The Integration and Advantages of Technology with Biomimicry

(Technical Paper)

Understanding the Methods and Implementations of the Engineering Design Process

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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

Have you ever given thought as to the origins of certain technologies, instruments, or tools you see or utilize on a daily basis? Whether it is sitting at home or running errands, we move through life with the intention of completing our task without realizing that throughout history, we have been affected by nature in the scope of technology. Simple objects such as tape, velcro, LED light bulbs, and suction cups were all inspired by nature: Tape, gecko; velcro, burdock burrs; LED light bulbs, the firefly; suction cups, the octopus (Vanderbilt, 2012). Other inspirations like apartment buildings, shinkansen trains, and sonar technology are more prominent examples where Scientists and engineers have studied the world around us to develop the technology. Being inspired by nature has more significance than most engineers think. Research from various institutes have shown that not only can we learn from other species to improve efficiency in infrastructure and machines, but we can also advance our current technology even on the microscopic scale. The study of nature can lead to a world where our society is more conscious of our environment and even so far advanced that the mortality rate is nearly zero percent.

The focus of this research is to analyze the methods in which the incorporation of nature and different species with mechanical and organic systems can improve our current technology by examining research conducted by various engineers and scientists. The study of bio-inspired mechanics and biomimicry is relatively new compared to most fields, but this study yields substantial evidence that our modern technology has yet to improve and can be done by implementing specific elements from nature. By creating a connection between nature and technology, engineers will be left with a systematic process that will allow others to gain insight and perspective to conduct a new form of applied science. Below I will provide the technical solution to create a method to create a new kind of engineering design process. Additionally, using Wicked Problems as a framework, I will assess the complexity of how an engineer understands the implementations of bio-inspired mechanics and biomimicry in the engineering design process. I will also prove that the integration of the two studies yield preferable results compared to traditional methods in designing and creating technology by presenting various studies that have been conducted. This method of thinking can be applied to the Capstone project provided by Christopher Goyne in multimedia real-time weather and traffic data integration. Throughout this paper, I will display how biomimicry can better technology and how changing engineers' comprehension of the problem to include aspects taken from nature can improve the final product. This connection will be made by researching various element of the system that is under observation and examine certain functions of the system that can be refined by bio-inspired mechanics.

Technical Problem

To arrive at the goal of obtaining an advanced method of the engineering design process, engineers must first deconstruct it from the beginning. According to Figure 1, the first step is "Identifying the Problem. This step engages the engineer or designer to have a general

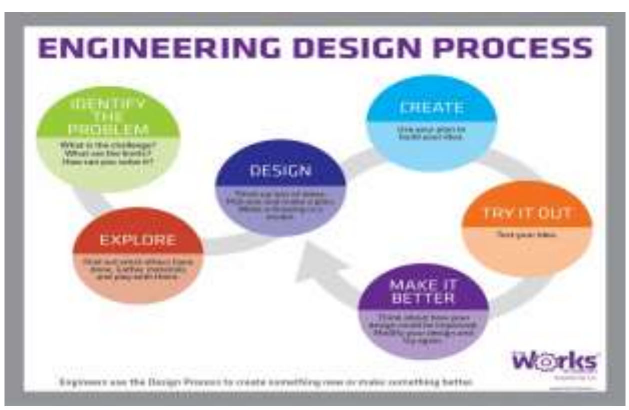

Figure 1: Engineering Design Process (The Works, 2008)

knowledge of the issue at hand. Having a certain goal in mind, the thinker must layout or brainstorm what issue lies ahead, like physical limitations. The second step is the "Exploration stage. Even though one may have a good base knowledge of the problem, intuition is not enough. Extensive research is needed in order to truly understand the system that is under observation. Collecting knowledge of the system requires extensive research on all areas that are physical and theoretical. Some may gain knowledge through example. It is possible that a person can learn via instructions, thus, giving him/her experience in mastering the manipulation of a material. Theoretical research refers to the study of its physical and biological function. Now that an understanding of the problem at hand is completed, the next step of "Design" can commence. This step is where using the collected knowledge, one can draft a blueprint or map out a physical brainstorm of the system. The draft of the system that is under observation consist of a range of inscriptions like a list of materials and its dimensions to basic instructions with diagrams. Doing so aids other engineers on what one is thinking. Not only is this a crucial step to an engineer, but this also becomes an opportunity for creativity to take its first form. The designing phase gives visual aid to the engineer, and with the understanding of a particular element from nature that is to be implemented, the engineer can render the system to cater to a new creation. At this stage bio-inspired mechanics/ biomimicry is embedded in modern mechanics.

Many inventions, like Velcro, were inspired by nature. (Tan, 2016) Velcro, that has been around since the 1950s, created when the Swiss electrical engineer, George De Mestral, was hiking and wondered why burdock seeds would stick to fabrics. The functions of the small thin arms that extrude from the center of the plant pod that reaches out in all directions to grab onto animals passing by to pollinate/relocate were introduced in the engineering process's design phase. The act of taking and replicating a function and developing a new form of technology has not only been done by many but also yields performance improvement. Many institutes and companies have adapted their thinking in experimenting with new products.

The integration of nature in technology that has yielded result that suggest higher rates of efficiency compared to modern machines that execute similar function can be seen today. Boston Dynamics created a four-legged nibble robot that is equipped with a sensor that is able to map environments, avoid obstacles, climb stairs, and open doors. One may think that this creation is, while impressive, not that practical. Adam Ballard, BP's facilities technology manager, stated, "There are thousands of pounds of pressurized combustible material out there. High-pressure oil and gas can create risks for people working in close proximity. If we could have a robot with the proper sensors out there, we would much rather do that." (Ballard, 2013) proves its practicalities. One function that was observed is its movement. Spot being the robot's name is articulated enough to mimic a four-legged animal. The ability to move in all directions and climb up straits makes for a better method in creating a robot if its goal was to manage pressurized combustible material and high-pressure oil and gasses. Without biomimicry's implementation, robots that are capable of doing the same job would not necessarily have arms or legs, but have wheels that hinder the robot's ability to maneuver over different surfaces, including stairs. Other than facilities being managed, Spot has also been integrated into NASA's mission. With their ability to walk over rugged terrain, rovers with traditional wheels are soon to be phased out of commission. In the years to come, the practice of creating technology inspired by nature will instill a dramatic change perspective that brings creativity. The following few steps in the engineering design process "Create, Testing, and Making it better" are all equally important steps compared to the rest though the main focus lies on the steps mentioned earlier, for they are the backbone of inspiration and biomimicry in its essence.

In general, the method of mimicking a particular function and manipulating it to foster nature's attributes can be used toward a pre-existing technology to enhance its efficiency. The Central Intelligence Agency's Insectothopter built during the Coldwar, was a miniature flying listening device that had the capability to collect audio intelligence and was the size of a dragonfly. As shown in Figure 2, the Insectothropter was made to function and mimic a dragonfly. Its effectiveness in surveillance was underemphasized. While not much is

Figure 2: The Insetrocopter (CIA, 1970)

known about the details of the Insectrocopter for reasons of national security, this device yields evidence of biomimicry being a type of innovation that improves technology. Other professional areas, such as medicine, have seen advantages in incorporating biomimicry inspired technologies. The Ultracane developed by a team of researchers at the University of Leed in the UK is a cane that biosensors. It lowers the chances of hospitalization and the need for drugs saving the patient from huge costs. The use of echolocation is the main function was taken from bats for their heightened sense of navigation. The Ultracane is catered for the visually impaired and It allows users to detect obstacles and is found to be more effective than the traditional cane that is dragged forward and is swung on the ground from side to side. It incorporates narrow wavelengths of ultrasonic wave emitters and sensors that can detect objects two to four meters ahead. It also uses haptic feedback as a way to tell the user that an obstacle is in his/her surroundings. By using catalysts to quickly decompose hydrogen peroxide and create a very fine spray of near-boiling acid, Bombardier beetles repel attacking insects. The beetle's protection mechanism inspired Swedish Biomimetics 3000, a company in Sweden, to develop a micro-mist spray technology called µMIST that has a lower carbon impact than aerosol sprays. µMIST is also believed to be the only known method that does not require a propellant like aerosol to eject highly viscous fluids. This adaptation can be applied to nebulizers for patients who suffer from respiratory issues. A team of micro engineers at Kansai University in Japan developed a method of delivering pain-free injections by studying the bites from mosquitoes. The team manufactured the mosquito's proboscis, the fabrication of the needle allows doctors to administer drugs without pain for the patients being a factor. Traditional needles can be painful due to its smooth structure. The steel needle creates a more significant contact of the surface area, thus, irritating nerve endings. With the new type of hypodermic needle in production that is designed around the mosquito's proboscis, we can eliminate pain. On a much smaller scale, biomimicry has made it into the world of nanotechnology. The Parasitic staple was developed as a new replacement for the traditional skin grafts for burn victims. This function of small teeth that parasites have to grab on to their hosts inspired the creation of this staple. Through extensive research, this tape is three times as strong as surgical tape. Tiny rows and columns of cone-shaped needles with a stiff center mimics the spiny-headed worm’s proboscis. In use, the tape is covered over the healing skin and makes contact with the water and natural tissue. The polyacrylic acid in the tips of the needle swell up under the epidermal layer and makes for a locking mechanism with minimal pain and risk of infection. Even a biodegradable version of the parasitic staple is now in development.

As engineers continue to embrace nature as a learning platform, creating a new invention has to change due to the unconventional methods of creativity and production of new devices. Referring back to the engineering design process, a new step is to be added to ensure a change in thinking makes for a new path in technology. During the design step, a new step should follow. This new step should ask the following questions in this order: Is the operation or function of the device in production have similar traits found in nature? If so, why should such a function be implemented into the design? Does this implementation yield a better outcome than the original design? Does this change in design alter the device's intentions? Asking such questions creates a train of thought and allows the engineer to think outside of the box to foster an unorthodox way of thinking. As humans, we have many limitations. We do not adapt well to the weather environment compared to other species. We have to shelter our body with clothes even with the smallest changes in weather, our movement is limited by our physical structures, so we build machines to compensate for them. We are also very vulnerable to diseases and other microbial infections. By learning from their species, we can learn how to survive and even dramatically decrease our mortality rate.

The use of nature in technology can be adapted to aid a technical issue in numerous ways. The Capstone research project provided by Christopher Goyne, UVA's Mechanical & Aerospace Professor, has tasked students to tackle the problem of Virginia's roadway multimedia real-time weather and traffic data integration. One of the main obstacles in providing real-time weather data is the execution of data collection that is done thought satellites in geocentric orbit. The data that is gathered via satellite has faulty reading that is caused by cloud coverage, rain, snow, and other natural phenomenon. Utilizing natures designs to solve this issue is very much possible. The suggestion of changing the camera in the satellite do record data was taken into account. The changing of the camera which is dependent on the quality of the lenses and how much light is can register is a challenge. Instead of replacing the pre-existing camera with one that is bigger and better, research in efficiency was conducted on the feasibility of mimicking the mantis shrimps' eye for it is know to be able to register a wide spectrum of light (Franklin, 2013). The mantis shrimp having 16 photoreceptor and able to detect UV light is an attribute that will be useful in documenting weather data.

The complexity of altering one's perception of the how the engineering design process should be executed is challenging. Straying from a linear path of though requires an STS framework. "Wicked Problem" introduces the idea that sustainability and recognizing the problematic issue with, in this respect, engineering, is an issue that is beyond the scope of normal, industrial engineering science (Seager, Selinger, Wiek, 2011). In this context, wicked problem applies to biomimicry in a way where engineers are to approach his/her problem through a lens that is less technical focused. The term implies a more significant and profound impact on society and the environment that engineers must be cautious of when solving issues. For this reason, we focus on the engineering design process and how it is strict in training the engineer to have a linear train of thought, wicked problems help the engineer to extend their knowledge in how their new device or invention can impact their surroundings. Sustainability as a sub-category of wicked problems is highlighted in this respect for the reason that when thinking about how to solve an issue, many would first have to face the difficulties in problem formulation, which is the first stage in the engineering design process. Among sustainability, business-as-usual is a method of thinking that many engineers fall into the habit of. With regards to the scale and efficiency of creating something new, many innovations that have made the quality of living to be extravagant are not typically thought to have long-lasting effects on the environment and social/ethical culture. The complexity of this attribute is the simplification of the reduction of impact on major aspects of our culture. See that biomimicry is mostly dependent on mother nature, training a new age of engineers to look at life as a source of knowledge challenges many to stray from modern influences. The lens that changes the way we as engineers think about innovation is trapped in aged knowledge and is bound to our way of thinking and seeing things. To better illustrate this phenomenon, we can take examples from our current quality of life. Analyzing our infrastructure of modern society, we live in houses, apartment buildings, cover long distances with cars, and even travel to a different continent by plane. In a world where we collectively as a human race were closer or hyper-conscious of mother nature. What would our day-to-day look like? Would we live in houses that are built so that wildlife can flourish without intervention? Would we still cut down large acres of woodland to build suburban homes? Would the city still have an abundance of tall buildings and have grid patterned roads? while our American culture and our way of life are different compared to other countries and nations, collectively, we do not give thought to the long-lasting effects of our survival. Observing depictions and illustrations of what life for the human race would look like in the future, dating back from the 1920s, would prove that there are societal issues and how the wicked problem is evident. The way we live has rooted itself in our daily lives, government, and much more. To tackle this issue, it must be broken down and analyzed via documentary and discourse analysis. We must extrapolate information from multiple research that can deduce that biomimicry has its benefits.

The main objective of this research is that the engineering design process lacks any formulation for innovation. We are faced with the issue that our culture disables our way of thinking. This is mainly due to the fact that we are taught to imagine, perceive, and analyze so linearly that we forget the long-lasting repercussions that follow. For this reason, the issue is so deeply rooted in many areas of our lives, a change must be made in our education system; so that our future generation can be aware of inevitable consequence when creating new technologies, our government must acknowledge the issues that hide in plain sight, and for the general population to see that our quality of life is not as pleasant as they seem. Many would argue that our healthcare system has never been as advanced as it is now or that our crime rate had dramatically decreased in the past several decades, but analyzing that past to argue that we are living well is almost an illusion. For the reason that convincing an engineer to stray from his or her linear thought process when tackling engineering problems comes with complications, proof of the benefit was given and research was provided to show that not only is there a connection between technology and biology but that an improvement is evident when conjoining the two studies.

Conclusion

Innovating new technology via biomimicry is only a subcategory of methods in bettering the future, this can be achieved through remodeling our way of thinking, which ultimately yields improvement in our technology. As we progress into the future, engineers making such modifications that holistically affects our culture starts with changing the engineering design process. Alteration to the engineering design process makes for a new generation of engineers who have the capability to go beyond the traditional methods of creation and construct technology that pushes the boundaries of engineering. The intention of convincing an engineer to stray from his or her linear thinking method comes with difficulties when solving engineering problems thus, proof of the advantages was given and analysis was shown to demonstrate that there is not only a correlation between technology and biology, but that when the two experiments are combined, an advancement is apparent. A substantial amount of research has shown the benefits of biomimicry and the implementation of nature's designs would formulate a significant advancement in technology. With time and utilizing the engineers who have these skills, our societal norms and culture will evolve into one that is superiorly advanced.

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