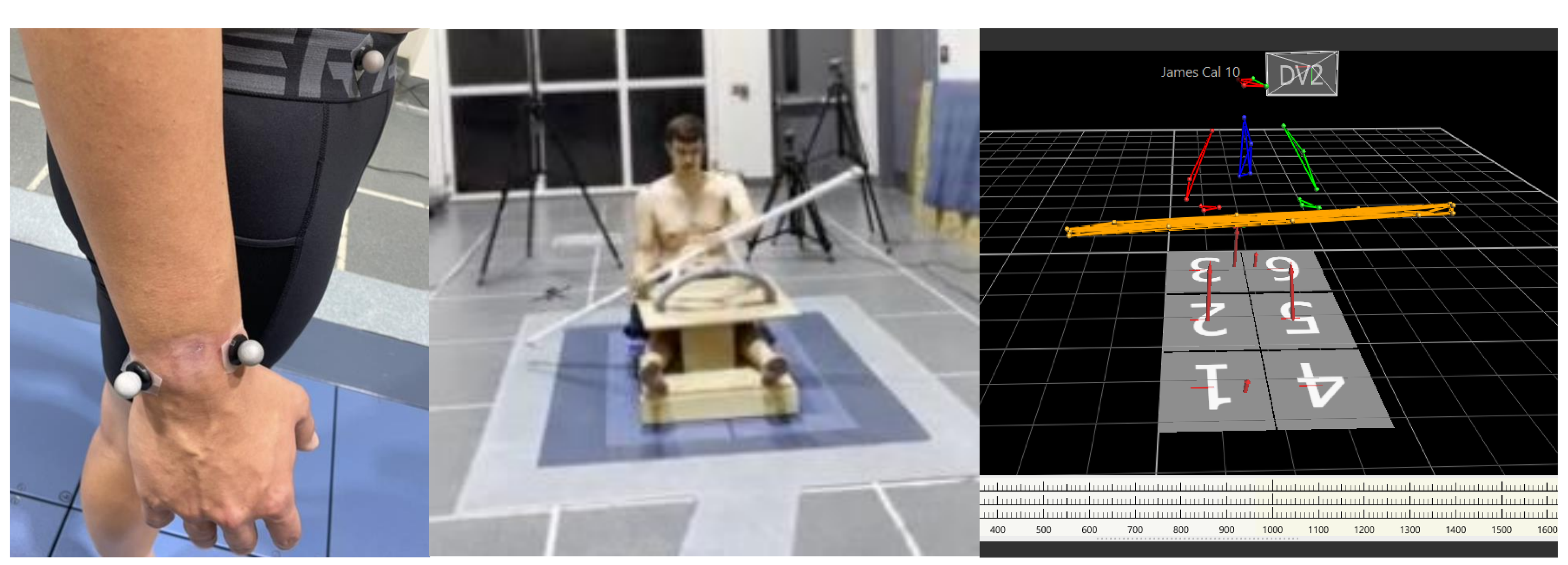


Figure 2: VICON Motion Capture was used to track the motion path of the prototype in the Embry-Riddle Aeronautical Universities Research Park (MicaPlex). Trackers were placed on the subject's body and then the data was uploaded to VICON and OpenSim to be processed.

Methodology

Material	Poisson's Ratio	Young's Modulus [MPa]	Strength (1-5)	Waterproof (1-5)	Result
Nylon	0.39	2700	5	3	8
Polypropylene (PP)	0.43	3200	4	5	9
Polylactic Acid (PLA)	0.35	3650	3	2	5

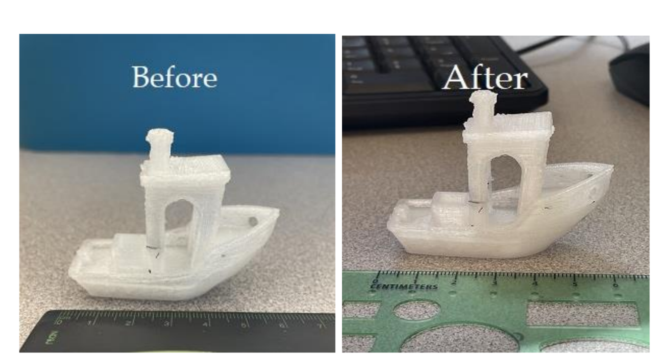
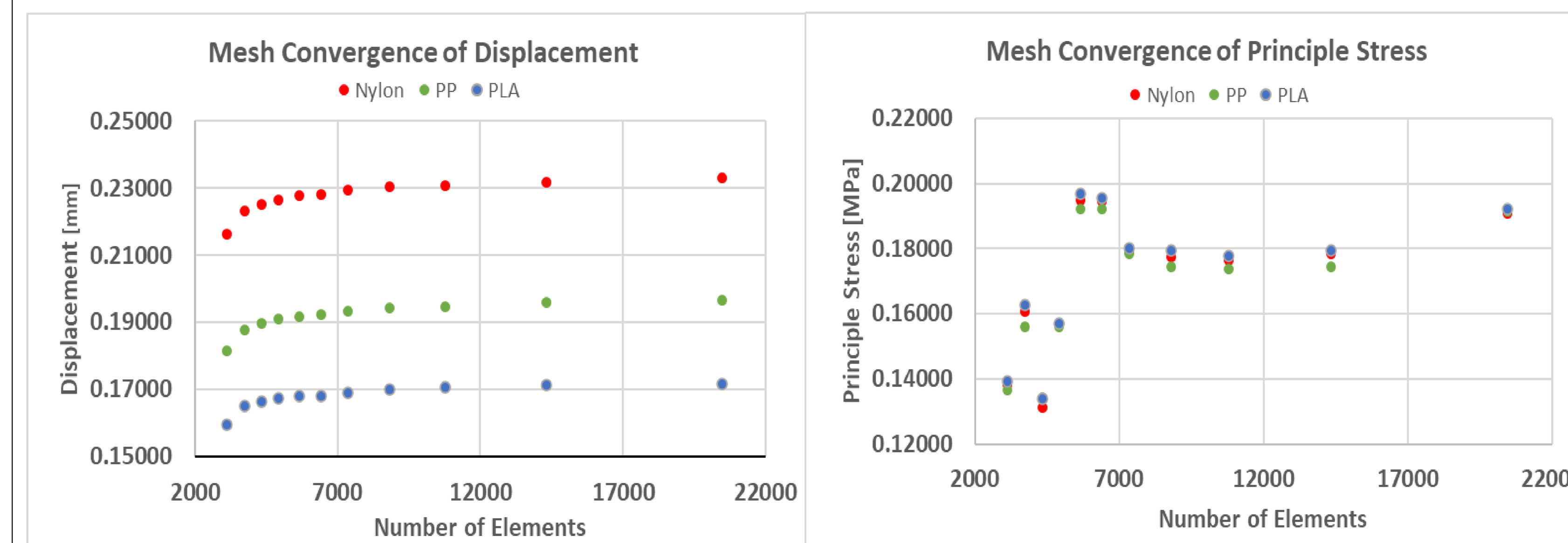


Figure 3: Submersion of polypropylene test piece in simulated brackish water after 72-hrs.

Equipment and Software	
EPPL's Makerbot Replicator 2X	ANSYS
Ultimaker	VICON
SolidWorks	OpenSim

Results

To create the most accurate and precise simulation of results, a mesh convergence study was performed to determine which mesh size(s) may be applied to the model.



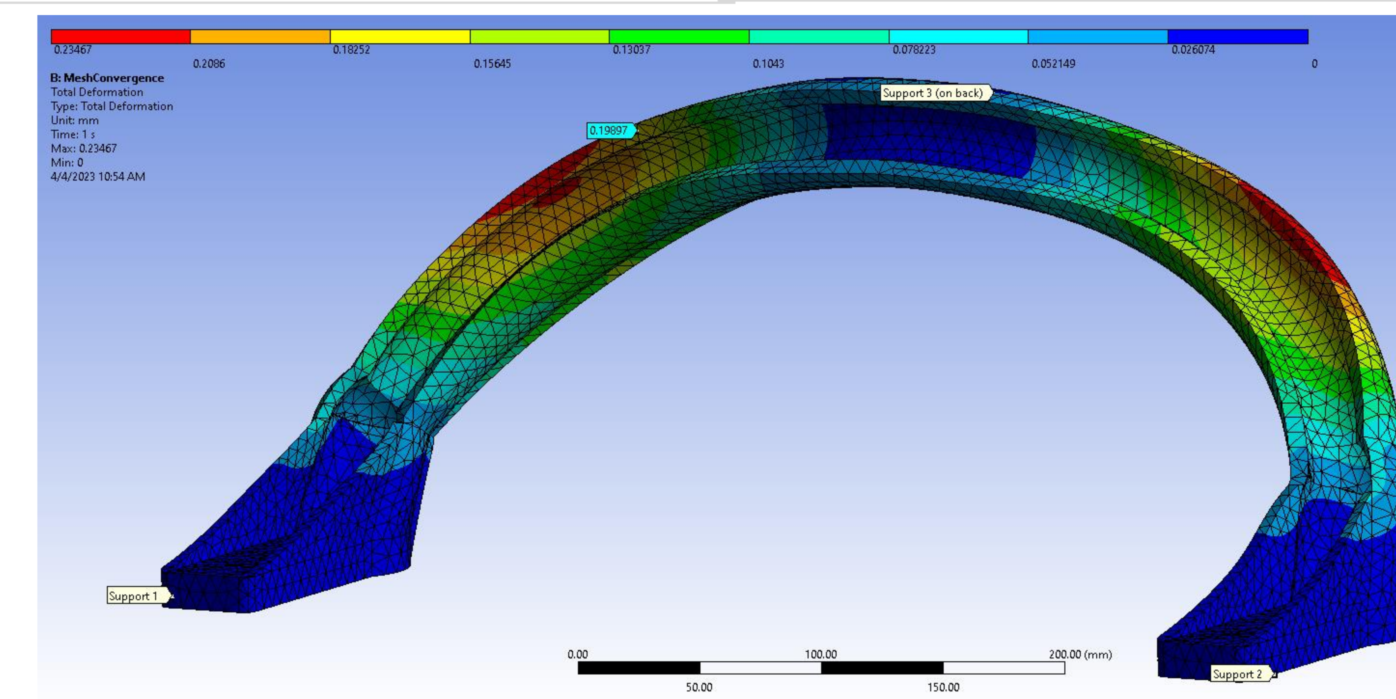


Figure 4: FEA of slotted arc simulated deformation

Conclusions

As it stands, the team has successfully created a fully working prototype that is undergoing motion capture studies to validate its functionality. The device's laboratory motion capture data has proven to follow the path of the motion path simulations made in SolidWorks, which are comparable to literature. Looking into the future, the team has been accepted to participate in the ASME 2023 International Mechanical Engineering Congress and Exposition (IMECE2023) as is expected to attend this conference to share our current findings.

References

[1] Americans with Disabilities Act National Network. (2022, December). What is the definition of disability under the ada. ADA National Network. https://adata.org/faq/

[2] National Center on Birth Defects and Developmental Disabilities, Centers for Disease Control and Prevention. (2022, October 28). Disability impacts all of us. CDC. https://www.cdc.gov/ncbddd/

[3] Harrison, S. M., Cleary, P. W., & Cohen, R. C. (2019). Dynamic simulation of flat-water kayaking using a coupled biomechanical-smoothed particle hydrodynamics model. Human movement science, 64, 252-273.

[4] López, C. L., & Serna, J. R. (2011). Quantitative analysis of kayak paddling technique: definition of an optimal stroke profile. Revista Andaluza de Medicina del Deporte, 4(3), 91-95.

Acknowledgments

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