

Thesis Project Portfolio

Pneumatically Actuated Soft Wearable Exoskeleton for Upper Limb Motion Rehabilitation
(Technical Report)

Social Determinism of the Da Vinci Surgical System
(STS Research Paper)

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Pneumatically Actuated Soft Wearable Exoskeleton for Upper Limb Motion Rehabilitation

Each year, around 16.9 million individuals experience a stroke, leading to approximately 33 million stroke survivors and 5.9 million deaths annually. As one of the leading causes of death globally, strokes are a significant contributor to acquired disabilities in adults. Of those, roughly 80% of stroke survivors face upper limb motor impairments. However, only a limited number of those with upper limb disabilities are able to participate as it requires a baseline level of physical ability. This project proposes a new design for a pneumatically actuated soft wearable upper limb rehabilitative exoskeleton. The exoskeleton will allow patients to achieve a level of use previously unavailable to them through current therapeutic practices. By being soft and lightweight, the exoskeleton is easily portable, meaning patients can access it from the comfort of their own home, drastically improving the quality of life and ease of recovery. The exoskeleton design features two pneumatically actuated soft muscles in series, and can achieve about 80 degrees range of motion in shoulder abduction. It can be controlled via a joystick in the user's hand so that it does not require any external assistance to operate. Additionally, the direction of the muscles can be rotated to achieve roughly 40 degrees range of motion when performing shoulder flexion and extension.

Social Determinism of the Da Vinci Surgical System

The Da Vinci robotic surgical system has been the most dominant and successful robotic medical device. It has been widely accepted by the medical community, and is a prime example of the integration of robotics in the medical community (Marchegiani et al., 2023). It is a fairly recent technology; medical robots have only been developed within the last three decades. Amidst the competition of early development, Da Vinci has proven itself and come out on top, and its development and usage is still continued today. With the increase of robotics in medical settings, what qualities about robotic devices help with their success and acceptance into the medical community? In this paper, I analyze the development, design, and effectiveness of the Da Vinci system to determine what factors affected its acceptance. I apply the theory of social determinism for my analysis of Da Vinci's development. Social determinism states that technology develops as a response to social needs and pressures (Gil-Garcia J. Ramon et al., 2014). Technology that is deemed unnecessary or does not fulfill social needs will not be developed. The overarching question I am trying to answer is, what technical qualities make a robotic medical device acceptable by both the patient and medical professional communities? I perform this analysis by taking a look at the history of medical robots. Understanding the development of medical robots and discovering which models were accepted and rejected can also help us answer the overarching question. Additionally, understanding what events influenced robotic medical device development may give us an idea of external factors that could have made the Da Vinci successful.

Sociotechnical Synthesis

The pneumatically actuated exoskeleton is a very new concept. There is nothing that exists that is similar to it in today's market. It has the potential to completely change physical therapy as both an assistive tool for physical therapists or a domestic tool that a user can take home and use by themselves. However, in order for it to be a successful product, it must appeal to the needs of society. Social determinism will affect whether or not the pneumatically actuated exoskeleton will receive continued support and development. Much like da Vinci's competitors, if there is a reason why the products stakeholders would prefer another method over the pneumatically actuated exoskeleton, then the development for the exoskeletons will receive less support to continue and may eventually cease completely. The analysis in my STS research performs analysis on the successful da Vinci in order to gain an idea of how social determinism affects medical technology development. It draws conclusions on what general qualities the medical and patient community look for in a medical product. Engineers who eventually make a finished product of the pneumatically actuated exoskeleton may be able to use this information to design the exoskeleton in a way that maximizes its stakeholder acceptance. For example, an important conclusion derived from the STS analysis was that patients care a lot about cost. If the pneumatically actuated exoskeleton costs more than current physical therapy solutions, then it must be far more effective than those current solutions. These conclusions can help engineers determine what features to prioritize when designing the product.