Project Notes:

Project Title: Development of a Modular Below-Elbow Prosthesis with Bidirectional Signaling for Children
Name: Travis Tran

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times so set aside enough time in your schedule.

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
durability	Reading journal article on different materials for prostheses	Article #8	10/3/22
comfort	Reading journal article on most important criteria for prosthetic comfort	Article #9,#14	11/18/22
sensory feedback	Call with Mr. Loven (11/19-11/20)	Article #7, project logbook	11/20/22
interchangeability/modular	Reading journal article on air pump powered socket	Article #10,#14	11/17/22
Mechanical movement types	Reading journal on prostheses movement types	Article #15,16	10/6/22

Arduino inputs and outputs (Backyard Brains)	Call with Mr. Loven (11/19-11/20, 12/4)	Project logbook	12/4/22

Literature Search Parameters:

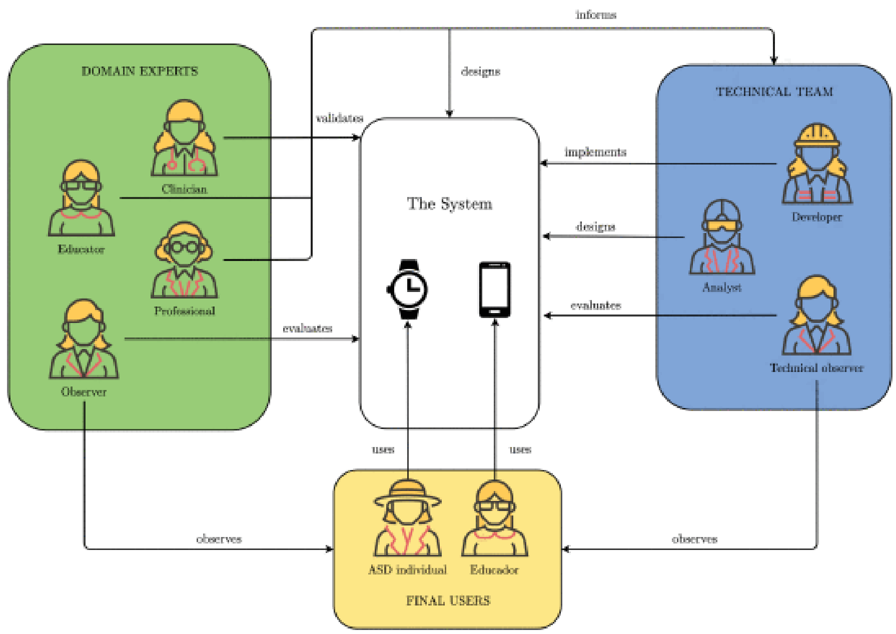
These searches were performed between (8/17/2022) and 1/1/2023.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Google scholar	durability	Located in Article #8
Google scholar	comfort	Located in Article #9,#14
IEEE	sensory feedback	Located in Article #7
Google Scholar	interchangeability/modular	Located in Article #10,#14
Google scholar	Mechanical movement types	Located in Article #15,16
Google patents	Prosthesis patents on mechanics	Located in Article #17,18

Article #1 Notes: “Hands-On Experiences With Assistive Technologies for People With Intellectual Disabilities: Opportunities and Challenges”

Article notes should be on separate sheets

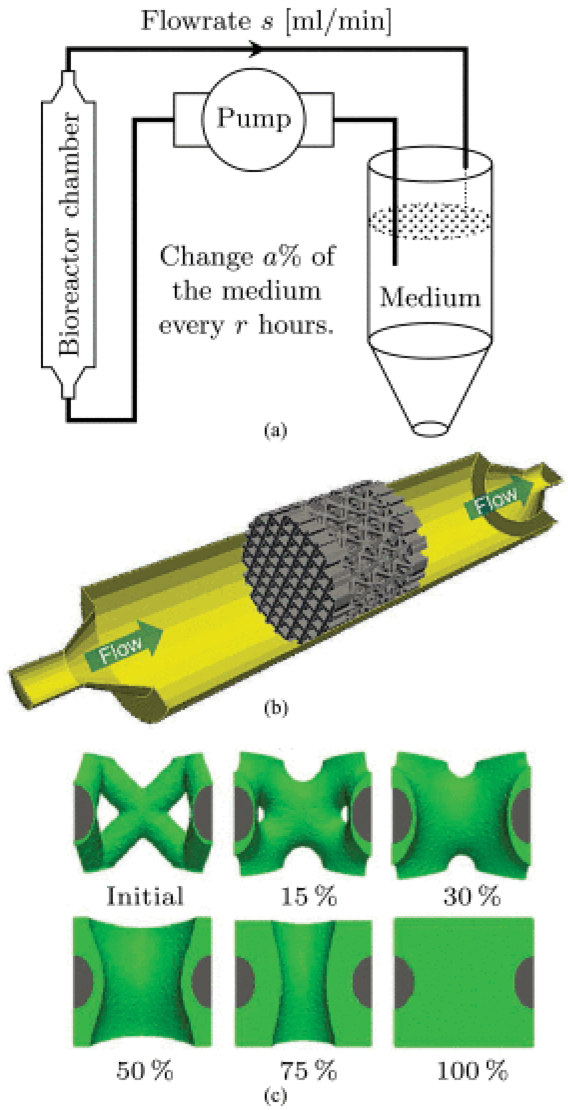
Source Title	“Hands-On Experiences With Assistive Technologies for People With Intellectual Disabilities: Opportunities and Challenges”
Source citation (APA Format)	Torrado, J. C., Gomez, J., & Montoro, G. (2020, June 4). *Hands-on experiences with assistive technologies for people with intellectual disabilities: Opportunities and challenges*. *IEEE Access*, vol. 8, pp. 106408-106424. Retrieved August 17, 2022, from https://ieeexplore.ieee.org/document/9108280
Original URL	https://ieeexplore.ieee.org/document/9108280
Source type	Journal Article
Keywords	Intellectual disabilities, assistive technologies for cognition
Summary of key points + notes (include methodology)	About one percent of the World’s population suffer from intellectual disabilities (IDs) and it has been very difficult to develop assistive technologies for cognition (ACTs) for patients. Some of the challenges to the development of ACTs are finding and recruiting subjects, ethics, full trust and transparency with the patients and their families, communication, and validity. To adjust to these restraints, the developers of the ACTs would have to adjust their schedules with their patients’, create publicly wearable/somewhat fashionable ACTs, comfort the patients, and make the tests appealing for them, and explain the conditions to the patients using precise language. The validity of the experiments is still questionable because one patient with an ID can be very different compared to a patient with the very same condition.
Research Question/Problem/ Need	People with IDs are disproportionately treated compared to other well-known diseases/ailments.

Important Figures	 Shows the various steps and people needed to develop functional ACT's
VOCAB: (w/definition)	ID - intellectual disability ACT - assistive technologies for cognition
Cited references to follow up on	*Diagnostic and Statistical Manual of Mental Disorders*, American Psychiatric Association, Philadelphia, PA, USA, 2013.
Follow up Questions	How can the validity of experiments like this be improved? Can a baseline or scale be created from which to measure the effectiveness of the ACTs, no matter the patient? How can more patients be recruited?

Article #2 Notes: “Bayesian Multiobjective Optimisation With Mixed Analytical and Black-Box Functions: Application to Tissue Engineering”

Article notes should be on separate sheets

Source Title	“Bayesian Multiobjective Optimisation With Mixed Analytical and Black-Box Functions: Application to Tissue Engineering”
Source citation (APA Format)	Olofsson, S., Mehrian, M., Calandra, R., Geris, L., Deisenroth, M. P., & Misener, R. (2019). Bayesian Multiobjective Optimisation With Mixed Analytical and Black-Box Functions: Application to Tissue Engineering. *IEEE Transactions on Biomedical Engineering*, *66*(3), 727–739. https://doi.org/10.1109/TBME.2018.2855404
Original URL	https://ieeexplore.ieee.org/document/8413171
Source type	Journal
Keywords	Multi-objective optimization, tissue engineering, cost/growth balance
Summary of key points + notes (include methodology)	Modern technological progress has given doctors and engineers patient-specific genetic information, opening the possibility of personalized healthcare and tissue growth or regeneration. When tissue engineering, there is a tradeoff between neotissue growth and the cost of the entire operation. A computer program/technique called multi-objective optimization (MOO) has been developed and can help to find the perfect tradeoff between neotissue growth and cost.
Research Question/Problem/ Need	How do we make tissue engineering both effective in quantity and cheap? What is the optimal balance between the two? How long can these organs be kept outside of a body after they are done developing?

Important Figures	 Cross-section of bioreactor and chamber and various neotissue filling levels
VOCAB: (w/definition)	MOO - multi-objective optimization
Cited references to follow up on	R. Saha et al., “Recent advances in the reconstruction of metabolic models and integration of omics data,” *Current Opinion Biotechnol.*, vol. 29, pp. 39–45, 2014.
Follow up Questions	How can MOO be changed to optimize different types of problems or different types of tissues (like brain tissue when we get there)? Are there any other methods besides the scalarization method and the pareto method for finding an optimal trade-off between objective functions? What happens when the computational cost of running the program becomes too great?

Article #3 Notes: “Mind-Controlled Prosthetic Hands Grasp New Feats, Users can move individual fingers simply by thinking about it”

Article notes should be on separate sheets

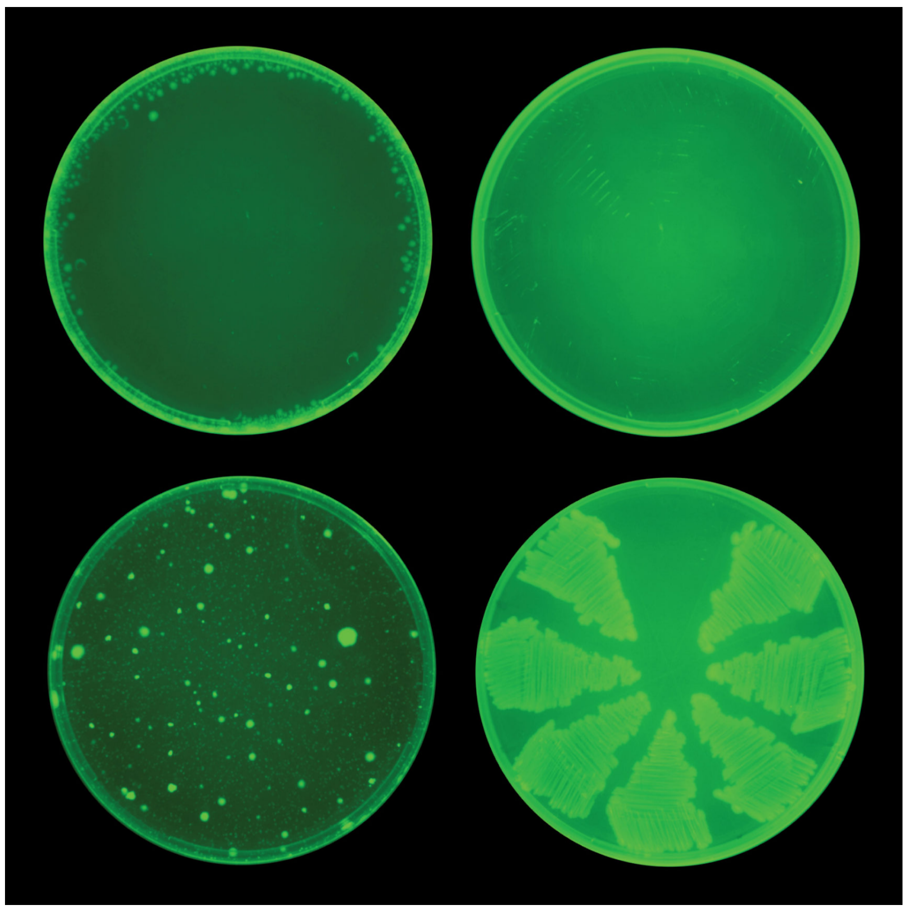
Source Title	“Mind-Controlled Prosthetic Hands Grasp New Feats”
Source citation (APA Format)	Hampson, M. (2022, April 6). Mind-Controlled Prosthetic Hands Grasp New Feats, Users can move individual fingers simply by thinking about it. Mind-Controlled Prosthetic Hands Grasp New Feats. Retrieved August 23, 2022, from https://spectrum.ieee.org/mind-controlled-prosthetic-hands-reach-new-feats
Original URL	https://spectrum.ieee.org/mind-controlled-prosthetic-hands-reach-new-feats
Source type	Article
Keywords	Prosthetics, AI
Summary of key points + notes (include methodology)	In the past decade, many advancements have been made in the field of mind-controlled artificial limbs, and now a breakthrough is allowing prosthetic hands to be controlled with 98 percent accuracy. The new advancement in assistive technology is based on an AI decoder that interprets nerve signals at the terminus of an amputated limb and gives users the ability to intuitively control a prosthetic hand with individual wrist and finger movements. This new advancement adds to how a machine can interact with the nervous system: interacting with the brain, muscles, and now nerves. Interacting with nerves allows the user more control over the prosthesis compared to muscles and provides less risk than interacting directly with the brain. Users can naturally think of the movement they desire and the artificial limb will execute it with the help of the AI decoder at a speed of 6 bits per second. This process is changing how effective and risk-free prostheses can be and opening the door for a plethora of assistive technologies to be made. Looking toward the future, the nerve-prosthetic process contains an intraneural electrode placement, an electrode that could give amputees a full array of sensations such as touch, texture, vibration, and temperature. This process could also be applied to other diseases such as epilepsy, persistent pain, heart failure, and diabetes.

Research Question/Problem/ Need	How can we improve current prosthetic technology using AI?
Important Figures	 A man testing the AI decoder prosthesis
VOCAB: (w/definition)	N/A
Cited references to follow up on	Sources not listed
Follow up Questions	Can we make the prosthesis smaller to mimic an actual arm? How can we make this more comfortable? Durable? Water resistant? Wireless?

Article #4 Notes: “Machine Learning Takes On Antibiotic Resistance”

Article notes should be on separate sheets

Source Title	“Machine Learning Takes On Antibiotic Resistance”
Source citation (APA Format)	Courage, K. H. (2020, March 9). *Machine Learning Takes On Antibiotic Resistance*. Quanta Magazine. https://www.quantamagazine.org/machine-learning-takes-on-antibiotic-resistance-20200309/
Original URL	https://www.quantamagazine.org/machine-learning-takes-on-antibiotic-resistance-20200309/
Source type	Article
Keywords	Antibiotics, Machine Learning
Summary of key points + notes (include methodology)	Antibiotics are a powerful tool in fighting against bacteria/infection and have been for the past century. Unfortunately, they are losing their effectiveness at an alarming rate because bacteria are becoming immune to current drugs. 700,000 people die each year from infections that could have once been treated by antibiotics. That number will rise to 10 million by the year 2050. In addition, the creation of novel antibiotics is significantly slowing down. To combat this issue, scientists at MIT are utilizing deep learning algorithms/deep neural networks to discover novel antibiotics. To find a new antibiotic for E. Coli, the scientists trained their neural network to look for any compound that would inhibit the growth of the bacteria. They did so by presenting the system with a database of known molecular structures; the neural network then found what compounds would work. In addition, the scientists filtered the search more by training the algorithm to predict the toxicity of the compounds. The scientists also provided the trained network to a library of 6,000 compounds already in use for treating humans to repurpose drugs. Out of this neural network screening of compounds, a drug the scientists named halicin emerged out of the pack as a candidate that would work. Through testing, halicin stopped the growth of E. Coli and also killed other bacteria. In addition, the E. Coli showed no signs of mutating to resist halicin. Through RNA-seq, the scientists discovered that halicin interferes with the movement of protons across bacterial membranes, affecting

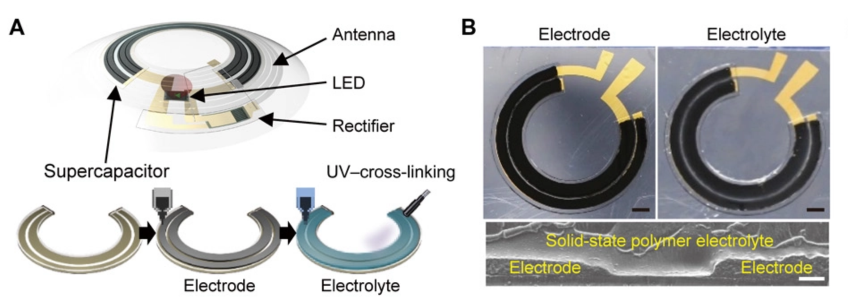
	the bacterial cells' metabolism. The scientists also screened a 107 million compound database through the neural network. From this, a second unnamed antibiotic arose. Looking toward the future, the scientists are looking to focus on certain pathogens more specifically to lead to the development of narrow-spectrum antibiotics that would have less impact on the body. They are also trying to automate and accelerate the whole process by having a machine test the compounds which the neural network finds. They are also considering trying to treat other diseases with the neural network method such as cancer and neurodegenerative diseases. The scientists are hoping to "get north of 90%" in predictive accuracy, but human experimentation will continue to be needed.
Research Question/Problem/ Need	Antibiotics are becoming ineffective, how do we stop this using machine learning?
Important Figures	 The top two culture dishes are treated with halicin, the novel antibiotic identified by a neural network. The bottom two dishes are treated with ciprofloxacin, a conventional antibiotic. Bacterial growth is greatly reduced in the top dishes because the cells do not seem to become resistant to halicin.

VOCAB: (w/definition)	N/A
Cited references to follow up on	Sources not listed
Follow up Questions	Can there be completely autonomous machine learning on drug development in the next three years? Will we be able to trust it? Can this be applied to diseases in addition to bacterial infections and viruses?

Article #5 Notes: “Printing of wirelessly rechargeable solid-state supercapacitors for soft, smart contact lenses with continuous operations”

Article notes should be on separate sheets

Source Title	“Printing of wirelessly rechargeable solid-state supercapacitors for soft, smart contact lenses with continuous operations”
Source citation (APA Format)	Park, J., Ahn, D. B., Kim, J., Cha, E., Bae, B.-S., Lee, S.-Y., & Park, J.-U. (2019). Printing of wirelessly rechargeable solid-state supercapacitors for soft, smart contact lenses with continuous operations. *Science Advances, 5(12)*. https://doi.org/10.1126/sciadv.aay0764
Original URL	https://www.science.org/doi/10.1126/sciadv.aay0764
Source type	Journal Article
Keywords	Smart contact lens, 3D-printing
Summary of key points + notes (include methodology)	In the past few decades, technology has been improving exponentially. Today, we find ourselves on the verge of wearable nanotechnology. The smart contact lens is a prime example of that. Recent advances in smart contact lenses point to medical applications as well as augmented reality through wireless communication systems. Continuous physiological monitoring of the human body, continuous monitoring of vital signs in the eyes and tears (containing biomarkers associated with diseases), and the potential for expanded applicability in smart devices for drug delivery are all on the horizon. However, previous research on smart contact lenses was conducted with a wired system or wireless power transfer with temporal and spatial restrictions, limiting their continuous use and requiring energy storage devices. In addition, the rigidity, heat, and large sizes of conventional batteries are not suitable for soft, smart contact lenses. To overcome these limitations in this experiment, a soft and smart contact lens with a wirelessly rechargeable, solid-state supercapacitor for continuous operation is explored. All of the smart contact lens components are fully integrated with stretchable structures without obstructing vision — all of the components of the device are outside the wearer’s pupil. Supercapacitors are known to exhibit long cycle lives and high-power density, which are suitable for consistent wireless charging. The

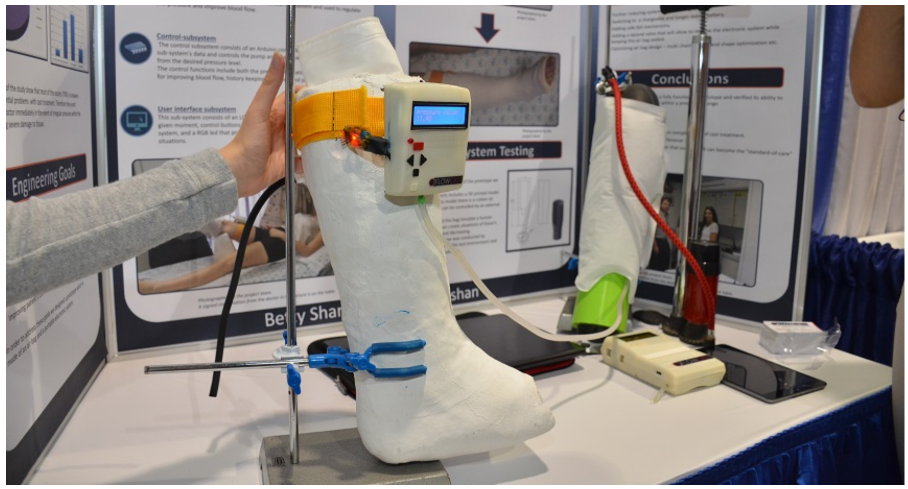
	supercapacitor in the smart contact lens also serves as physical support for the electronic circuits and antenna. The wireless charging system is combined with the solid-state supercapacitor to enable continuous operation of the smart contact lens with no external electrical port for charging. These systems showed great endurance after 300 cycles with a biaxially tensile strain of 30%. The wireless charging avoided abrupt heating, ensured that the wearer's eyes were safe, and protected the electrical devices from tear fluid over 7 days. The antenna was composed of stretchable AgNF-AgNW hybrid conductors. The power signal was received wirelessly as AC and then converted into DC in the rectifier for storing energy in the supercapacitor. The supercapacitor was fully charged during the wireless charging, showing that it can provide reliable performance and suggesting its potential for long-term use for smart contact lenses. The supercapacitor also operated the LED pixel continuously for 60 seconds. The temperature of the lens was maintained at ~22.9°C and although the wireless power transfer system increased the temperature to ~38.8°C, its wireless function prevented it from touching the eye or the contact lens. In addition, various stability tests demonstrated the long-term usability of the smart contact lens. A human pilot trial and in vivo tests conducted using live rabbits demonstrated the biocompatibility of this lens during the charging and discharging processes. For the in vivo experiments, a male New Zealand white rabbit was used and a human volunteer tested the smart contact lens for the human pilot trial (for 10 minutes). Note that as of now, the smart contact lens has no functionality except for providing power via wireless charging. There is good reliability against thermal and electromagnetic radiation and the results of the in vivo tests provide great promise for functionality in the future for smart contact lenses.
Research Question/Problem/ Need	How can an effective smart contact lens be made?
Important Figures	 Diagram of the smart contact lens and how they are electronically powered by wireless electodes
VOCAB: (w/definition)	MIS - monolithically integrated solid-state

Cited references to follow up on	T.-i. Kim, J. G. McCall, Y. H. Jung, X. Huang, E. R. Siuda, Y. Li, J. Song, Y. M. Song, H. A. Pao, R.-H. Kim, C. Lu, S. D. Lee, I.-S. Song, G. Shin, R. al-Hasani, S. Kim, M. P. Tan, Y. Huang, F. G. Omenetto, J. A. Rogers, M. R. Bruchas, Injectable, cellular-scale optoelectronics with applications for wireless optogenetics. Science 340, 211–216 (2013).
Follow up Questions	Is there any way in which this process could be done on other wearable tech, like hearing aids? What are some health applications to this technology? AR applications? Metaverse?

Article #6 Notes: “Pressure and Blood Flow Regulating System Inside an Orthopedic Cast”

Article notes should be on separate sheets

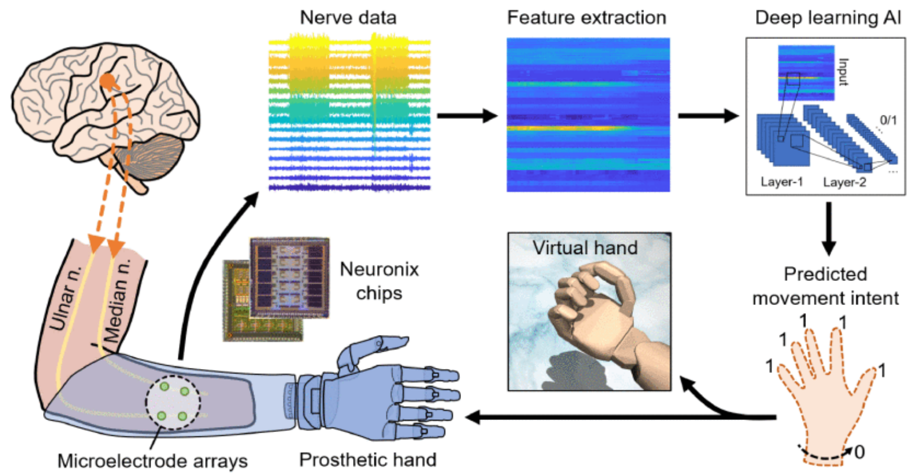
Source Title	“Pressure and Blood Flow Regulating System Inside an Orthopedic Cast”
Source citation (APA Format)	Shoshan, M., & Shamaev, B. (2015). *Pressure and Blood Flow Regulating System Inside an Orthopedic Cast*. Abstract Search. Retrieved September 5, 2022, from https://abstracts.societyforscience.org/Home/FullAbstract?ISEFYears=0%2C&Category=Biomedical%20Engineering&AllAbstracts=True&FairCountry=Any%20Country&FairState=Any%20State&ProjectId=12362
Original URL	https://abstracts.societyforscience.org/Home/FullAbstract?ISEFYears=0%2C&Category=Biomedical%20Engineering&AllAbstracts=True&FairCountry=Any%20Country&FairState=Any%20State&ProjectId=12362
Source type	Abstract only (couldn’t find/access the full paper - out of Israel)
Keywords	Cast pressure, pressure regulation
Summary of key points + notes (include methodology)	Purpose of the Experiment: Today, it is impossible to control inner-cast pressure during the patient's healing process. The human limb can change its volume after an injury therefore irregular pressure can be formed within the cast. This pressure can harm the wanted bone position, delay the patient's recovery and might cause irreversible damage to nerves and tissues. Solution and working procedure: Our solution is a pressure regulating system which contains an air bag that replaces the cast's soft layer, and is installed using a new casting method. The system consists of a sensor, a micro-controller, an air pump and a user interface. The micro-controller will instruct the air pump to control the pressure according to the sensor's readings and the doctor's recommendation. At the beginning of the casting process the doctor will set the system and determine the wanted pressure, after that there is no need to interfere and the system is working on its own and regulating the pressure. Besides the ability to regulate pressure the system can identify a dangerous pressure values and problems in itself (such as a hole in the air bag) and notify the user. Conclusions: During the project we built a fully functioning prototype which can be used as a base for a marketable product. Our product is simple, mostly

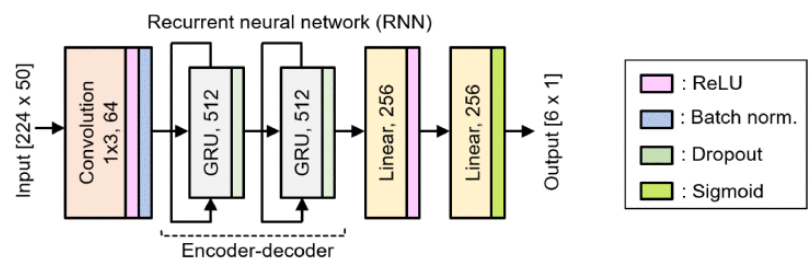
	reusable and is providing a solution for a well-known medical issue. We predict our product becoming a wide-spread, standard part of the casting process.
Research Question/Problem/ Need	Is there a way to create a pressure regulating orthopedic cast?
Important Figures	 Cast shown above with the microprocessor and air pump
VOCAB: (w/definition)	N/A
Cited references to follow up on	N/A
Follow up Questions	Couldn’t find whole article Are there any other applications in which something like this could be applied? Internally (with internal bleeding)? Brain injuries?

Article #7 Notes: “Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface”

Article notes should be on separate sheets

Source Title	“Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface”
Source citation (APA Format)	Luu, D. K., Nguyen, A. T., Jiang, M., Drealan, M. W., Xu, J., Wu, T., Tam, W., Zhao, W., Lim, B. Z. H., Overstreet, C. K., Zhao, Q., Cheng, J., Keefer, E. W., & Yang, Z. (2022). Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface. *IEEE Transactions on Biomedical Engineering*, 69(10), 3051–3063. https://doi.org/10.1109/TBME.2022.3160618
Original URL	https://ieeexplore.ieee.org/document/9738457
Source type	Journal Article
Keywords	Sensory feedback
Summary of key points + notes (include methodology)	The next generation prosthetic hand that moves and feels like a real hand requires a robust neural interconnection between the human minds and machines. Employing an artificial intelligence (AI) agent to translate the amputee’s movement intent through a peripheral nerve interface. The AI agent is designed based on the recurrent neural network (RNN) and could simultaneously decode six degree-of-freedom (DOF) from multichannel nerve data in real-time. The decoder’s performance is characterized in motor decoding experiments with three human amputees. Individual finger and wrist movements up to 97-98% accuracy. Second, we demonstrate the AI agent’s real-time performance by measuring the reaction time and information throughput in a hand gesture matching task. Third, we investigate the AI agent’s long-term uses and show the decoder’s robust predictive performance over a 16-month implant duration.
Research Question/Problem/ Need	Sensory feedback using AI applications for prostheses.

<table>
<tr><td>Important Figures</td><td>


(A)


(B)
(A) Overview of the AI neural decoder and signal processing paradigm. Nerve data are acquired from the subject's amputated arm by Neuronix neural interface chips, followed by feature extraction. The deep learning AI then uses feature data to predict the subject's intent of moving several DOF simultaneously. The predictions are mapped to movements of a virtual hand or a prosthetic hand in real-time. (B) Design of the deep learning AI based on the recurrent neural network (RNN) architecture.</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>RNN - recurrent neural network</td></tr>
<tr><td>Cited references to follow up on</td><td>K. Ziegler-Graham , "Estimating the prevalence of limb loss in the United States: 2005 to 2050," Arch. Phys. Med. Rehabil., vol. 89, no. 3, pp. 422–429, 2008.</td></tr>
<tr><td>Follow up Questions</td><td>How strong is the signal after months of use? Is there a way to produce this type of neural network/deep learning without intensive GPU systems?</td></tr>
</table>

Article #8 Notes: Materials of Prosthetic Limbs

Article notes should be on separate sheets

Source Title	"Materials of Prosthetic Limbs"
Source citation (APA Format)	Mota, A. (2017). *Materials of Prosthetic Limbs*. California State Polytechnic University, Pomona, Mechanical Engineering Department. https://scholarworks.calstate.edu/downloads/h128ng975/
Original URL	https://scholarworks.calstate.edu/downloads/h128ng975/
Source type	Memorandum
Keywords	Materials
Summary of key points + notes (include methodology)	Brief history of prostheses. Metals: Aluminum, Titanium, Magnesium, Copper, Steel, used for support, mechanisms Polymers: used for joints, 3D printing not discussed, less durable Carbon fibers: low weight, high durability, brittle Supporting materials: silicone liners, nylon liners for biocompatibility, no skin blisters, rashes Future materials: interchangeability?
Research Question/Problem/ Need	What material do we create prostheses from?
Important Figures	N/A
VOCAB: (w/definition)	Polymers - plastics, plastics are made of polymers
Cited references to follow up on	Schreiber, N.S., & Gettens, R.T.T. *Aquatic Design for Individuals with Disabilities: Upper Limb Prosthesis*. Department of Biomedical Engineering, Western New England University.
Follow up Questions	Will 3D printed plastics work? 3D printed carbon fiber? How do we make these materials less brittle? Interchangeability?

Article #9 Notes: “Comfort and function remain key factors in upper limb prosthetic abandonment: findings of a scoping review”

Article notes should be on separate sheets

Source Title	“Comfort and function remain key factors in upper limb prosthetic abandonment: findings of a scoping review”
Source citation (APA Format)	Smail, L. C., Neal, C., Wilkins, C., & Packham, T. L. (2021). Comfort and function remain key factors in upper limb prosthetic abandonment: Findings of a scoping review. *Disability and Rehabilitation: Assistive Technology*, *16*(8), 821–830. https://doi.org/10.1080/17483107.2020.1738567
Original URL	https://wpi-illiad-oclc-org.ezpv7-web-p-u01.wpi.edu/illiad/illiad.dll?Action=10&Form=75&Value=128097
Source type	Journal article
Keywords	Prosthesis; upper limb; abandonment; rejection; comfort; function
Summary of key points + notes (include methodology)	Prostheses are abandoned at such a high rate because of comfort and usability/functionality. Across time, reasons for abandonment could be broadly categorized into comfort and function. Weight, temperature and perspiration were among the most common and persistent comfort-related reasons for abandonment. Regarding function, studies-reported abandonment was attributed to key concerns about control and sensory feedback, whereby participants may feel more functional without their device. Currently, there are four main types of upper limb prosthetic devices available for individuals living with upper limb loss: passive, body powered, myoelectric and hybrid. Very variable abandonment rate for each type of prosthesis. This challenge is inherently difficult because of the number of amputees and their different situations. Evolution over

	time of abandonment? A scoping review was conducted to allow us to compile and develop a thematic summary from the relevant literature on upper limb prosthesis abandonment. 6 criteria: • 1. Identifying the research question • 2. Identifying relevant studies • 3. Study selection • 4. Charting the data • 5. Collating, summarizing and reporting results • 6. Consultation. Ultimately, through screening, 9 articles were chosen for the review. • Painful • Heavy • Not functional • Does not belong to them, like a tool they are using • Too many repairs • Needs to be much more mechanically complex • Weight • Temp • Sensory feedback • Bilaterals and dominant arm amputees did not abandon as much because of the need for independence • Lack of training with the prosthesis • weight=comfort • More control • 3d printing helps with comfort • Closed loop control • myoelectric
Research Question/Problem/ Need	Why are prostheses abandoned at such a high rate?

Important Figures

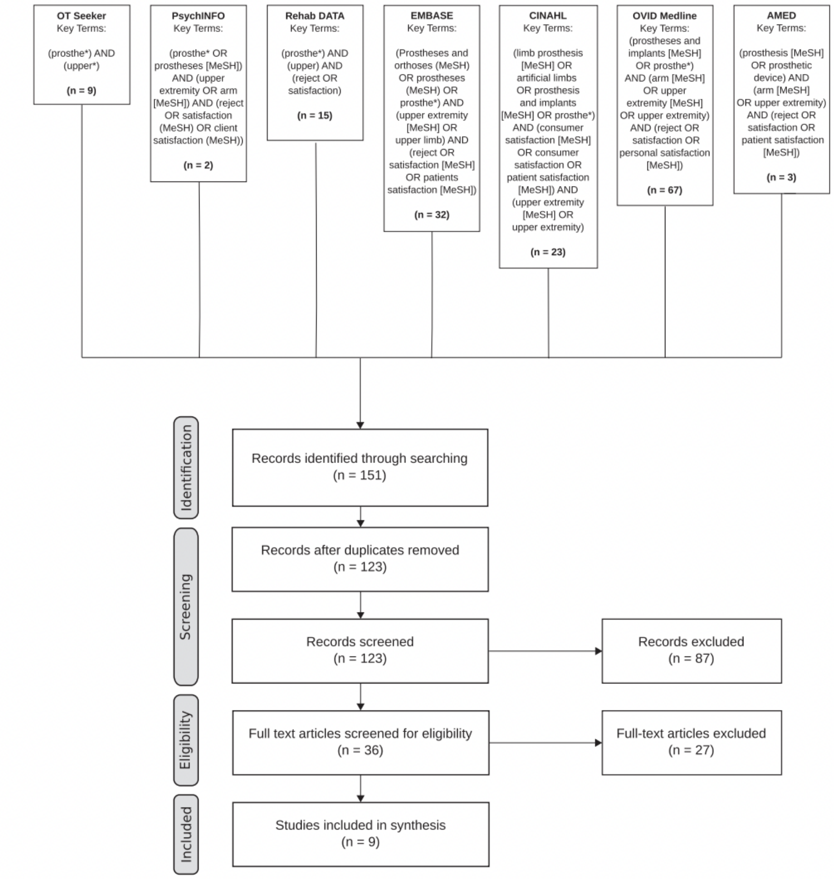


Figure 1. PRISMA diagram.

The screening process for choosing the articles to review

Table 2. Reasons for prosthetic abandonment by device type, condensed across years.

	Device type				
Theme	Passive	Body-powered	Myoelectric	Hybrid	Not Specified
Comfort	Temperature [4,18] Weight [4] Perspiration [18] Damaged clothing [4]	Temperature [4,18] Weight [4,18,20,22] Perspiration [18] Damaged clothing [4] General discomfort [20,22] Harness irritation [4] Poor fit [20,22] Pain [20]	Temperature [4] Weight [4,16,18,20,22] Pain [20] General discomfort [20,22] Poor fit (22)	Weight [22] Poor fit [22] General discomfort [22]	Temperature [6] Weight [6,17,21] Perspiration [6,21] Socket discomfort [17,21] General discomfort [6] Harness irritation [21]
Function	Lack of functional benefit [20]	Difficult to control [4,22]	Difficult to control [4,20,22]	Lack of functionality [22]	Difficult to control [21]
	Not durable [18]	Not durable [4,22]	Slow response speed [4,16] Lack of sensory feedback [18] Poor dexterity [18]	Difficult to use [22] Not durable [22] Too much fuss [22]	Slow response speed [21] Lack of sensory feedback [6] Poor dexterity [21]
		Lack of functionality [22]	Not durable [4,16,20,22]		Limited or lack of functional benefit [6,17]
			Lack of functionality [22] Too much fuss [22]		Difficulty gripping objects [21]
Other		Aesthetics [4,22]	Aesthetics [22]	Aesthetics [22]	Dissatisfaction with technology [6,21] Predisposing factors (e.g., gender, level of limb loss, hand dominance) [6,24] Lack of established need [21,24] Lack of information, training and follow-up appointments [21,24]

Table of current prosthetic issues

VOCAB: (w/definition)

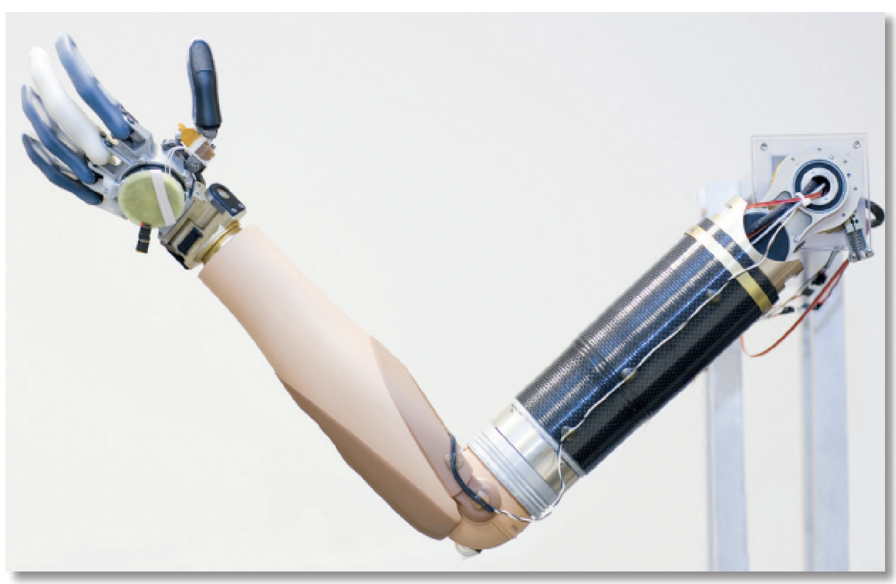
Gray literature - materials and research produced by organizations outside of the traditional commercial or academic publishing and distribution channels

Cited references to follow up on	Resnik L, Ekerholm S, Borgia M, et al. A national study of Veterans with major upper limb amputation: survey methods, participants, and summary findings. PLoS One. 2019; 14:e0213578.
Follow up Questions	Not in-depth about hybrid prostheses, how does that data look now, three-four years later. How can this research be expanded to new, modern hybrid prostheses now? How would the data be skewed if current myoelectric data was added?

Article #10 Notes: "An Overview of the Developmental Process for the Modular Prosthetic Limb"

Article notes should be on separate sheets

Source Title	"An Overview of the Developmental Process for the Modular Prosthetic Limb"
Source citation (APA Format)	Johannes, M. S., Bigelow, J. D., Burck, J. M., Harshbarger, S. D., Kozlowski, M. V., & Doren, T. V. (2011). An Overview of the Developmental Process for the Modular Prosthetic Limb. *JOHNS HOPKINS APL TECHNICAL DIGEST*, *30*(3), 10.
Original URL	https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.685.7837&rep=rep1&type=pdf
Source Type	Journal
Keywords	Modular, upper limb, prosthetic/prosthesis
Summary of key points + notes (include methodology)	● First purpose was to restore limb function to those who had lost them in the line of duty (not born with it)/history of prostheses in this context ● 7 degrees of motion for the original old model ● Noninvasive neural strategies ● Closed loop neurological control again ● For prototype 1: 22 degrees of motion Possibilities: Electromechanical • Mesofluidic (hydraulic) • Monopropellant (pneumatic using a hydrogen peroxide and catalyst system) From these potential technologies, the following viable system configurations were considered: • Full limb electromechanical intrinsic • Full limb electromechanical extrinsic

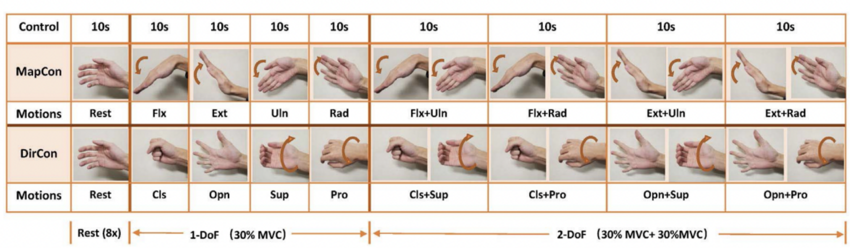
	• Full limb mesofluidic • Full limb monopropellant • Hybridmesofluidichand/electromechanicalupper arm • Hybrid mono Criteria Development risk (requirements compliance, technology readiness, number of required development cycles, undeveloped components, intellectual property issues) • Comfort (mass, mass distribution, fluid or gas emissions, noise) Cosmesis (shape, volume, appearance, elasticity, durability) • Function [energy per day, torque, speed, dexterity (DOF), range of motion] • Cost (development, engineering labor costs, prototype costs, first cost, life-cycle cost) • Supportability (reliability, maintainability) • Commercial viability (amputation levels accommodated, transportability, manufacturability) • Operational safety (battery safety, drive power safety, uncontrolled impact safety, controlled impact safety) Software can also be interchanged
Research Question/Problem/ Need	How do we create a modular prosthetic arm?
Important Figures	 First prototype of the modular prosthetic limb (MPL)
VOCAB: (w/definition)	MPL - modular prosthetic limb

Cited references to follow up on	n/a
Follow up Questions	How can neural networks, osseointegration, and other modern prosthetic technologies be integrated into this modular build form of a prosthesis?

Article #11 Notes: “Myoelectric Control Performance of Two Degree of Freedom Hand-Wrist Prosthesis by Able-Bodied and Limb-Absent Subjects”

Article notes should be on separate sheets

Source Title	“Myoelectric Control Performance of Two Degree of Freedom Hand-Wrist Prosthesis by Able-Bodied and Limb-Absent Subjects”
Source citation (APA Format)	Zhu, Z., Li, J., Boyd, W. J., Martinez-Luna, C., Dai, C., Wang, H., Wang, H., Huang, X., Farrell, T. R., & Clancy, E. A. (2022). Myoelectric Control Performance of Two Degree of Freedom Hand-Wrist Prosthesis by Able-Bodied and Limb-Absent Subjects. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *30*, 893–904. https://doi.org/10.1109/TNSRE.2022.3163149
Original URL	https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9744113
Source type	Journal Article
Keywords	Prosthesis Control, EMG-force, EMG signal processing, electromyogram, myoelectric control
Summary of key points + notes (include methodology)	Using surface electromyogram signals from remnant muscles as the control input. Two such regression-based controllers, along with conventional, sequential two-site control with co-contraction mode switching (SeqCon), in box-block, refined-clothespin and door-knob tasks, on 10 able-bodied and 4 limb-absent subjects. Subjects operated a commercial hand and wrist using a socket bypass harness. One 2-DoF controller (DirCon) related the intuitive hand actions of open-close and pronation-supination to the associated prosthesis hand-wrist actions, respectively. The other (MapCon) mapped myoelectrically more distinct, but less intuitive, actions of wrist flexion-extension and ulnarradial deviation. SeqCon performed better statistically than MapCon in the predominantly 1-DoF

	box-block task (> 20 blocks/minute vs. 8–18 blocks/minute, on average). In this task, SeqCon likely benefited from an ability to easily focus on 1-DoF and not inadvertently trigger co-contraction for mode switching. The remaining two tasks require 2-DoFs, and both 2-DoF controllers each performed better (factor of 2–4) than SeqCon. We also compared the use of 12 vs. 6 optimally-selected EMG electrodes as inputs, finding no statistical difference. ● Opn-Cls & ProSup direct control, a new Ext-Flx & Rad-Uln mapping control with translation, and conventional two-site sequential control. ● Six or twelve optimally-sited electrodes (out of 16 total) were tested on a prosthesis to investigate the minimum number of electrodes feasible on commercial prostheses ● Programmed in matlab ● MapCon = congenital ● Too much calibration - challenge for self adjusting at home for my proj
Research Question/Problem/ Need	What is the best current method of control for myoelectrics?
Important Figures	 The eight different movements tracked in this experiment
VOCAB: (w/definition)	Regression models (no standards) = regression for data points applied to prosthetic movement Pronate = down = rad Supinate = up MVC = model view controller
Cited references to follow up on	Z. Zhu et al., “EMG-force and EMG-target models during force-varying bilateral hand-wrist contraction in able-bodied and limb-absent subjects,” IEEE Trans. Neural Syst. Rehabil. Eng., vol. 28, no. 12, pp. 3040–3050, Dec. 2020.
Follow up Questions	What is the optimal amount of electrodes?

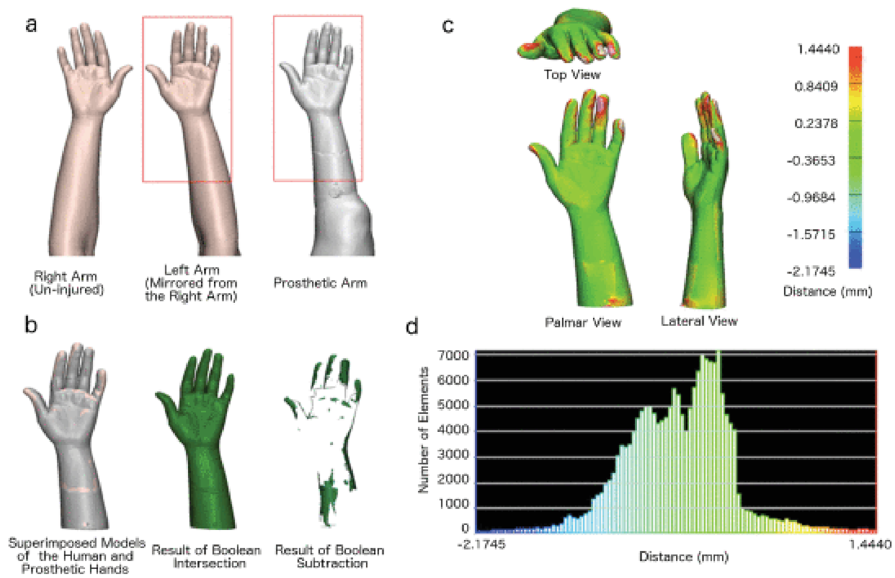
Article #12 Notes: "A Method for 3-D Printing Patient-Specific Prosthetic Arms With High Accuracy Shape and Size"

Article notes should be on separate sheets

Source Title	"A Method for 3-D Printing Patient-Specific Prosthetic Arms With High Accuracy Shape and Size"
Source citation (APA Format)	Cabibihan, J.-J., Abubasha, M. K., & Thakor, N. (2018). A Method for 3-D Printing Patient-Specific Prosthetic Arms With High Accuracy Shape and Size. *IEEE Access*, *6*, 25029–25039. https://doi.org/10.1109/ACCESS.2018.2825224
Original URL	https://ieeexplore.ieee.org/abstract/document/8334526
Source type	Journal Article
Keywords	3D printed prostheses Accurate shape, size CT Scan Silicone Casting
Summary of key points + notes (include methodology)	● Restates that comfort and appearance are desired features ● The prosthetic arm was found to have high accuracy on the basis of the Dice Similarity Coefficient (DSC; 0.96), percent error (0.67%), and relative mean distance (0.34 mm, SD = 0.48 mm), median -0.32mm ● The socket achieved high accuracy based on those measures: DSC (0.95), percent error (2.97%), and relative mean distance (0.46 mm, SD = 1.70 mm), median -0.35mm ● Difference in volume: maximum distance of 1.44 mm and a minimum of −2.17 mm in selected locations of the prosthetic arm. ● Overlap of 5.07 mm, however, other regions of the socket have available space for the displaced tissue to occupy. This corresponds to a distance of −4.41 mm from the stump to the available space at the wall of the socket. ● Advantages: First, the patient has to visit the hospital once for a CT scan to be done. The patient does not have to get measured by the prosthetists or designers because the measurements are directly taken from the CT data. Second, there is no need for using digital photographs for scaling

<table>
<tr>
<td></td>
<td>prosthetic hands or arms. That approach can result in numerous errors from the depth of focus and lighting from the way the photos were taken.

Lastly, the 3D printing fabrication method is highly suitable for one-off patient-specific prosthesis. There are different levels of amputation and there is no one-size-fits-all prosthesis. Low Cost.
3 parts, all accurate
Overall, this paper demonstrates that CT imaging, computed-aided design, desktop 3-D printing, and silicone casting can achieve patient-specific cosmetic prosthetic arms with high accuracy.
Stigma, we need to fix this
Process: CT scan/portable 3D scanner, CAD software, mirrored, structural support in CAD, silicone mold, socket, fit together
Overall good results
Weight and aesthetics can be improved, sensation as well

</td>
</tr>
<tr>
<td>Research Question/Problem/ Need</td>
<td>How do we create an accurate fitting of a 3D printed/silicone casted prosthesis cheaply and efficiently?</td>
</tr>
<tr>
<td>Important Figures</td>
<td>

(a) non-affected arm + mirror image + CT scan data of the prosthetic arm. (b) Superimposed human and prosthetic hands: Boolean intersection and subtraction operations. (c) Part comparisons showing the various views, color indicates max distance of the prosthetic from the human arm. (d) Histogram showing the distribution of elements and the relative distance of the prosthetic arm from the human arm.</td>
</tr>
</table>

VOCAB: (w/definition)	Shuttle lock mechanism - A shuttle lock is fabricated into the bottom of the socket which the pin liner inserts into locking the residual limb in place. There is a simple unlocking mechanism which can be accessed at the bottom of the socket to release the pin from the lock.
Cited references to follow up on	A. Y. Alhaddad et al., "Toward 3D printed prosthetic hands that can satisfy psychosocial needs: Grasping force comparisons between a prosthetic hand and human hands" in Social Robotics, Cham, Switzerland:Springer, pp. 304-313, 2017. - psychological effects of prosthetics
Follow up Questions	How much lighter does a prosthesis need to be compared to the weight of the opposite healthy arm for a user to not complain about the weight. At 22-23% lighter, the user still thinks that the prosthesis is too heavy.

Article #13 Notes: "Age at First Prosthetic Fitting and Later Functional Outcome in Children and Young Adults with Unilateral Congenital Below-Elbow Deficiency: A Cross-Sectional Study"

Article notes should be on separate sheets

Source Title	"Age at First Prosthetic Fitting and Later Functional Outcome in Children and Young Adults with Unilateral Congenital Below-Elbow Deficiency: A Cross-Sectional Study"
Source citation (APA Format)	Huizing, K., Reinders-Messelink, H., Maathuis, C., Hadders-Algra, M., & van der Sluis, C. K. (2010). Age at First Prosthetic Fitting and Later Functional Outcome in Children and Young Adults with Unilateral Congenital Below-Elbow Deficiency: A Cross-Sectional Study. *Prosthetics and Orthotics International*, *34*(2), 166–174. https://doi.org/10.3109/03093640903584993
Original URL	https://journals.sagepub.com/doi/full/10.3109/03093640903584993
Source type	Journal Article
Keywords	Prosthetic fitting, age, children and young adults, congenital below-elbow
Summary of key points + notes (include methodology)	Objective: to evaluate whether prosthetic fitting before the age of one year is associated with better outcomes in children with unilateral congenital below-elbow deficiency compared to children fitted after the age of one. Twenty subjects aged 6–21 years were recruited (five prosthetic users and 15 non-users). The Child Amputee Prosthetics Project-Prosthesis Satisfactory Inventory (CAPP-PSI) and the Prosthetic Upper Extremity Functional Index (PUFI) were used to assess patient satisfaction and functional use of the prosthesis. Videotapes were used to assess motor performance. Initial prosthetic fitting before one year of age was related to use of a prosthesis for at least four years. Age at first fitting was not associated with satisfaction with the prosthesis, functional use of the prosthesis or motor skills. Discrepancies between ease of performance with prosthesis and usefulness of the prosthesis as well as between capacity and performance of activities were found. The video

<table>
<tr><td></td><td>assessments showed impaired movement adaptation to some tasks in six subjects. In conclusion, early prosthetic fitting seems to have a limited impact on prosthesis use during later stages of life.</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>Does the age of fitting a prosthesis to a congenital amputee affect the outcome of use later in life for the amputee?</td></tr>
<tr><td>Important Figures</td><td>
<table>
<tr><th>Respondents</th><th>Gender</th><th>Age</th><th>Side</th><th>Level</th><th>Age at first fit</th><th>Prosthesis[‡]</th><th>Reason of rejection[†]</th><th>Age at rejection</th><th>Wearing years</th></tr>
<tr><td>1</td><td>M</td><td>10.0</td><td>R</td><td>1/3</td><td>0.8</td><td>Passive</td><td>0</td><td>4</td><td>3.2</td></tr>
<tr><td>2</td><td>F</td><td>6.8</td><td>L</td><td>1/3</td><td></td><td></td><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td>F</td><td>7.1</td><td>L</td><td><1/3</td><td>2.8</td><td>Body-powered</td><td>1</td><td>5</td><td>2.3</td></tr>
<tr><td>4</td><td>F</td><td>14.6</td><td>L</td><td><1/3</td><td>0.9</td><td>Passive</td><td>0</td><td>4</td><td>3.1</td></tr>
<tr><td>5</td><td>F</td><td>13.7</td><td>L</td><td>1/3</td><td>0.6</td><td>Myo</td><td>0</td><td>11</td><td>10.4</td></tr>
<tr><td>6</td><td>M</td><td>21.1</td><td>R</td><td>1/3</td><td>0.7</td><td>Passive</td><td>0</td><td>17</td><td>16.3</td></tr>
<tr><td>7</td><td>F</td><td>18.1</td><td>L</td><td>>1/3</td><td>0.6</td><td>Myo</td><td>3</td><td>No rejection</td><td>17.4</td></tr>
<tr><td>8</td><td>F</td><td>12.9</td><td>L</td><td>>1/3</td><td>8.0</td><td>Myo</td><td>3</td><td>No rejection</td><td>4.9</td></tr>
<tr><td>9</td><td>M</td><td>20.0</td><td>L</td><td><1/3</td><td>2.4</td><td>Passive</td><td>3</td><td>No rejection</td><td>17.6</td></tr>
<tr><td>10</td><td>M</td><td>12.8</td><td>R</td><td><1/3</td><td>0.8</td><td>Myo</td><td>2</td><td>10</td><td>9.3</td></tr>
<tr><td>11</td><td>M</td><td>20.5</td><td>R</td><td><1/3</td><td>0.7</td><td>Myo</td><td>0</td><td>9</td><td>8.3</td></tr>
<tr><td>12</td><td>M</td><td>18.3</td><td>R</td><td><1/3</td><td>0.5</td><td>Passive</td><td>0</td><td>13</td><td>12.5</td></tr>
<tr><td>13</td><td>F</td><td>19.8</td><td>L</td><td>>1/3</td><td>10.0</td><td>Myo</td><td>0</td><td>14</td><td>3.8</td></tr>
<tr><td>14</td><td>F</td><td>16.5</td><td>R</td><td><1/3</td><td>0.7</td><td>Passive</td><td>0</td><td>12</td><td>11.3</td></tr>
<tr><td>15</td><td>M</td><td>11.2</td><td>L</td><td><1/3</td><td>0.5</td><td>Myo</td><td>0</td><td>7</td><td>6.5</td></tr>
<tr><td>16</td><td>F</td><td>14.3</td><td>R</td><td>>1/3</td><td>0.8</td><td>Myo</td><td>3</td><td>No rejection</td><td>13.4</td></tr>
<tr><td>17</td><td>F</td><td>14.0</td><td>R</td><td>>1/3</td><td>0.7</td><td>Myo</td><td>0</td><td>7</td><td>6.3</td></tr>
<tr><td>18</td><td>F</td><td>8.1</td><td>R</td><td>>1/3</td><td>1.5</td><td>Body-powered</td><td>0</td><td>5</td><td>3.5</td></tr>
<tr><td>19</td><td>M</td><td>6.2</td><td>L</td><td>1/3</td><td>0.8</td><td>Myo</td><td>3</td><td>No rejection</td><td>5.5</td></tr>
<tr><td>20</td><td>F</td><td>21.5</td><td>L</td><td>1/3</td><td>11.4</td><td>Myo</td><td>1</td><td>13</td><td>1.6</td></tr>
<tr><td>Median</td><td></td><td>14.2</td><td></td><td></td><td>0.8</td><td></td><td></td><td>9.5</td><td>6.5</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>users 13.4</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>non-users 6.4</td></tr>
</table>
Table containing the information of 20 amputees, their fitting age, and how/when/if they abandoned their prosthesis. Also contains the median of all 20 amputees.</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>UCBED - unilateral congenital transverse below-elbow deficiency
Neuronal Group Selection Theory (NGST) - developed by Edelman in 1989.8–10 From the NGST point of view, children with UCBED may lack the representation of the missing part of the limb in the cerebral cortex.</td></tr>
<tr><td>Cited references to follow up on</td><td>Scotland TR, Galway HR A long-term review of children with congenital and acquired upper limb deficiency. J Bone Joint Surg Br 1983;65:346–349.</td></tr>
<tr><td>Follow up Questions</td><td>If this study were to be performed on non-congenital amputees, how would the results differ? Would they differ?</td></tr>
</table>

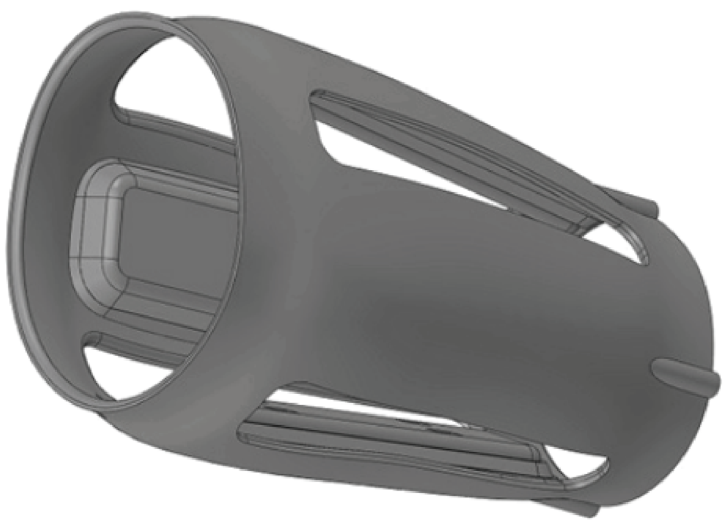
Article #14 Notes: “A novel socket design for upper-limb prosthesis”

Article notes should be on separate sheets

Source Title	“A novel socket design for upper-limb prosthesis”
Source citation (APA Format)	Sang, Y., Li, X., Gan, Y., Su, D., & Luo, Y. (2014). A novel socket design for upper-limb prosthesis. In *International Journal of Applied Electromagnetics and Mechanics, Vol. 45, p. 886*. https://doi.org/10.3233/JAE-141920
Original URL	https://www.researchgate.net/profile/Yuanjun-Sang/publication/279056094_A_novel_socket_design_for_upper-limb_prosthesis/links/57385a0708ae298602e29033/A-novel-socket-design-for-upper-limb-prosthesis.pdf
Source type	Journal article
Keywords	Novel socket design, prosthetic interface, upper limb prosthesis, safety, comfort, functionality
Summary of key points + notes (include methodology)	● Prosthetic socket is the only channel for load transfer between limb stump and prosthetic limb, so its design is most important in meeting the requirements of comfort and function ● In order to improve comfort and functionality of the upper-limb prosthetic socket, this paper presents a novel design concept of the socket in which the areas and working time of compression can be alternated in needs ● A physical model of prosthesis socket with four pressure-adjustable chambers driven by a vacuum pump was designed to form pressure units in the socket to simulate its function in changing compression loads ● The effectiveness of the design was proved by experiments ● Spring and air pump system ● 4 sections around the 3D printed socket, lined with silicone ● Measured pressure between relaxed and tight modes as well as the time and degree of axial load when 4kg was applied to the end of the socket

Research Question/Problem/ Need	How do we create a more comfortable prosthetic socket?

Important Figures

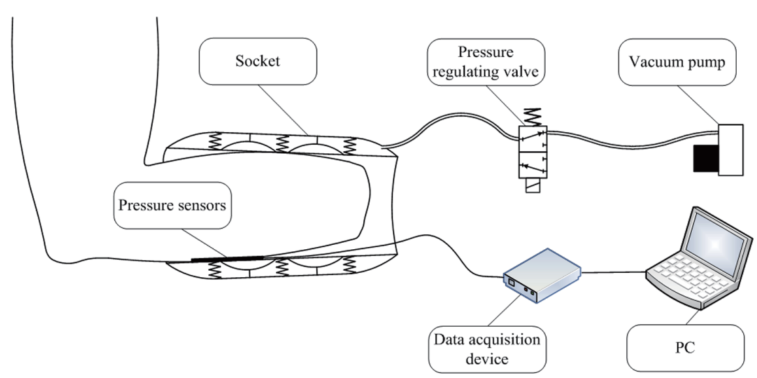


(a)

3D cad model of the socket

Table 1
Experimental results in different working status

Status	Compression pressure/mmHg				Switching time/s	Deflection angles
	Area 1	Area 2	Area 3	Area 4		
Tight status	134.82	89.95	122.13	124.96	–	2.5°
Relax status	43.31	41.13	34.62	42.85	2.3 (from tight status to relax status)	5.5°
Tight status	133.08	90.43	119.81	124.65	0.2 (from relax status to tight status)	2.5°



Data and diagram of the experiment

VOCAB: (w/definition)	Ischemic - loss of blood supply
Cited references to follow up on	R.D. Alley, B. Sc. and C.P., Advancement of upper extremity prosthetic interface and frame design, Proceedings of the 2002 MyoElectric Controls/Powered Prosthetics Symposium Fredericton,

	Canada, 2002.
Follow up Questions	How could this be applied on a larger scale to allow the whole prosthesis to open and close (grow) with the user as they (a child) grow up?

Article #15 Notes: "The MANUS-HAND Dextrous Robotics Upper Limb Prosthesis: Mechanical and Manipulation Aspects"

Article notes should be on separate sheets

Source Title	"The MANUS-HAND Dextrous Robotics Upper Limb Prosthesis: Mechanical and Manipulation Aspects"
Source citation (APA Format)	Pons, J. L., Rocon, E., Ceres, R., Reynaerts, D., Saro, B., Levin, S., & Van Moorleghem, W. (2004). The MANUS-HAND Dextrous Robotics Upper Limb Prosthesis: Mechanical and Manipulation Aspects. *Autonomous Robots*, *16*(2), 143–163. https://doi.org/10.1023/B:AURO.0000016862.38337.f1
Original URL	https://link.springer.com/content/pdf/10.1023/B:AURO.0000016862.38337.f1.pdf
Source type	Journal article
Keywords	dextrous hands, prosthetic hands, EMG control
Summary of key points + notes (include methodology)	For the mechanical part 1. the finger mechanism, 2. the thumb mechanism, and 3. the wrist mechanism. 10 joints total, 3 individual, the rest are underactuated Pulley tendon system Geneva mechanism thumb Spring system between the object and the palm of the hand Finger activation is blocked after equilibrium is reached 3 different levels of EMG amplitude to do different things known as 3 bit control This results in 17 usable different commands that the user can send to the arm Senses position and force with hall sensors

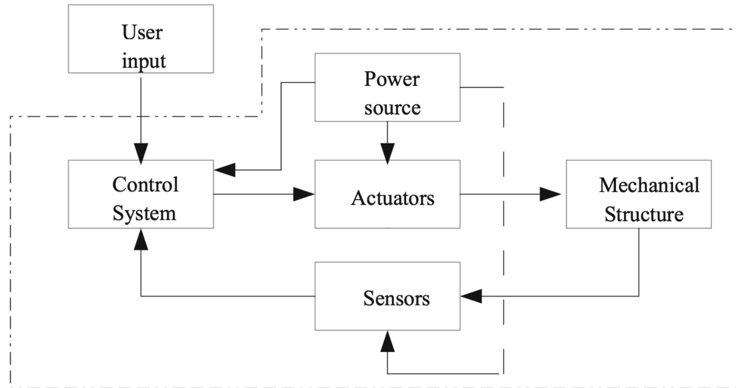
<table>
<tr><td></td><td>Fingers obey hooke’s law, acting as a spring
Trained on VR</td></tr>
<tr><td>Research Question/Problem/ Need</td><td>To develop a dextrous robotic arms/hands.</td></tr>
<tr><td>Important Figures</td><td>
<table>
<caption>Table 2. Importance of actuation properties.</caption>
<tr><th>Properties</th><th>Importance</th></tr>
<tr><td>Performance</td><td>Very important</td></tr>
<tr><td>Energy storage capacity</td><td>Very important</td></tr>
<tr><td>Specific power</td><td>Very important</td></tr>
<tr><td>Required transmission</td><td>Very important</td></tr>
<tr><td>Self braking</td><td>Very important</td></tr>
<tr><td>Noise</td><td>Very important</td></tr>
<tr><td>Safety</td><td>Very important</td></tr>
<tr><td>Robustness</td><td>Important</td></tr>
<tr><td>Volumetric power</td><td>Important</td></tr>
<tr><td>Bandwidth</td><td>Less important</td></tr>
<tr><td>Controllability</td><td>Less important</td></tr>
</table>
All design criteria for the manus-hand</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>Dextrous - multiple uses
Unactuated principle - having less motors than joints
extrinsic movements - holding something and moving it around (grasping)
intrinsic movements - moving something within the hand (dynamic manipulation)
Geneva-wheel - gear mechanism
Martensitic - malleable (for prosthetic fingers) can be bent into shape no mechanical parts</td></tr>
<tr><td>Cited references to follow up on</td><td>Otto Bock System Electric Hand, 647H326, Nov. 2001, Otto Bock, Germany.
Kyberd, P.J. and Chappel, P.H. 1994. The Southampton hand: An</td></tr>
</table>

	intelligent myoelectric prosthesis. Journal of Rehabilitation Research and Development, 31(4):326–334.
Follow up Questions	The prosthesis was fixed to some of the amputees' residual limbs with velcro and such. Would using current 3D scanning tech for liners change the data received? How so? How can we implement modularity into this spring mechanical system?

Article #16 Notes: “Mechanical Design of a Prosthetic Human Arm and its Dynamic Simulation”

Article notes should be on separate sheets

Source Title	“Mechanical Design of a Prosthetic Human Arm and its Dynamic Simulation”
Source citation (APA Format)	Leal-Naranjo, J., Ceccarelli, M., & Torres San miguel, C. (2017). *Mechanical Design of a Prosthetic Human Arm and its Dynamic Simulation* (Vol. 540, p. 490). https://doi.org/10.1007/978-3-319-49058-8_52
Original URL	https://www.researchgate.net/profile/Jose-Leal-Naranjo/publication/311099028_Mechanical_Design_of_a_Prosthetic_Human_Arm_and_its_Dynamic_Simulation/links/5d484acb299bf1995b67de9c/Mechanical-Design-of-a-Prosthetic-Human-Arm-and-its-Dynamic-Simulation.pf
Source type	Journal article
Keywords	Biomechanics Upper limb Prosthetic arm Prosthetic design
Summary of key points + notes (include methodology)	• Include shoulder and 7DoF • Shoulder disarticulation • technical limitations of the device, discomfort, appearance and lack of user training are reasons for abandonment • The MPL [6] is the result of a 6 years program that was sponsored by the • Advance Research Projects Agency of USA. It allows patients with different amputation levels to use it. The upper arm is composed by the shoulder with two actuators, a humeral rotator, elbow and the battery. Its main features are 26° of freedom (including the hand), 17 motors, and a total mass of 4.8 kg with battery and a payload of 155 N with the static wrist. • Cad designed in solidworks
Research Question/Problem/ Need	The objective of this design is to create an anthropomorphic, functional, and low cost prosthesis. Mimic kinematics of normal arm

Important Figures	 Systems diagram of the prosthesis
VOCAB: (w/definition)	MPL - modular prosthetic limb Cardan joint - joint used to make elbows
Cited references to follow up on	Johannes, M., Bigelow, J., Burck, J., Harshbarger, S., Kozlowski, M., Van Doren, T.: An overview of the developmental process for the modular prosthetic limb. Johns Hopkins APL Tech. Dig. 30(3), 207–216 (2011)
Follow up Questions	How do I extend the ability for multiple amputation levels to use a prosthesis for one person growing with it?

Article #17 Notes: CONTROL SYSTEM FOR A GRASPING DEVICE - EP 2 642 953 B1 (Patent)

Article notes should be on separate sheets

Source Title	CONTROL SYSTEM FOR A GRASPING DEVICE - EP 2 642 953 B1
Source citation (APA Format)	Dalley, S. A., Varol, H. A., & Goldfarb, M. (2016). *Control system for a grasping device* (European Union Patent No. EP2642953B1). https://patents.google.com/patent/EP2642953B1/en?oq=EP2642953B1
Original URL	https://patents.google.com/patent/EP2642953B1/en?oq=EP2642953B1
Source type	patent
Keywords	Grasping device, control system, mechanical devices
Summary of key points + notes (include methodology)	Embodiments of the invention concern control systems for grasping devices. In accordance with the invention, a method for operating a grasping device using a plurality of parallel, bi-directional state flow maps each defining a sequence of poses for a plurality of joints in the grasping device, as defined in independent claim 1, is provided. Preferred embodiments are defined in the dependent claims. ● Two versions: direct control and pattern recognition ● Two emg, one on biceps, one on triceps ● Has an opposable thumb ● 7 poses, located in the table below
Research Question/Problem/ Need	How to create a grasping mechanical device with a control system and various DoFs.

Important Figures

Table 1. Average transition times of all subjects between different poses for the native hand*.

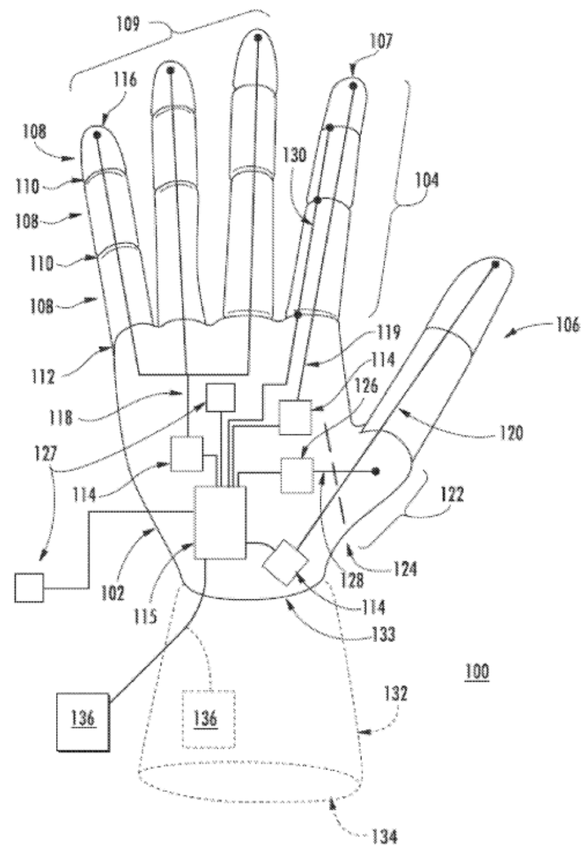
		Target Pose						
		Lateral	Hook	Point	Reposition	Opposition	Tip	Cyl/Sph/Tri
Original Pose	Lateral		0.81 (0.36)	0.81 (0.36)	0.79 (0.36)	0.76 (0.50)	0.78 (0.25)	0.74 (0.21)
	Hook	0.59 (0.12)		0.69 (0.25)	0.90 (0.65)	0.67 (0.19)	0.80 (0.28)	0.72 (0.19)
	Point	0.72 (0.31)	0.62 (0.15)		0.81 (0.60)	0.73 (0.19)	0.88 (0.26)	0.82 (0.28)
	Repos.	0.76 (0.25)	0.72 (0.18)	0.86 (0.48)		0.65 (0.28)	0.82 (0.50)	0.86 (0.22)
	Oppos.	0.82 (0.30)	1.02 (0.48)	1.06 (0.53)	0.71 (0.19)		0.89 (0.30)	0.97 (0.38)
	Tip	0.77 (0.12)	0.94 (0.47)	0.90 (0.33)	0.96 (0.33)	0.71 (0.23)		0.91 (0.39)
	Cyl/Sph/Tri	0.85 (0.42)	0.92 (0.33)	0.86 (0.31)	0.86 (0.27)	0.72 (0.15)	0.84 (0.24)	

*Standard deviations are displayed in parenthesis.

Table 2. Average transition times of all subjects between different poses for multigrasp myoelectric control*.

		Target Pose						
		Lateral	Hook	Point	Reposition	Opposition	Tip	Cyl/Sph/Tri
Original Pose	Lateral		1.20 (0.63)	1.32 (0.53)	1.37 (0.21)	2.02 (0.70)	2.43 (0.68)	2.70 (0.69)
	Hook	0.67 (0.14)		0.89 (0.29)	1.05 (0.14)	1.60 (0.39)	2.03 (0.51)	2.50 (0.95)
	Point	1.12 (0.35)	0.84 (0.22)		0.81 (0.43)	1.25 (0.36)	1.67 (0.32)	2.21 (0.50)
	Repos.	1.82 (0.96)	1.34 (0.36)	1.02 (0.31)		0.92 (0.51)	1.36 (0.51)	1.57 (0.56)
	Oppos.	1.84 (0.44)	1.79 (0.56)	1.38 (0.43)	0.75 (0.26)		1.11 (0.43)	1.47 (0.88)
	Tip	2.16 (0.44)	2.18 (0.56)	1.68 (0.38)	1.15 (0.44)	0.61 (0.13)		0.75 (0.10)
	Cyl/Sph/Tri	2.40 (0.40)	2.46 (0.61)	1.97 (0.55)	1.40 (0.37)	0.88 (0.17)	0.85 (0.22)	

*Standard deviations are displayed in parenthesis.

	 FIG. 2 A diagram of the prosthesis with all of the joints and control components labeled
VOCAB: (w/definition)	Actuator - a device that causes a machine or other device to operate. Co-contraction - contracting both antagonizing muscles at the same time (e.g. biceps and triceps)
Cited references to follow up on	n/a
Follow up Questions	Is there any way to simplify this design so that it has less actuators to allow the space for a modular approach? For the co-contraction, is there a way to turn that mode off for specific tasks?

Article #18 Notes: PROSTHETIC HAND SYSTEM - US 20200330246A1 (Patent)

Article notes should be on separate sheets

Source Title	PROSTHETIC HAND SYSTEM - US 20200330246A1
Source citation (APA Format)	Tognetti, A., Donati, G., Bacchereti, M., Ferretti, L., Pellicci, G., Vitetta, N., & Carbonaro, N. (2020). *Prosthetic hand system* (United States Patent No. US20200330246A1). https://patents.google.com/patent/US20200330246A1/en?oq=US+20200330246A1+
Original URL	https://patents.google.com/patent/US20200330246A1/en?oq=US+20200330246A1+
Source type	patent
Keywords	Prosthetic hand system, mechanical finger
Summary of key points + notes (include methodology)	A prosthetic hand structure including at least one mechanical finger having a metacarpal support and a proximal stiff link connected to the metacarpal support by a proximal cylindrical joint. The mechanical finger includes a transmission member connected to the proximal stiff link. The transmission member includes a worm screw integral to the proximal stiff link. The transmission member includes a flexible rack having a first end portion, pivotally connected to the metacarpal support, and a second end portion arranged to engage with the threaded profile of the worm screw at an engagement zone of the flexible rack. The structure also includes an actuator mounted to the mechanical finger and to actuate the worm screw, causing it to rotate about its rotation axis, in such a way that, when the actuator moves the worm screw, the mechanical finger extends or flexes. ● Utilizes a screw-rack system for the joints in the fingers and hand ● EMG control from muscles as well
Research Question/Problem/	How to develop and create a prosthetic hand system that utilizes mechanical fingers

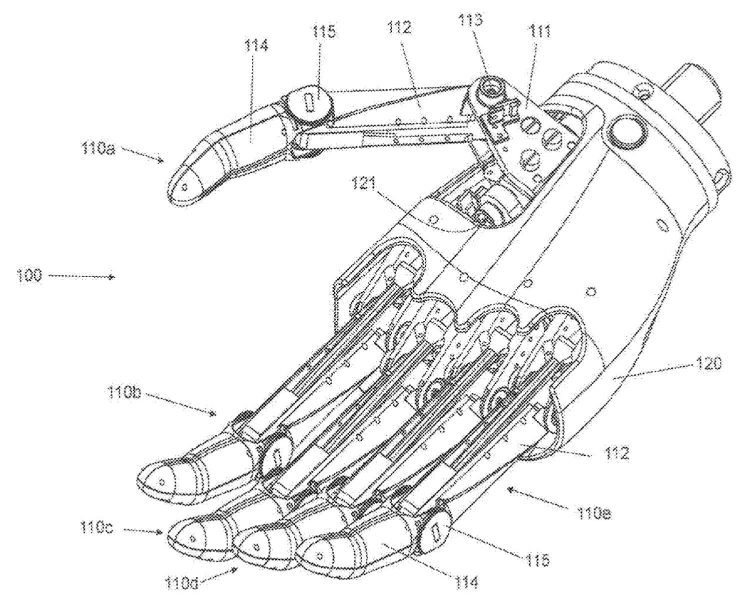
<table>
<tr><td>Need</td><td></td></tr>
<tr><td>Important Figures</td><td>

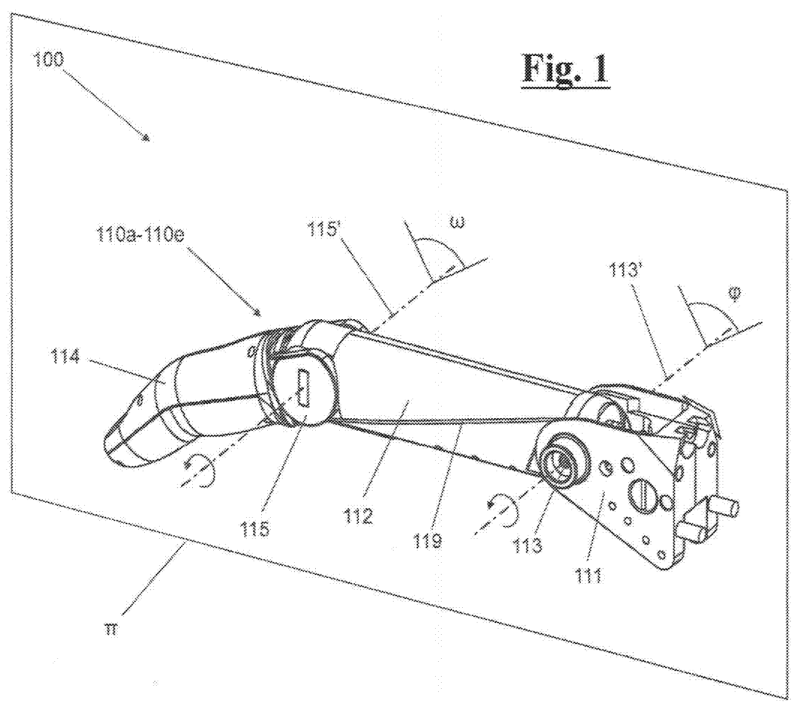
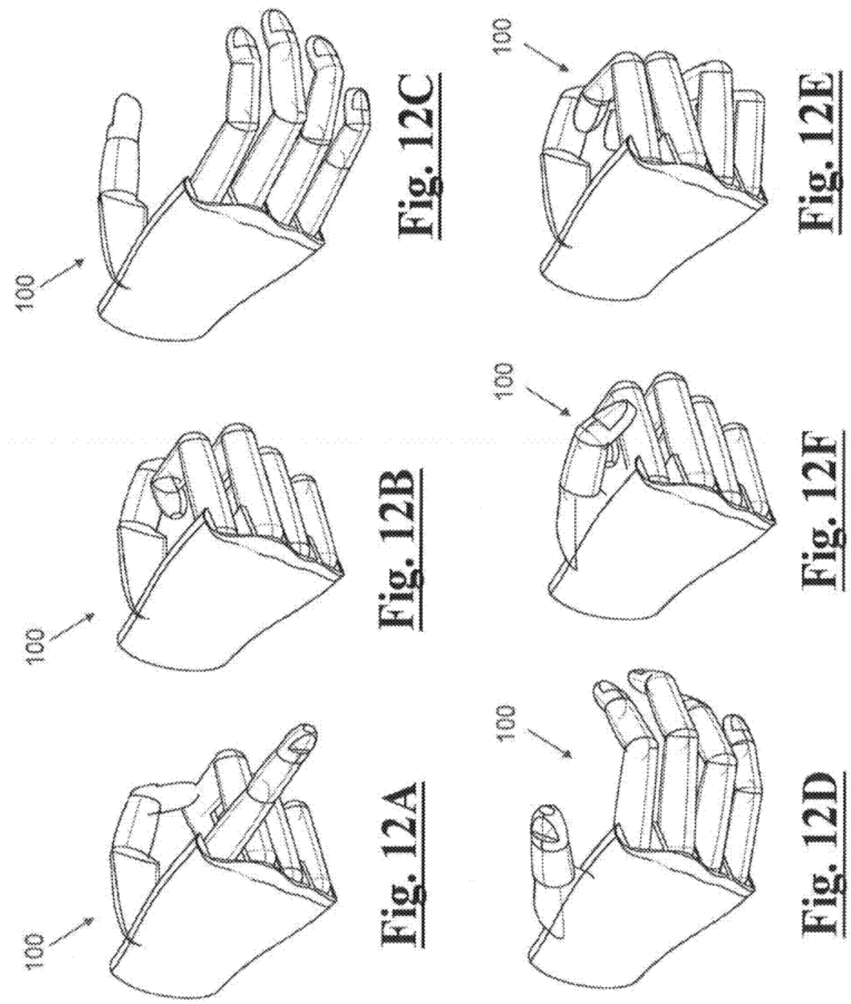
Image of the prosthetic hand labeled with all of the joints


Image of an individual finger</td></tr>
</table>

	 Images of the multiple grips for the prosthesis
VOCAB: (w/definition)	proximal cylindrical joint - Cylindrical joints constrain two bodies to a single axis while allowing them to rotate about and slide along that axis Worm screw - a threaded rod with one or more screws
Cited references to follow up on	n/a
Follow up Questions	Is there any way to utilize the screw-rack system for underactuated fingers in the prosthesis? Is there a way to 3D print this with polymers or carbon fiber instead of metal?