Prospectus

Self-Sufficient Light Up Vest Design
(Technical Topic)

Analysis of the Failure of the TALOS Exo-Skeleton Suit
(STS Topic)

By

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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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Introduction

Energy efficient technology is an up and coming field that is at the forefront of political arguments due to the increased focus on climate change. A specific sector of energy efficient technology, self-sufficient technology, is an energy efficient technology that can power itself. Further, wearable advances in technology involve technology that is worn on the body of a human. With this in mind, sometimes the only way someone can exercise is by running during times of low visibility, whether that is during the early morning, late at night or during foggy conditions. Low visibility creates its own issues, from cars being unable to see the runner, to random attackers, low visibility can cause danger while running (Svrluga, 2015). The problem of designing wearable technology for human safety is a socio-technical problem, and must be designed with both technical and social aspects in mind.

The technical solution that our group is proposing is a safer solution to running in low visibility by creating a vest that powers lights using the mechanical motion of a runner's torso. A runner wears the vest while running, and using the natural oscillation of the torso converted into electrical energy, the vest will light up strips of LED lights making the runner more visible and creating safer running conditions. The main benefit is higher visibility for the runner during the run at lower visibility time and a feeling of more safety for the runner.

In order for the proposed technical solution to succeed, we also need to learn more about how technologies have to function within larger networks made up of different actors, both human and non-human, all of which can contribute to a network's successes. To do this, I will analyze the case of the TALOS exoskeleton military project. A parallel can be drawn between the design of our vest and a suit that has been in development for the military for many years. Both of the technologies that are being developed for these projects are being developed for the purpose of making people's everyday life safer. The military exoskeleton suit is being developed as a bulletproof suit that can be worn by a soldier, making different types of missions much safer for the soldier (Machi, 2018). Looking into the social aspects of the case increase the understanding of the social aspects of the proposed technical design. I will outline the design of a vest that can increase runner safety by harnessing mechanical energy into electrical energy to provide power to LED lights. Then, I will use actor-network theory to address how the design of an exoskeleton suit for the military failed.

Technical Problem

Electrical energy can be harnessed from the vibrations caused by the running motion of a human. One of five key running dynamic variables is vertical oscillation, which varies greatly from runner to runner. It is characterized by the amplitude of the oscillation of a runner's center of mass and is measured in centimeters (cm) (Folland, 2017). An important factor of vertical oscillation is that it is both repetitive and predictable for one runner, allowing it to be manipulated for energy-harvesting purposes. This can be done through the use of an electromagnetic Faraday generator to create electrical energy. In a typical linear Faraday generator, a magnet is placed in an ideally-frictionless, cylindrical chamber wrapped in a coiled wire. The magnet is allowed to oscillate between the two ends where it bounces off springs to conserve its residual momentum (Mah, 2008). The movement of this magnet generates electricity through Faraday's law of induction: electromotive force is directly proportional to the number of turns of wire and the change in magnetic field and inversely proportional to change in time (The Editors of *Encyclopaedia Britannica*, 2013). A common way of storing electrical energy is through supercapacitors, which are a type of electrochemical energy storage device. When a voltage is applied to a supercapacitor, opposite charges accumulate on either side of the device.

The technical portion was written in collaboration with Kyle Peter

An electrolyte solution between the two sides balances the overall charge of the electrodes. The generated charge can then be released quickly for a number of uses.

The given technical design problem of converting physical energy to electrical energy through exercise is not addressed directly in today's market. An existing product that partially addresses this problem is a Faraday flashlight, which houses a linear Faraday generator in the body of a flashlight acting as the light's power source ("Shake Light 40 Rechargeable Flashlight," n.d.). Because the use of this product is predicated upon deliberate, isolated movement of the flashlight through a shaking movement of the arm, it does not meet the requirements of the technical design problem at hand. A product on the market that supplements the given problem is a high visibility (hi-vis) running vest, but no versions are mechanically rechargeable as they rely on conventional batteries or capacitors that need to be charged through a power outlet ("Safety Depot Mesh Safety Vest", n.d.).

With the introduction of a new technology that clearly meets the requirements of this technical design problem, users can gain the ability to capture energy from exercise. Within the context of running, this ability has not yet been experienced and there is a great deal of mechanical energy that can be harvested and re-used for practical purposes.

Our team is designing a high-visibility running vest that can translate the energy from human exercise to provide light. Through the use of four Faraday generators fixated to the vest (two on the front and back each), the mechanical energy from the vertical oscillation of human running will be translated into electrical energy. This energy will charge supercapacitors which will then be stored and released to power strips of LED lights. The vest will also be equipped with strips of reflective material like those on current hi-vis vests. Runners wearing the vest will be seen much more easily and have safer runs in low-visibility conditions such as late nights, early mornings, or fog.

Existing products will be modified to create the projected design: a shake flashlight, LED light strips, and a hi-vis vest. In the prototyping phase, the shake flashlight will be deconstructed in order to isolate the desired part: the linear generator. Modifications to the linear generator will be made if necessary and its period will be adjusted to match that of the runner's vertical oscillation. The hi-vis vest will be made more form-fitting, if not-so already, to increase isolation of the runner's vertical oscillation, and compartments/Velcro strips will be added to house the linear generators and attach the LED strips. Once developed, a user will wear the vest while running to test the product.

STS Problem

Exoskeletons are an emerging technology with a variety of applications, mainly in the military field. Exoskeletons are suits that are worn on the outside of the body which are used to enhance the abilities of the user. This can be done in a variety of manners, from reducing stress on joints, providing support for different parts of the body, or enhancing human capabilities.

The United States Special Operations Command (SOCOM) was designing a suit which was akin to that worn by Iron Man in the popular Marvel movies. The suit was called the Tactical Assault Light Operator Suit (TALOS) (Tucker, 2019). To design TALOS, SOCOM enlisted the help of nearly 100 different corporations, including Raytheon, General Dynamics, Nike, Adidas, and Revision Military (Smith, 2015). The main goal of the TALOS suit is to help the survivability of the first commando in a room during a raid (Machi, 2018). SOCOM scrapped plans for the suit because the technology of today was not advanced enough to create the suit.

This explanation of the failure misses the bigger role that other human and non-human actors played within the network of the design. By looking only through the lens of technical failures, we miss out on the many other factors that are connected to the failure of TALOS. One major issue that SOCOM ran into when designing the suit is that the large number of companies involved created an unsustainable chain of communication. With almost 100 companies working on different parts of the same project, making sure communication was synchronized throughout the companies was difficult (McCaney, 2015). Another social impact is similar to the "Google Effect." As Carr states in "How smartphones hijack our minds," "Anticipating that information would be readily available in digital form seemed to reduce the mental effort that people made to remember it" (Carr, 2017). Remembrance of miniscule facts has gone away, and a parallel can be drawn to exoskeletons. Once exoskeletons become mass produced, soldiers may lose their unique, human abilities. The soldiers may become so reliant on the suits that they no longer have appreciation or need for their human abilities (Spiekermann, 2015). Another factor affecting the downfall was that US taxpayers were paying for SOCOM to spend money doing research and development for 6 years on a suit that never came to fruition. SOCOM kept pushing back deadlines for its project until it scrapped it altogether. This caused US taxpayers to pay much longer than previously expected.

By not exploring these other issues, the public misses out on learning why research and design of TALOS failed, creating the opportunity to fail the same way in the future. I argue that, in addition to the technological dead ends that were experienced, the money spent on TALOS, in conjunction with a failure to synchronize multiple companies, and the de-humanization of the soldiers using the suit led to the downfall of TALOS. My analysis of this case relies on the science, technology, and society framework of actor-network theory, which analyzes the dynamics that occur in a network of human and non-human actors assembled by a network builder to accomplish a goal (Cressman, 2009). More specifically, I will look at the role of SOCOM as a network builder, and its inability to synthesize the actors, both human and non-human, towards the common goal of creating the suit. The human actors include the US taxpayers, as well as the companies involved in the design of the suit. The non-human actors include the insufficiency of the technology, the chain of command and communication of the companies, and the impending de-humanization of the soldiers using the suit.

Conclusion

The technical report will provide a new design for a vest that will harness the naturally occurring mechanical energy during running and use it to power LED lights. The design will use linear generators, connected to a vest that will be brightly colored, and will provide additional safety for the user. The STS research paper will highlight an exoskeleton suit that was being developed by the US military for additional soldier safety and how the human and non-human actors factored into the failure of the suit.

Together, these two papers will work together to address the socio-technical problem of designing wearable technology for human safety. The design of the vest will be improved due to the findings of the STS research paper. Learning from these findings, we can design the vest to avoid the multitude of failures that occurred during the design of the exoskeleton. The vest design will address the field of runner safety, and the STS paper will show complications that occurred during the design of the TALOS exoskeleton for soldier safety.

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