

Wearable Robotics in Muscular Rehabilitation
(Technical Topic)

Technology and Surf Extinction; How Artificial Waves Threaten Traditional Surf Ideals
(STS Topic)

A Thesis Prospectus
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Prospectus

Introduction

The nature of sports creates an inherent competitive drive among athletes to be the best, leading to the constant and rapid evolution of sports technology. Athletes want the ideal settings with the best gear and the least limitations to allow them to perform at their best, all of which are made possible by technological progress in wearable technology. Wearable technology takes many forms, such as cleats and helmets, electronic sensors such as heart rate monitors, or even prosthetics and robotics to assist those with disabilities. The latter example represents the forefront and future of wearable technology, and has countless possible uses such as assisting those with motor function problems to accomplish daily activities independently (Tong, 2018). The goal for the proposed capstone project is to develop an upper limb exoskeleton that aids the user in upper body movements by reading their muscle activations, which can be applied to hospital patients with neuromuscular disorders.

Wearable technology is not the only sector of sports technology that has seen significant strides recently. Creating artificial environments for sports has been around for centuries, with innovations such as turf fields for soccer and indoor pools for swimming. Perhaps the most impressive of these innovations in recent history is the ability to simulate the power of ocean swells. Just within the past six years, wave pool technology has advanced to the point where perfect, six-foot, barreling waves are created on demand, opening a world of possibilities to both recreational and competitive surfers. This technology brings the sport to landlocked individuals, and also provides the opportunity for repetition in training, something that is immensely scarce in nature. Despite these benefits, many in the surf community argue that these pools really lead to dilution of skill, de-spiritualization of the sport, and even class division. The proposed

research paper plans to discuss the effects of wave pool technology on the surf community, as well as the possible impact that this social reaction may have back on the development and implementation of wave pool technology itself.

Technical Topic: Upper-Limb Exoskeleton

The medical application of wearable electronics has been extremely beneficial to both patients and providers for a multitude of reasons, such as robotic prosthetics and biometric monitors. Wearables are a non-intrusive way to collect data and assist in rehabilitation for either disease or accident-related injuries. This technical project of creating an upper body exoskeleton aims to comfortably assist patients with neuromuscular disorders to accomplish daily tasks with their upper body. Furthermore, the goal is to create the most efficient design both mechanically and electronically to ensure that the exoskeleton is usable for long periods of time. Initially, the group will learn and understand each component of a mechatronic system as basic background to reach the final goal. Once each component has been experimented with and understood, the team will be divided into three groups: one to design and perfect the circuitry and sensors behind the exoskeleton, one to draft and create the mechanical structure of the shoulder joint, and one to design the structure of the elbow joint. I will be a part of the elbow mechanical design team, with the goal of designing the actuators to achieve the two degrees of freedom observed in the elbow joint. The three parts will then be integrated into one design, and the exoskeleton will be refined as a whole. After the initial prototype is completed, the team plans on obtaining feedback by having UVA hospital patients use the exoskeleton, and surveying both patients and providers to determine ways to improve the next iteration of the design.

This exoskeleton will integrate the use of electromyographic (EMG) signals and pneumatic actuators controlled by air pressure. EMG signals measure electrical currents

produced by the nervous system during muscle activity (Raez, 2006). These signals function as an intention prediction of human motion, specifically in a human-robot collaboration such as this one. Pneumatic actuators imitate the contraction and relaxation of muscles and allow for an accurate range of motion without rigidity of DC motors. There are many different types of actuators and choosing the best design, along with the use of EMG sensors, will provide the basis for a working and efficient exoskeleton. After the research, design, and prototypes, the final deliverable will be a functioning upper limb exoskeleton that accurately predicts and assists the user's arm and upper body muscle movements.

STS Topic: Artificial Wave Pools

Surfing culture is incredibly nuanced, and is not quite like any other sports community. This distinction in part has to do with the fact that most surfers do not simply see surfing as a sport; instead, surfers will claim that there is an inherent connection with nature and its power, a spiritual and therapeutic connection, and even a religious connection. Human rights researcher Mark Stranger claimed that surfing is a “pursuit of an ecstatic communion with nature” (Stranger, 1999), illustrating the tie that surfing has always had with nature. Human geographer Jon Anderson also wrote that surfing is “not simply a site of human-nature relations, but also as a space of spirituality” (Anderson, 2013). People will give up career and relationship opportunities for the sake of building a life around surfing, and in surf towns the social hierarchy can depend on one's wave riding ability, such as at North Shore, Oahu. Not to mention, the Hawaiian people have an ancestral tie to the sport, as surfing was born from the Hawaiian natives and was a sign of class (Surfing History and Origins of Surfing, n.d.). All this to say that surfing is more than a simple athletic activity. With such a passionate community, surfers tend to become defensive

about protecting their sacred sport, especially when there is something that threatens to change the entire sport.

There are two main subsections of modern surf culture, the “soul” surfers and industry surfers. The former conforms to a more traditional mindset in surfing, in line with the ideals described above such as leisure, freedom, spirituality (Roberts & Ponting, 2020). In more recent history, however, there has been a major commercialization of surfing. Commercialization involves huge media attention, popularization of surf style, the rise of professional surfing as a competitive sport, and utilizing surf tourism for profit (Warren & Gibson, 2014). This side of surfing is the industry side. Although it can be argued that both sides need each other to be sustained, there has always been conflict from “soul” surfers claiming that the industry is full of “sell-outs” and that it is not true to surfing, it isn’t authentic. In 2016, 11x world champion Kelly Slater unveils his Surf Ranch: an artificial, mechanically produced perfect wave, complete with perfect barrels and long rides (Is Kelly Slater’s Artificial Wave the Future of Surfing? - Los Angeles Times, n.d.). Slater’s wave pool is perhaps the largest development in surf history, and also the furthest extreme of surf commercialization. On one hand, this technological development provides perfect waves on demand, allowing repetition in practice, something that is scarce in the ocean. It could be a perfect training ground, and even bring surfing to those without access to surf. Despite these benefits, “soul” surfers will say that this is not real surfing; there is no reading the waves, duck-diving, sense of adventure, connection with nature, risk of drowning, and much more. In short, it lacks “authenticity,” something that is very important to lifestyle sports such as surfing, climbing, and snowboarding (van Bottenburg & Salome, 2010). In addition, due to surfing’s innate tie to nature, the idea of sustainability has long been a focus in surf culture (Lazarow & Olive, 2017). Wave pool technology contradicts this interest, as wave

pools have significant negative effects on the environment (Hill & Abbott, 2009). Years later, the debate about wave pools has not waned, and wave pools are only expanding across the globe.

Will wave pool technology be the future of surfing, or the death of it?

In order to sufficiently address the polarizing topic of artificial surfing waves, the frameworks of social construction of technology and technological momentum will be utilized. Social construction of technology (SCOT) is the idea that social constructs in society are pivotal in shaping how technology develops. SCOT has five major related components: interpretive flexibility, relevant social group, closure and stabilization, the wider context, and the technological frame (Klein & Kleinman, 2002). These concepts together describe how different groups can have different influences on technology development. While SCOT is a key concept in beginning to analyze the relationship between society and technology, it has been criticized for its lack of structure (Klein & Kleinman, 2002) and lack of detailed analysis on technological development itself (Pinch, 1996). Despite not providing a detailed approach on unearthing an exact cause-effect sequence for society and technology, SCOT as a general framework is still helpful in shedding light on social influences on technology. SCOT will be used to discuss how the social perception of wave pools by surf culture could reshape the design and implementation of wave pool technology in the future. Surfers tend to reject industrialization and embrace tradition, so this social hesitancy to surfing change could greatly inhibit wave pool technology development.

Technological Momentum is the idea that the relationship between societal influence and technology is time dependent; a new technology is often shaped by the society around it, but as the technology grows larger and more complex it becomes the shaper of society (Hughes, 1994). Technology historian Thomas Hughes says this provides a more accurate, time dependent

approach to viewing society and technology than just SCOT or technological determinism. It is argued, however, that technological momentum does not actually present any new model as an alternative to social construction and technological determinism, but instead it is just combining the two and presenting it in a different package (Colarossi, n.d.). This being said, technological momentum is still a useful concept to use because even if it is not a completely new framework, it still provides a useful junction of social construction and technological determinism and provides structure to when each one should be used. Technological momentum is helpful for this research because it gives insight into how wave pool technology may end up reshaping surf culture itself in the future, as opposed to the other way around. While wave pool technology is young right now and surfers have the ability to reject the technology, there may be a future where wave pool technology is deterministic in surfing, forcing all surfers to adapt to surfing's new reality.

Research Questions and Methods

The specific research question is: How do artificial wave pools threaten the traditional social ideals of surf culture, and how will this technology shape the future of the sport? I plan to discuss the social ramifications that wave pool technology has posed to the surf community, and then determine how this social outlook on the technology may influence the design and implementation of wave pools in the future. Using search engines specifically for academic research papers, I have been gathering sources that apply to the research question. In searching for academic papers, using key words such as “wave pool,” “surfing,” “social construction,” “authenticity,” “surf parks,” and “lifestyle sports” narrows down search options to papers discussing the social aspects of surfing and similar sports, as well as papers discussing wave pool technology and its critiques. I am also using more colloquial articles from popular surf

magazines to provide opinions from people in the surf community directly, to be used as evidence. Using this document research method, I have procured a collection of sources which all pertain to the concepts of wave pool technology and surf culture. With these sources, I will use discourse analysis to compile the important and relevant aspects of these sources and construct an argument to my research question based on this research. This method will provide a well-informed approach to answering the research question, enabling analysis of all sides of the conversation equally and totally.

Conclusion

The technical deliverable will be a functional upper-limb exoskeleton, with the purpose of assisting those who suffer from neuro-muscular disorders with day-to-day movements. Electromyographic (EMG) sensors will be used to detect muscular activation in the user in order to predict movement intentions. Pneumatic actuators will be used as artificial muscles in order to replicate the human arm motion with similar contraction qualities as real muscles. The design will be tested and reviewed by UVA Hospital patients experiencing neuro-muscular disorders, leading to subsequent redesigns to optimize user experience.

The STS deliverable will be a thorough analysis of how new wave pool technology threatens the traditional social ideals of surf culture, as well as how the social perception of wave pools by surfers will alter and shape the future of the technology. This includes gathering a collection of research papers related to topics such as surf culture, surf industry, wave pool technology, authenticity in sports, and commercialization of lifestyle sports. The important information and ideas from these sources will be looked at using the frameworks of social construction of technology and technological momentum, providing evidence to form an argument or discussion pertaining to the social repercussions of wave pools.

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