Procedure for joining "Smart Morphing Wing" or "Smart Prosthetics" Senior Design Projects

1 Overview

"Smart Morphing Wing" or "Smart Prosthetics" Senior Design Projects (SDPs) are among the research-based "Smart Systems and Structures" (SSS) SPDs that Dr. Peter L. Bishay founded and is supervising at CSUN's Mechanical Engineering Department.

1.1 Smart Morphing Wing (SMW)

Smart Morphing Wing (SMW) SDP started in 2016-17 academic year with the goal of designing innovative models of morphing aerodynamic systems such as Unmanned Aerial Vehicle (UAV) with seamless morphing wings and wind turbine blades. Smart materials and structures, such as Shape Memory Alloy (SMA) wires, Macro-Fiber Composite (MFC) patches, corrugated and zero-Poisson-ratio structures, etc. can possibly be integrated in the designs to expand the applications of such new materials and structures. The enrolled students get involved in reading recent research papers on the current advances in this technology, propose analytical and computational models, run computer simulations on their models to justify their designs, physically build their innovative models, test their performance, and present their work at several events such as the American Institute of Aeronautics and Astronautics (AIAA) regional student conference and competition, CSUN's annual research and creative works symposium (CSUNposium), and CSUN's Senior Design Project Showcase (SDPS). Preliminary and Critical Design Reviews (PDR and CDR) are also scheduled in the Fall semester, where students get the chance to receive feedback from industry professionals, faculty members, graduate students, and peer undergraduate students. Students also give biweekly presentations and write bimonthly reports throughout the semester.

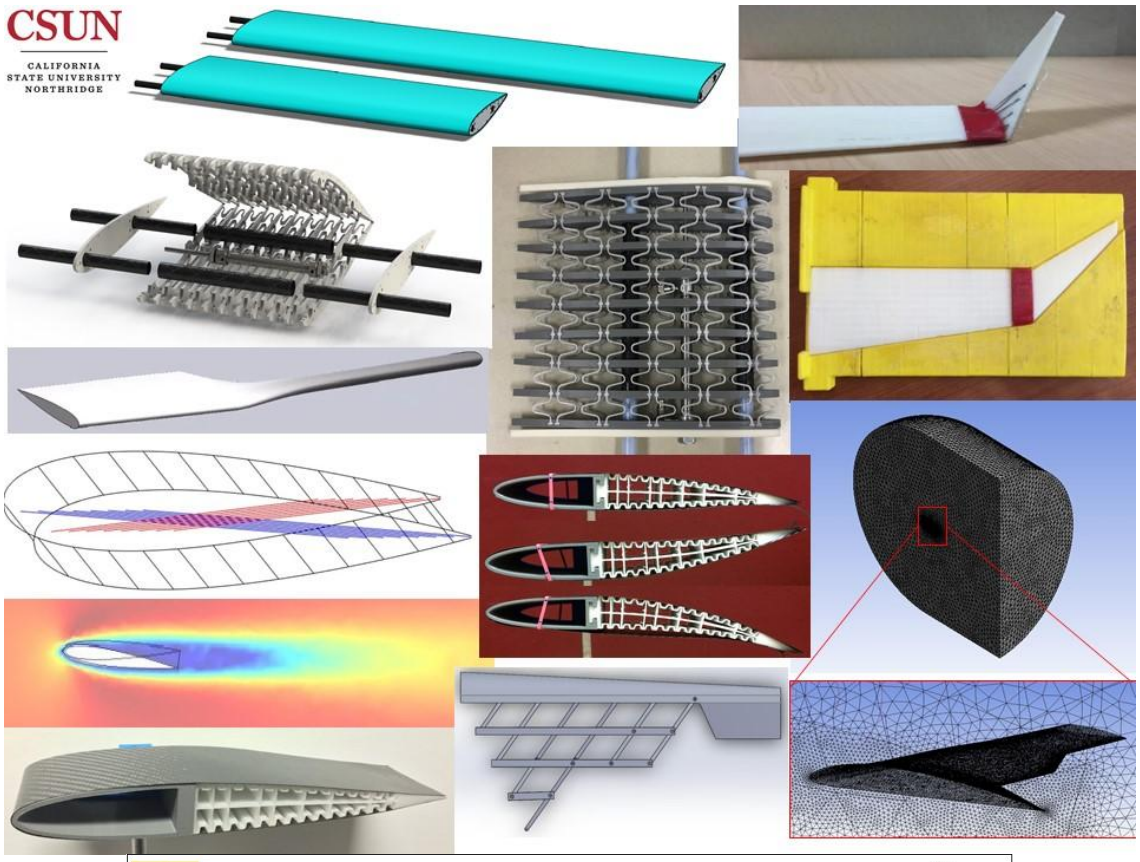
In its first year (**2016-17**), SMW SDP made the following achievements:

(1) Five teams presented their research and designs at the AIAA regional student conference at San Jose State University (SJSU). The "Span Morphing" team's paper entitled "*Design and Manufacturing of a New Span Morphing Wing*" won the **third place** (Award certificates and $125) in the competition after USC and University of Arizona.

(2) Five teams presented their research and designs at CSUN's 21st annual research and creative works symposium (CSUNposium). The "Morphing Winglets" team presentation, entitled "*Integrated Morphing Winglet Design with Shape Memory Alloy Driven Actuation*", won the **first place** (Award certificates and $200) in the College of Engineering and Computer Science session of the symposium, while the "Twist

Morphing" team presentation, entitled "*Development of a twist morphing wing design using an SMA based smart soft composite*", won the **second** place (Award certificates and $100).

(3) Technical paper on the span morphing wing core design has been published in *designs* journal (MDPI publisher) entitled "***Development of a New Span-Morphing Wing Core Design***." https://doi.org/10.3390/designs3010012.



designs
MDPI
Article

Development of a New Span-Morphing Wing Core Design

Peter L. Bishay *, Erich Burg, Akinwande Akinwunmi, Ryan Phan and Katrina Sepulveda

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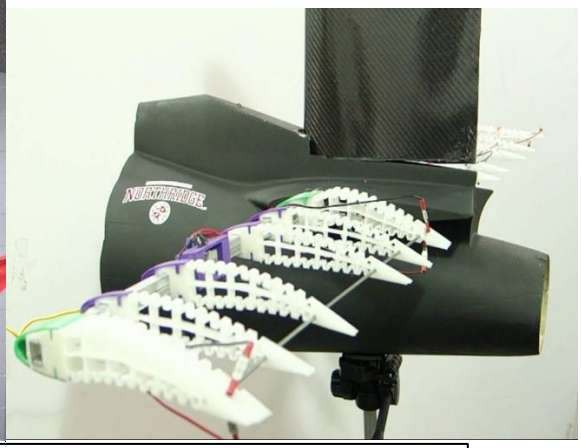
In its second year (**2017-18**), SMW SDP made the following achievements:

(1) Two teams presented their research and designs at the AIAA regional student conference at UC Merced. The 11-page technical paper entitled: "*Design and Manufacturing of an SMA-based Seamless Camber Morphing UAV Tail Section*" won the **second place** (Award certificates and $300) in the competition after USC and followed by University of Washington in the 3rd place.

(2) Technical paper on the camber morphing tail-section core design was published in *Smart Materials and Structures* journal, entitled "***Development of an SMA-based camber morphing UAV tail core design***" https://iopscience.iop.org/article/10.1088/1361-665X/ab1143.



IOP Publishing Smart Materials and Structures

Smart Mater. Struct. **28** (2019) 075024 (11pp) https://doi.org/10.1088/1361-665X/ab1143

Development of an SMA-based camber morphing UAV tail core design

Peter L Bishay, Ryan Finden, Shawn Recinos, Christian Alas, Erik Lopez, Dvin Aslanpour, Douglas Flores and Efrain Gonzalez

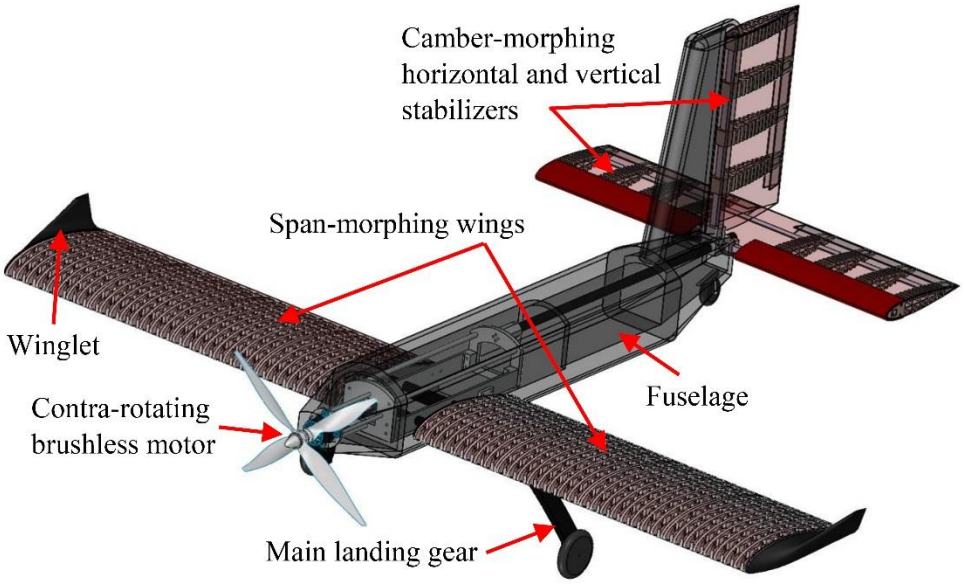
Department of Mechanical Engineering, California State University of Northridge, Northridge, CA, 91330, United States of America

The goal of the third cohort (2018-19) was to **design, build and fly a fully morphing UAV with span-morphing wings and camber morphing stabilizers.** The team made the following achievements:

(1) **Second place** (Award certificates and $300) at the AIAA regional student conference and competition, Cal Poly San Luis Obispo (April 6-7). 11-page technical paper title: *Matamorph 1: A New Experimental UAV with Span-Morphing Wing and Camber-Morphing Tail*.

(2) **First place** (Award certificates and $200) at the 10-minute presentation competition of CSUN's 23rd annual research and creative works symposium (CSUNposium), College of Engineering and Computer Science session.

(3) **First place** (Award certificates and $200) at the 3-minute presentation competition of CSUN's 23rd annual research and creative works symposium (CSUNposium). Presentation title: *Wind Tunnel Testing of Two New Morphing Wing Designs*.



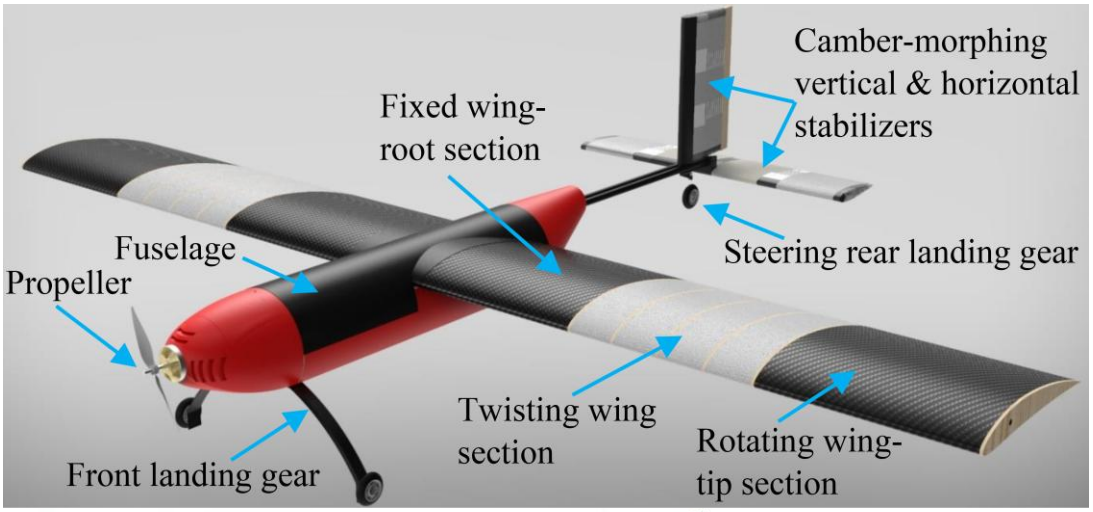
The goal of the fourth cohort (2019-20) is to **design, build and fly a fully morphing UAV with twist-morphing wings and camber morphing stabilizers.** The team made the following achievements:

(1) **First place** (Award certificates and $200) at the 10-minute presentation competition of CSUN's 24th annual research and creative works symposium (CSUNposium).

(2) **First place** (Award certificates and $200) at the 3-minute presentation competition of CSUN's 24th annual research and creative works symposium (CSUNposium). Presentation title: *Can we fly an airplane with wings that change their shape inflight?*

(3) **First place** (Award certificates and $500) at the AIAA regional student research competition. The competition included 13 teams from University of Southern California (USC), Arizona State University (ASU), University of Washington (UW), Portland State University (PSU), Embry-Riddle Aeronautical University and University of Alaska, Fairbanks. After CSUN, a team from UW got 2nd place and a team from USC got third place. A team representative presented the team's 11-page technical paper at the AIAA 2021 virtual SciTech Forum in January 2021, and the paper was also be published as part of the 2021 SciTech conference proceedings (Schlup, A.E.; Bishay, P.L.; McLennan, T.L.; Barajas, C.; Talebian, B. L.; Thatcher, G.C.; Flores, R.B.; Perez-

Norwood, J.D.; Torres, C.L.; Kibret, K.B.; Guzman, E.E. (2021): ***MataMorph 2: A new experimental UAV with twist-morphing wings and camber-morphing tail stabilizers***. *AIAA SciTech 2021 Forum*, Jan. 11-15 & 19-21, 2021. https://doi.org/10.2514/6.2021-0584).



AIAA SciTech Forum
11–15 & 19–21 January 2021, VIRTUAL EVENT
AIAA Scitech 2021 Forum

10.2514/6.2021-0584

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MataMorph 2: A new experimental UAV with twist-morphing wings and camber-morphing tail stabilizers

Adam E. Schlup[1], Tommy L. MacLennan[1], Cristobal Barajas[1], Bianca L. Talebian[1], Gregory C. Thatcher[1], Richard B. Flores[1], Justin D. Perez-Norwood[1], Christian L. Torres[1], Kebron B. Kibret[1], Edgar E. Guzman[1]
and
Dr. Peter L. Bishay[2]
California State University, Northridge, Northridge, CA, 91330, United States

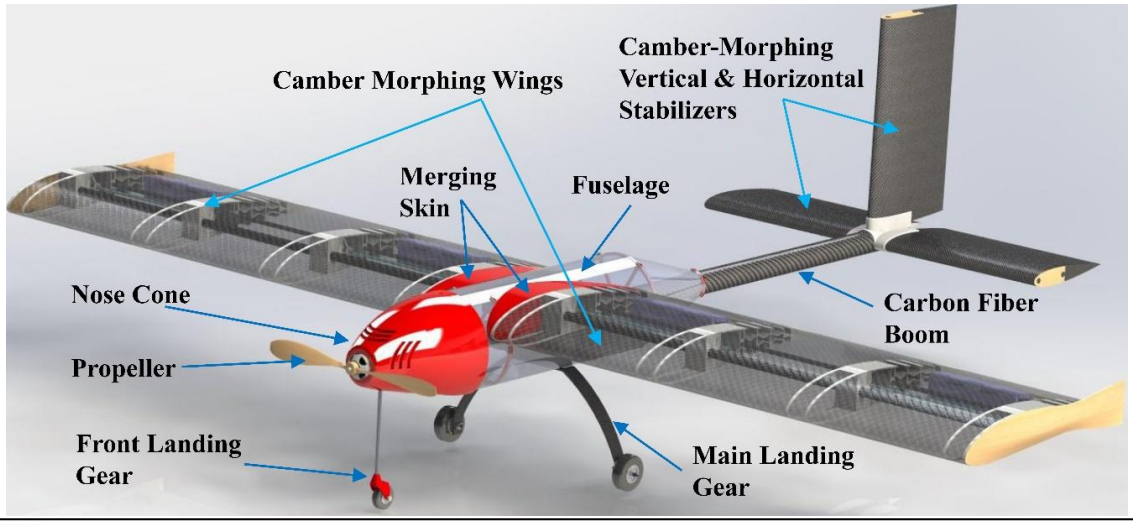
The goal of the fifth cohort (2020-21) was to **design, build and fly a fully morphing UAV with camber-morphing wings and tail stabilizers.** The team made the following achievements:

(1) **Second place** (Award certificates and $100) at the 10-minute presentation competition of CSUN's 25th annual research and creative works symposium (CSUNposium).

(2) **Second place** (Award certificates and $300) at the virtual AIAA regional student research competition. First place went to CalTech's team and third place to USC's team. The team's 11-page technical paper is entitled "*Design and analysis of MataMorph-3: An experimental fully morphing UAV with camber-morphing wings and tail stabilizers.*"

(3) Only representative of CSUN's College of Engineering and Computer Science (CECS) at the **2021 CSU Statewide Student Research Competition**.

(4) Publication of a research paper in *Aerospace* journal: Bishay, P.L.; Kok, J.S.; Espinoza, B.M.; Ferrusquilla, L.J.; Heness, A.; Buendia, A.; Zadoorian, S.; Lacson, P.; Ortiz, J.D.; Basilio, R.; Olvera, D. (2022): ***Design and analysis of MataMorph-3: A fully morphing UAV with camber-morphing wings and tail stabilizers***. *Aerospace*, vol. 9, no. 7, art. 382. https://doi.org/10.3390/aerospace9070382.



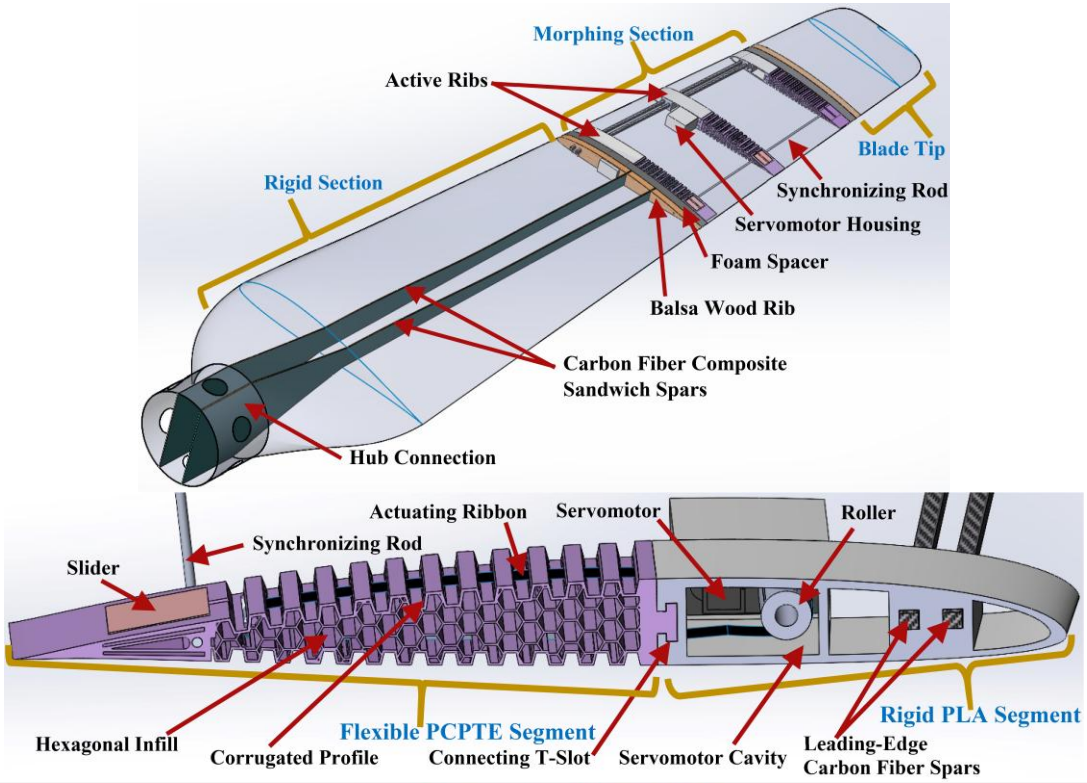
The scope of SMW changed in 2021-22, and the sixth cohort focused on **designing a camber-morphing wind turbine blade for improved efficiency and load alleviation**. The team made the following achievements:

(1) Published journal paper: **Bishay, P.L.**; McKinney, T.; Kline, G.; Manzo, M.; Parian, A.; Bakhshi, D.; Langwald, A.; Ortega, A.; Gagnon, M., Alfaro, G.F. (2024): ***SCAMORSA-1: a camber-morphing wind turbine blade with sliding composite skin***. *Journal of Engineering Research*, vol. 12, issue 4, pp. 931-940.https://doi.org/10.1016/j.jer.2024.04.006.

(2) Presentation at the 2022 AIAA regional student research conference and competition (UC Merced). The team's 11-page technical paper is entitled "***SCAMORSA-1: a camber-morphing wind turbine blade with sliding composite skin***."

(3) **First place** (Award certificates and $200) at the poster competition of CSUN's 26th annual research and creative works symposium (CSUNposium). Poster title: *Design of a Camber Morphing Wind Turbine Blade for Load Alleviation and Improved Aerodynamic Efficiency*.

(4) Presentation at CSUN's 2022 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).



Journal of Engineering Research 12 (2024) 931–940

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SCAMORSA-1: A camber-morphing wind turbine blade with sliding composite skin

Peter L. Bishay *, Toby McKinney, Garrett Kline, Maria Manzo, Arthur Parian, Derenik Bakhshi, Andrew Langwald, Abraham Ortega, Matthew Gagnon, Gerbert Funes Alfaro

Department of Mechanical Engineering, California State University, Northridge, Northridge, CA 91330, USA

The seventh cohort (2022-23) designed **a bio-inspired bird-like non-flapping unmanned aerial vehicle (UAV), called "MataGull"**. The flexible wing and tail morphing mechanisms were presented in an *Applied Sciences* journal paper. They made the following achievements:

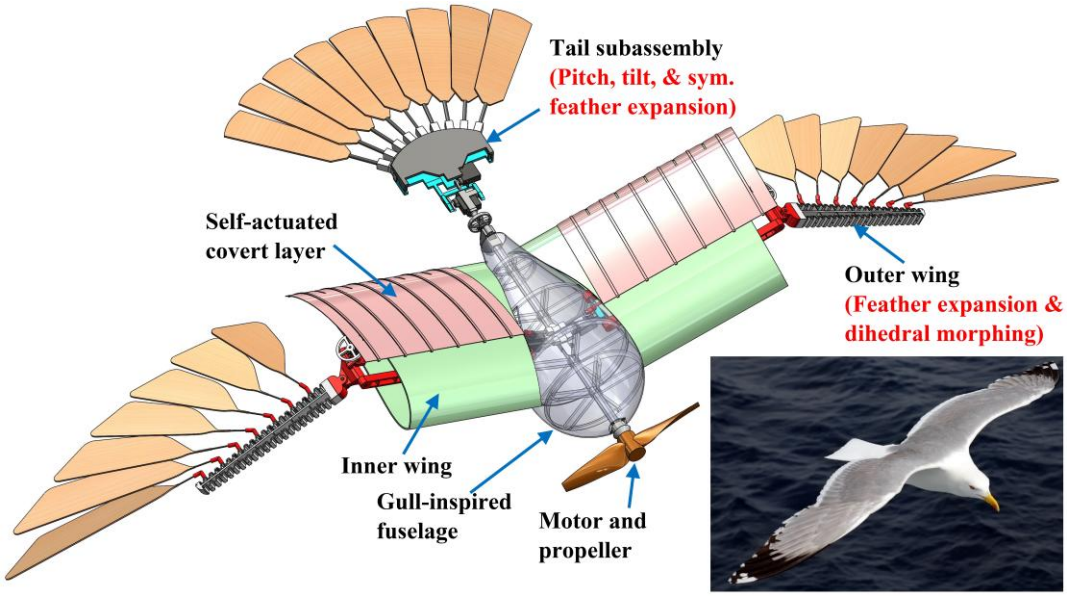
(1) Honorable mention at the AIAA regional student research conference and competition (UC Davis, March 25-26, 2023). Technical paper was published at AIAA ARC: "***MataGull: A lightweight bio-inspired non-flapping bird-like morphing drone***" https://doi.org/10.2514/6.2023-72218.

(2) **First place** (Award certificates and $300) at the 10-minute presentation competition of CSUN's 27th annual research and creative works symposium (CSUNposium). Presentation title: MataGull, a bio-

(3) inspired lightweight non-flapping bird-like morphing drone.

(4) Mechanical Engineering **Project Display Winner** at CSUN's 2023 College of Engineering and Computer Science Senior Design Project Showcase (SDPS) (Award certificates and $500).

(5) Paper publication: Bishay, P. L.; Brody, M.; Podell, D.; Corte Garcia, F.; Munoz, E.; Minassian, E.; Bradley, K. (2023): ***3D-Printed Bio-Inspired Mechanisms for Bird-like Morphing Drones***. *Applied Sciences*, Vol. 13(21), 11814, https://doi.org/10.3390/app132111814.



The eighth cohort (2023-24) designed **CGull, a bio-inspired bird-like non-flapping unmanned aerial vehicle (UAV), that is entirely made of composite shells**. They made the following achievements:

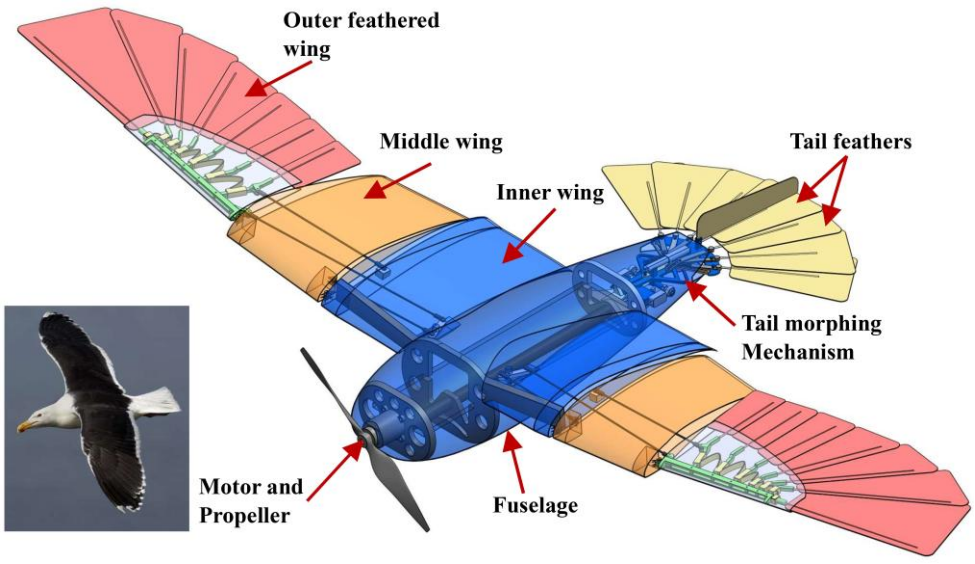
(1) **First place** at the AIAA regional student research conference and competition (Santa Clara University, March 23-24, 2024). Conference paper published at the *AIAA SciTech 2025 Forum*, Orlando, FL, Jan. 6-10, 2025: Brambila, M.; Rini, R.; Eghdamzamiri, J.; Yousefi, H.; Herrera, J.; Hanna, D.; Black, C.; Saad, Y.; Arias-Rodas, A.; Bishay, P.L., ***Design of a non-flapping seagull-inspired composite morphing drone***, https://doi.org/10.2514/6.2025-0124.

(2) **First place** (Award certificates and $300) at the 10-minute presentation competition of CSUN's 28th annual research and creative works symposium (CSUNposium). Presentation title: *CGull: A bio-inspired non-flapping bird-like morphing drone*.

(3) Mechanical Engineering **Project Display Winner** at CSUN's 2024 College of Engineering and Computer Science Senior Design Project Showcase (SDPS) (Award certificates and $500).

(4) Presentation at *the 1st International Online Conference on Biomimetics*, May 15-17, 2024 (by Dr. Bishay). Presentation title: *CGull: A Non-Flapping Seagull-Inspired Composite Morphing Drone*.

(5) Paper publication: Bishay, P.L.; Rini, A.; Brambila, M.; Niednagel, P.; Eghdamzamiri, J.; Yousefi, H.; Herrera, J.; Saad, Y.; Bertuch, E.; Black, C.; Hanna, D.; Rodriguez, I.; Arias-Rodas, A. (2024): CGull: a non-flapping bioinspired composite morphing drone. *Biomimetics*, vol. 9(9), no. 527. https://doi.org/10.3390/biomimetics9090527.



AIAA SciTech Forum
6-10 January 2025, Orlando, FL
AIAA SCITECH 2025 Forum

10.2514/6.2025-0124

Check for updates

Design of a non-flapping seagull-inspired composite morphing drone

Moises Brambila[1], Alex Rini[1], Jordan Eghdamzamiri[1], Hariet Yousefi[1], Joshua Herrera[1], Donovan Hanna[1], Caleb Black[1], Youssef Saad[1], Aramar Arias-Rodas[1] and Peter L. Bishay[2]

Department of Mechanical Engineering, California State University, Northridge

biomimetics

MDPI

Article

CGull: A Non-Flapping Bioinspired Composite Morphing Drone

Peter L. Bishay *, Alex Rini, Moises Brambila, Peter Niednagel, Jordan Eghdamzamiri, Hariet Yousefi, Joshua Herrera, Youssef Saad, Eric Bertuch, Caleb Black, Donovan Hanna and Ivan Rodriguez

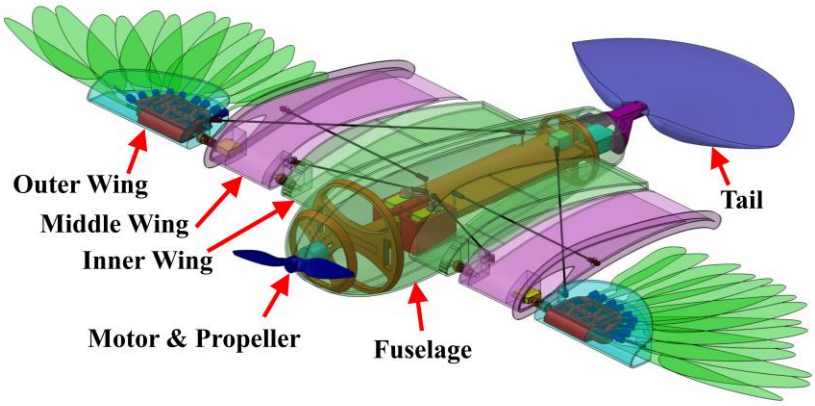
Department of Mechanical Engineering, California State University, Northridge, CA 91330, USA
* Correspondence: peter.bishay@csun.edu

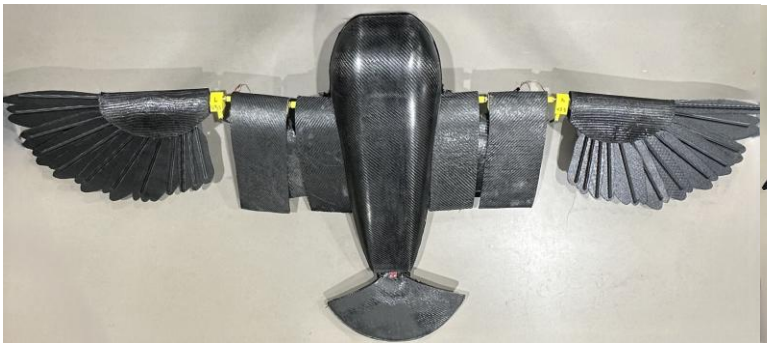
The ninth cohort (2024-25) extended the design of CGull by adding more degrees of freedom in the wing, along with more sensors, and a wind generator unit for testing "CGull-2". They made the following achievements as of April 23rd, 2025:

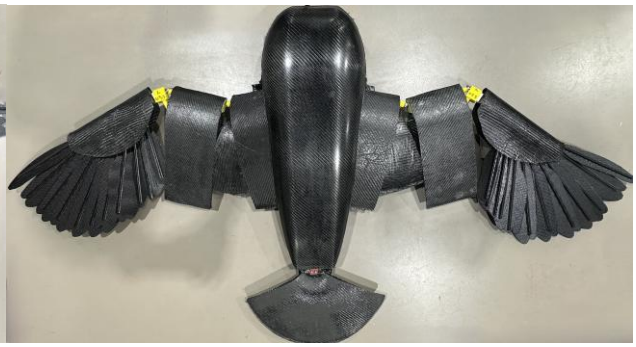
(1) **Third place** at the AIAA regional student research conference and competition (University of California Irvine, March 29-30, 2025). Conference paper to be published at AIAA ARC: Aguilera Fuentes, J.; Astorga, J.; Zuloaga, M.; LeMaster, J.; Corral, A.G.; Balan, J.; Mackey de Zela, J.; Martin, M.E.; Gill, H.; Murphy, B.; Bishay, P.L. (2025): Design of a non-flapping morphing drone inspired by the western gull. *AIAA Regional Student Conference*, UC Irvine, USA, Mar. 29-30, 2025.

(2) **First place** (Award certificates and $300) at the 10-min and 3-min presentation competitions of CSUN's 29th annual research and creative works symposium (CSUNposium). 10-min Presentation title: *Design of a Non-Flapping Morphing Drone Inspired by the Western Gull's Flight.* 3-min Presentation title: *Composite Bird Feathers: A Combination of Engineering and Nature*.

(3) Mechanical Engineering **Project Display Winner** at CSUN's 2025 College of Engineering and Computer Science Senior Design Project Showcase (SDPS) (Award certificates and $500).







Design of a Non-Flapping Morphing Drone Inspired by the Western Gull

Jose Aguilera Fuentes[1], Jeffrey Astorga[2], Marco Zuloaga[3], Jeremy LeMaster[4], Adrian G. Corral[5], Jonathan Balan[6], Joseph Mackey de Zela[7], Matthew Emil Martin[8], Harmandeep Gill[9], Brianna Murphy[10], and Peter L. Bishay[11]

Department of Mechanical Engineering, California State University, Northridge

The tenth cohort (2025-26) will focus on designing, building, and testing a new drone that resembles the red-tailed hawk, given its popularity in this region of California, and the presence of a taxidermy of the bird, which is used in one of Dr. Bishay's current projects in collaboration with CSUN's biology department.

Table 1: SMW achievements table

Cohort	AIAA competition	CSUNposium		Other
		10-min	3-min	
First (2016-17)	3rd place	1st & 2nd places	-	Paper in ***Designs*** journal.
Second (2017-18)	2nd place	-	1st place	Paper in ***Smart Materials & Structures*** journal.
Third (2018-19): XM1	2nd place	1st place	1st place	
Fourth (2019-20): XM2	1st place	1st place	1st place	Paper in ***AIAA SciTech Conference*** Proceedings.
Fifth (2020-21): XM3	2nd place	2nd place	-	- Only representative of CSUN's CECS in the 2022 CSU-statewide competition. - Paper in ***Aerospace*** journal.
Sixth (2021-22): SCAMORSA-1 wind turbine blade	-	-	-	- 1st place: CSUNposium Poster. - Paper in ***Journal of Engineering Research***
Seventh (2022-23): MataGull	Honorable Mention	1st place	-	- Project Display winner at **Senior Design Project Showcase.** - Paper in ***AIAA ARC.*** - Paper in ***Applied Sciences*** journal.
Eighth (2023-24): CGull	1st place	1st place	-	- Project Display winner at **Senior Design Project Showcase.** - Paper in ***AIAA ARC.*** - Presentation at *the 1st International Online Conference on Biomimetics.* - Paper in ***Biomimetics*** journal.
Ninth (2024-25): CGull-2	3rd place	1st place	1st place	- Project Display winner at **Senior Design Project Showcase.** - Paper in ***AIAA ARC.***

For more details, visit: http://www.csun.edu/~pbishay/projects.php.

1.2 Smart Prosthetics

Smart Prosthetics SDP started in 2017-18 academic year with the goal of designing biomimetic innovative prosthetic hand model based on smart materials and structures (such as Shape Memory Alloy (SMA) wires, Twisted and Coiled Polymer (TCP) wires, Smart Soft Composites (SSC), etc.). The enrolled students get involved in reading recent research papers on the current advances in this technology, propose analytical and computational models, run computer simulations on their models to justify their designs, physically build their innovative models, test their performance and present their work at several events such as the American Society of Biomechanics (ASB) regional meetings, CSUN's annual research and creative works symposium (CSUNposium), and CSUN's Senior Design Project Showcase (SDPS). Preliminary and Critical Design Review (PDR and CDR) are scheduled in the Fall semester, where students get the chance to receive feedback from industry professionals, faculty members, graduate students and peer undergraduate students. Students also give biweekly presentations and write monthly reports throughout the semester.

In its first year (**2017-18**), Smart Prosthetics SDP made the following achievements:

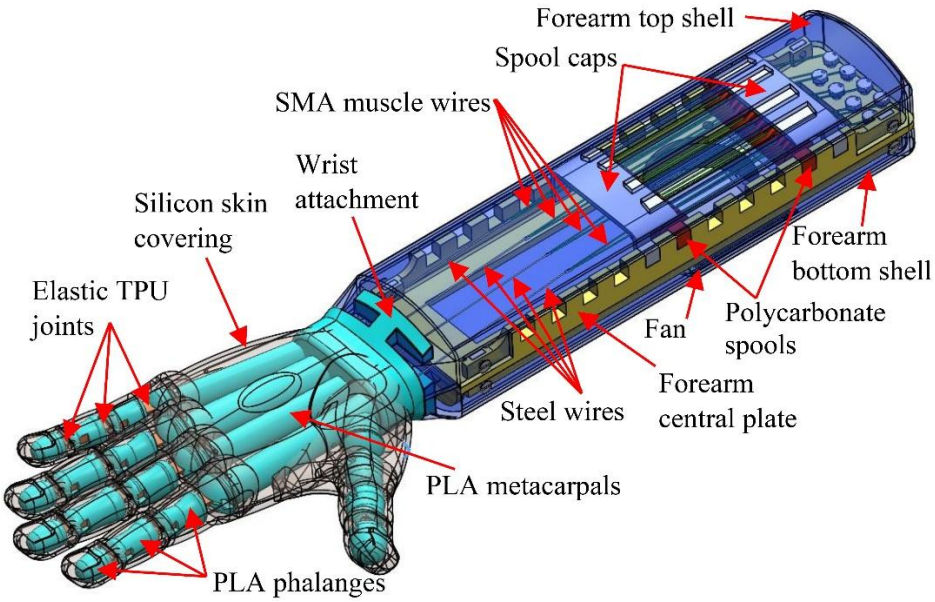
(1) **Grand Prize** Winner ($1000), Mechanical Engineering Oral Presentation Winner ($500) and Project Display Winner ($500) at CSUN's 2018 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).

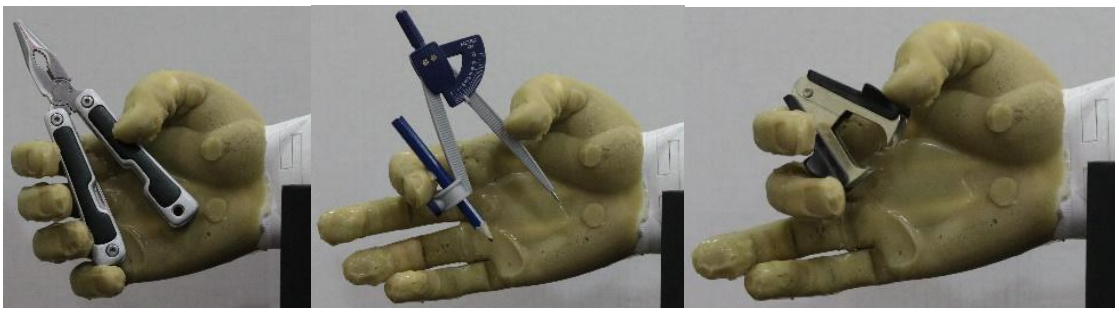
(2) **First** place (Award certificates and $200) at the oral presentation competition of CSUN's 22nd annual research and creative works symposium (CSUNposium), College of Engineering and Computer Science session. Presentation title: "*Development of a New, Innovative, Smart Prosthetic Hand*".

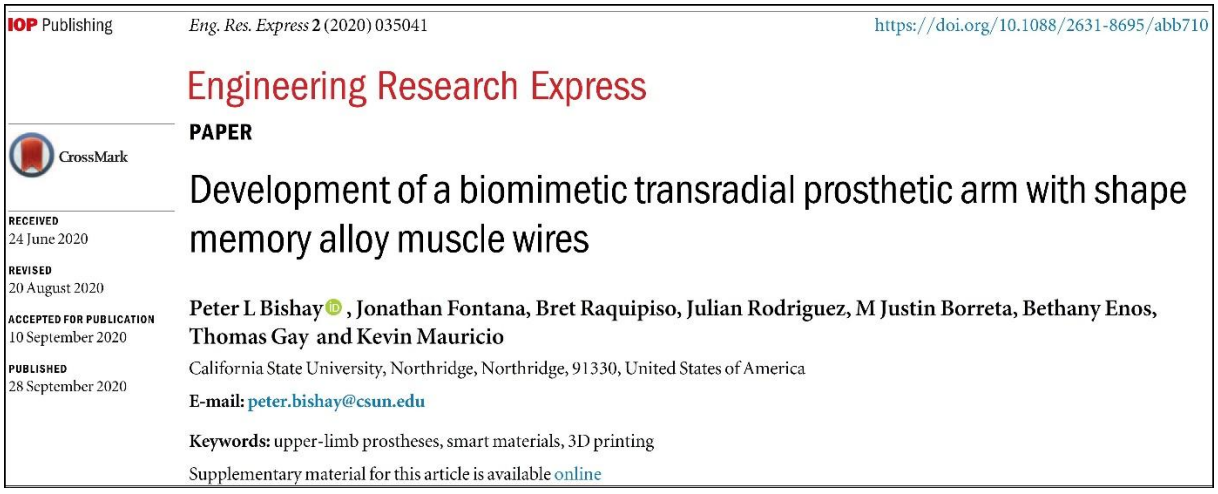
(3) Poster presentation at the 8th annual Rocky Mountain American Society of Biomechanics (RMASB) regional meeting (April 13-14, 2018, Estes Park, CO).
Extended Abstract available at: http://www.csun.edu/~pbishay/pubs/SP_RMASB_2018.pdf

(4) Poster presentation at the 14th annual Northwestern American Society of Biomechanics (NWASB) regional meeting (May 4-5, 2018, Bellingham, WA).
Extended Abstract available at: http://www.csun.edu/~pbishay/pubs/SP_NWASB_2018.pdf

(5) Technical paper published in *Engineering Research Express* journal, entitled "***Development of a biomimetic transradial prosthetic arm with shape memory alloy muscle wires***."
https://iopscience.iop.org/article/10.1088/1361-665X/ab1143







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Engineering Research Express

PAPER

Development of a biomimetic transradial prosthetic arm with shape memory alloy muscle wires

Peter L Bishay, Jonathan Fontana, Bret Raquipiso, Julian Rodriguez, M Justin Borreta, Bethany Enos, Thomas Gay and Kevin Mauricio

California State University, Northridge, Northridge, 91330, United States of America

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Keywords: upper-limb prostheses, smart materials, 3D printing

Supplementary material for this article is available online

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The goal of the second cohort (2018-19) was to **design, build and test an affordable lightweight below-the-elbow prosthetic hand with better functionality, controllability and power consumption.** The team made the following achievements:

(1) Mechanical Engineering **Oral Presentation Winner** ($500) at CSUN's 2019 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).

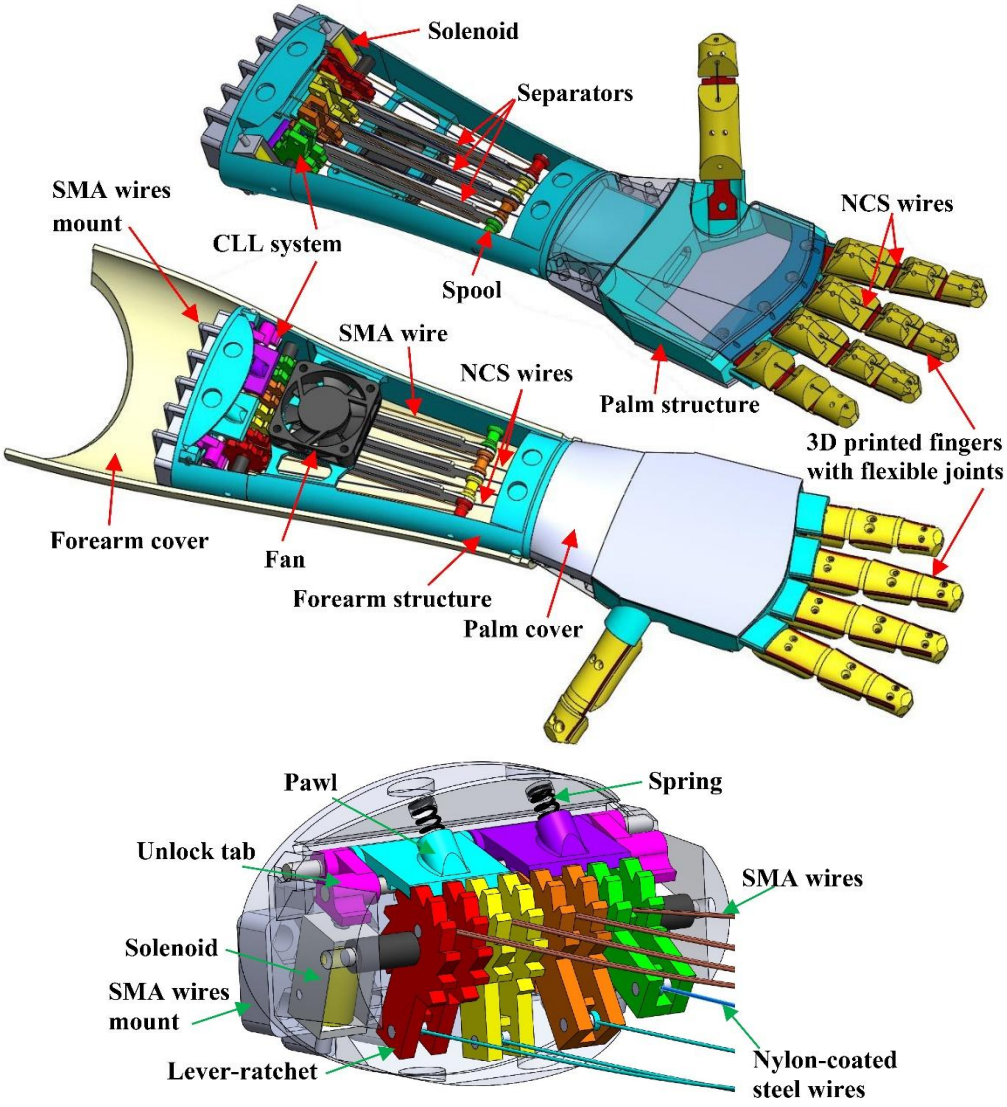
(2) **First place** (Award certificates and $200) at the 10-minute presentation competition of CSUN's 23rd annual research and creative works symposium (CSUNposium). Presentation title: *Development of a New Lightweight Low-Cost SMA-Based Transradial Prosthetic Arm*.

(3) **Third place** ($5,000) at the third CSUN Bull Ring competition.

(4) Poster presentation at the 9th annual Rocky Mountain American Society of Biomechanics (RMASB) regional meeting (April 5-6, 2019, Estes Park, CO).

(5) **First place** at the poster presentation competition of CSUN's California Renewable Energy and Storage Technology (CREST) conference (November 10, 2018). Poster title: "*Efficient power systems in shape-memory alloy (SMA) actuated prostheses*".

(6) Technical paper published in the 2021 *ASME-SMASIS Conference proceedings*, entitled "***Design of a lightweight shape memory alloy stroke-amplification and locking system in a transradial prosthetic arm***." https://doi.org/10.1115/SMASIS2021-68248.



Proceedings of the ASME 2021 Conference on Smart Materials,
Adaptive Structures and Intelligent Systems
SMASIS2021
September 14-15, 2021, Virtual, Online

SMASIS2021-68248

DESIGN OF A LIGHTWEIGHT SHAPE MEMORY ALLOY STROKE-AMPLIFICATION AND LOCKING SYSTEM IN A TRANSRADIAL PROSTHETIC ARM

Peter Bishay[1], Christian Aguilar[1], Arshak Amirbekyan[1], Kevin Vartanian[1], Martin Arjon-Ramirez[1], David Pucio[1]

[1]California State University, Northridge, CA, USA

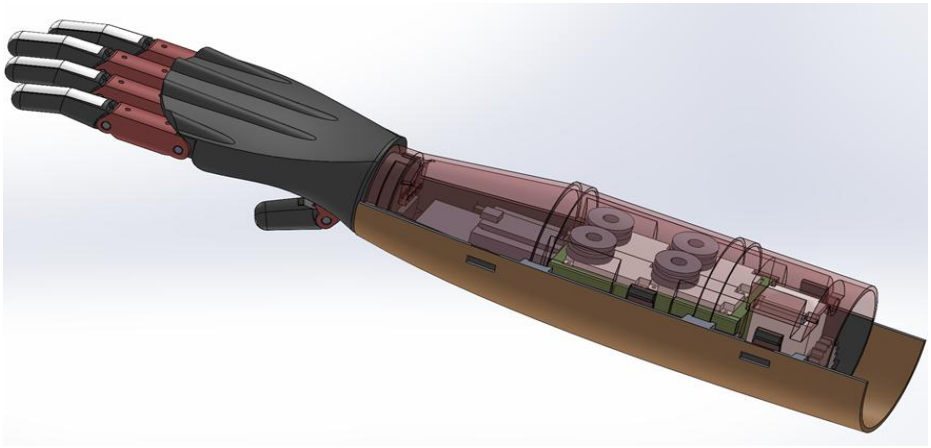
The third cohort (2019-20) designed two prosthetic arm devices: (1) ***MyOwn*** design that features new finger design with fingertip force sensors, and improved grip performance and (2) ***Hall-n-Oates*** design that features innovative actuation system as a mechanical computer for adaptive gripping, and works with only one actuator so has very low power consumption. The team made the following achievements:

(1) Presentations at the virtual CSUN's 24th annual research and creative works symposium (CSUNposium).

(2) Presentation at CSUN's 2020 virtual College of Engineering and Computer Science Senior Design Project Showcase (SDPS).

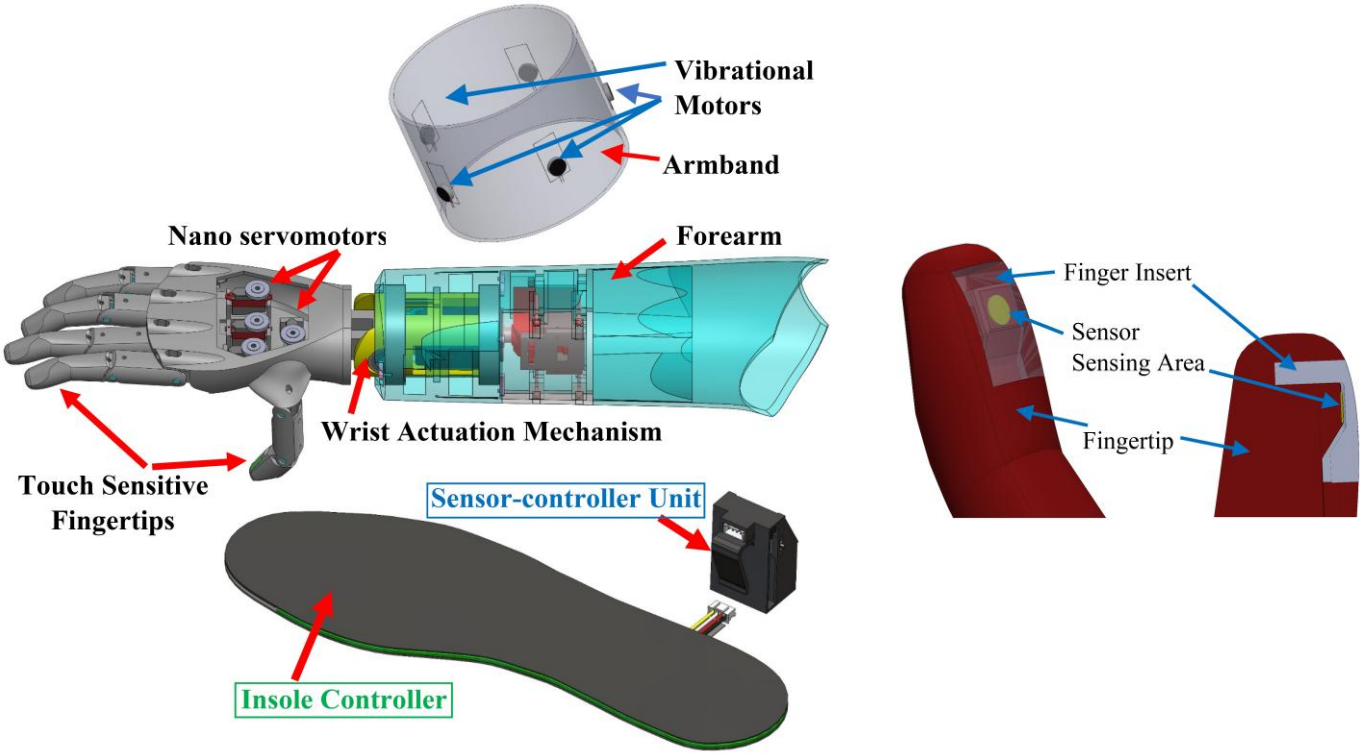
The fourth cohort (2020-21) designed a prosthetic arm called "***Hercules***," that features wrist rotation mechanism and a tactile feedback system. The team made the following achievements:

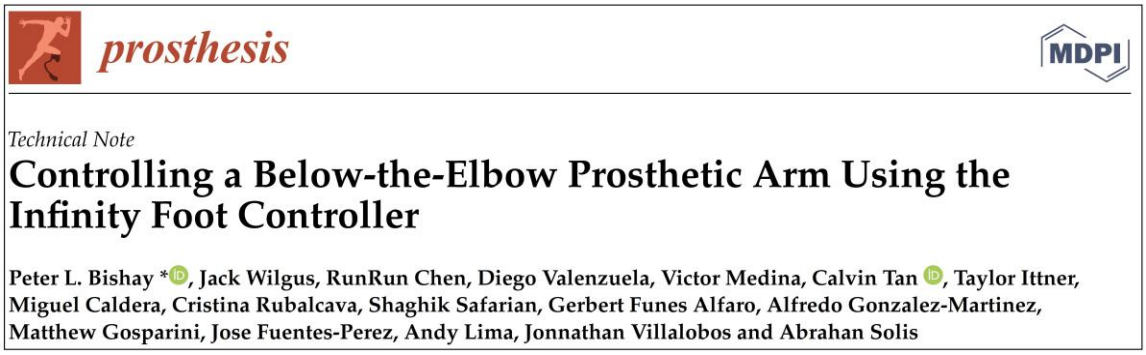
(1) Presentations at the virtual CSUN's 25th annual research and creative works symposium (CSUNposium).
(2) Presentation at CSUN's 2021 virtual College of Engineering and Computer Science Senior Design Project Showcase (SDPS).



The fifth cohort (2021-22) designed a prosthetic arm called the "***Infinity***" arm, that features wrist bending and rotation mechanism, improved haptic feedback system and a foot controller. The details of the designs were presented in a *Prosthesis* journal paper. The team made the following achievements:

(1) **First place** (Award certificates and $200) at the 10-minute presentation competition of CSUN's 26th annual research and creative works symposium (CSUNposium). Presentation title: *3D Printed Below-the-Elbow Prosthetic Arm with Foot Control, Wrist Actuation, and Haptic Feedback Systems*.
(2) Only representative of CSUN's College of Engineering and Computer Science (CECS) at the **2022 CSU Statewide Student Research Competition**.
(3) The team will present at CSUN's 2022 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).
(4) Paper publication: Bishay, P. L.; Wilgus, J.; Chen, R.; Valenzuela, D.; Medina, V.; Tan, C.; Ittner, T.; Caldera, M.; Rubalcava, C.; Safarian, S.; Alfaro, G.F.; Gonzalez-Martinez, A.; Gosparini, M.; Fuentes-Perez, J.; Lima, A.; Villalobos, J.; Solis A. (2023): ***Controlling a Below-the-Elbow Prosthetic Arm Using the Infinity Foot Controller***. *Prosthesis*, Vol. 5(4), 1206-1231, https://doi.org/10.3390/prosthesis5040084.





prosthesis

MDPI

Technical Note

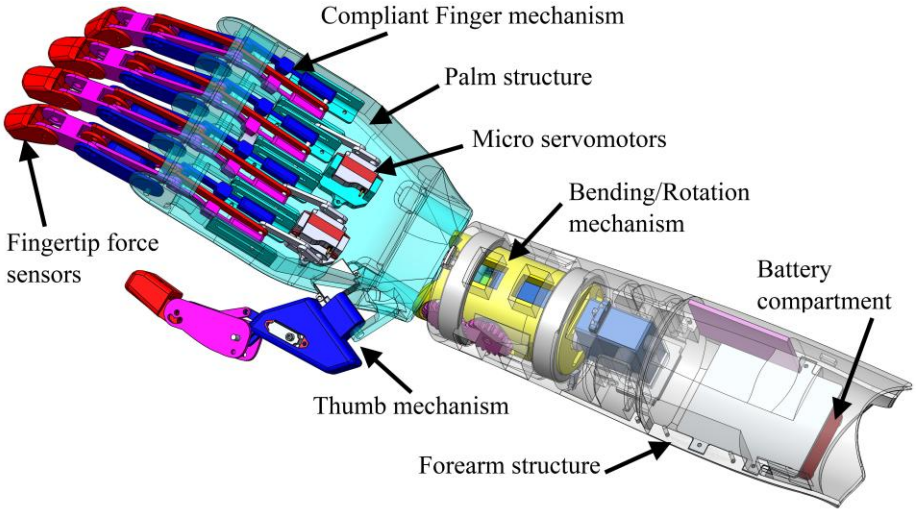
Controlling a Below-the-Elbow Prosthetic Arm Using the Infinity Foot Controller

Peter L. Bishay *, Jack Wilgus, RunRun Chen, Diego Valenzuela, Victor Medina, Calvin Tan, Taylor Ittner, Miguel Caldera, Cristina Rubalcava, Shaghik Safarian, Gerbert Funes Alfaro, Alfredo Gonzalez-Martinez, Matthew Gosparini, Jose Fuentes-Perez, Andy Lima, Jonnathan Villalobos and Abrahan Solis

The scope of the sixth cohort (2022-23) was to further improve the hand motion and grasping force of "Infinity" arm and enhance its foot controller and haptic feedback system. "Clock" arm was designed with linkage-based fingers and joystick-actuated foot control. The team made the following achievements:

(1) **Second place** (Award certificates and $200) at the 10-minute presentation competition of CSUN's 27th annual research and creative works symposium (CSUNposium). Presentation title: *Infinity-2: A lightweight below-the-elbow prosthetic arm with enhanced grip functionality, haptic feedback system, and a foot controller*.

(2) Oral presentation and project display at CSUN's 2023 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).



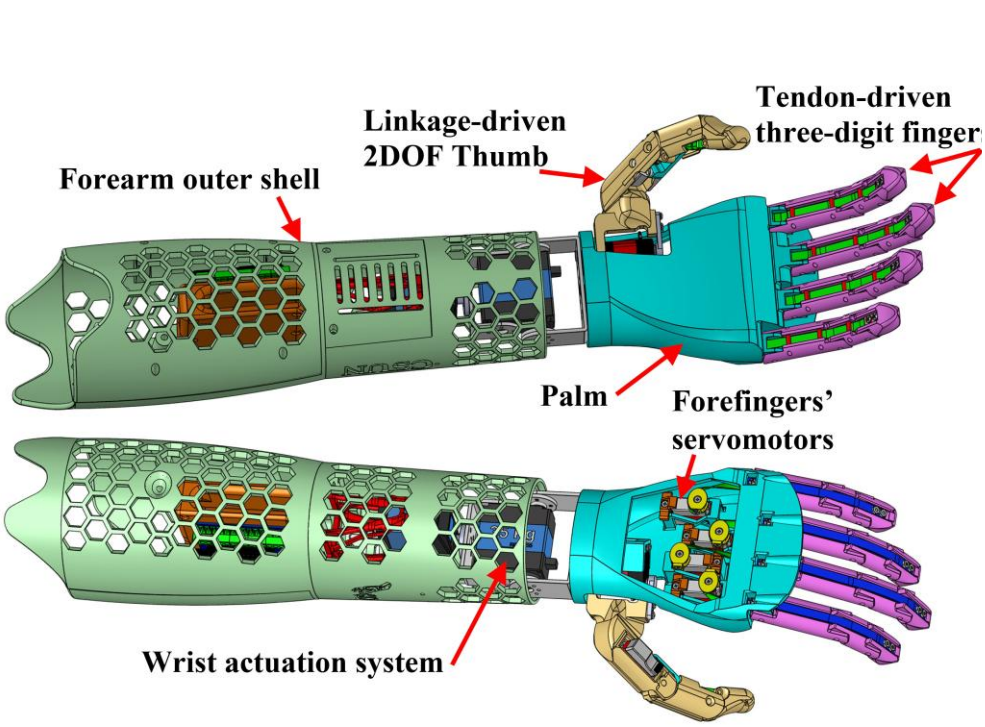
The seventh cohort (2023-24) designed the "**Persistence**" and the "**Precision**" arms. Persistence is a tendon-based hand, while Precision is a linkage-based hand, both are connectable to the same forearm design that features wrist rotation and bending mechanism. The foot controller has also been transformed to a sleeve that does not need a shoe to be used, and Bluetooth has been used for communication. The new haptic feedback system is now totally integrated in a sensing glove that can work with any prosthetic hand. The team made the following achievements:

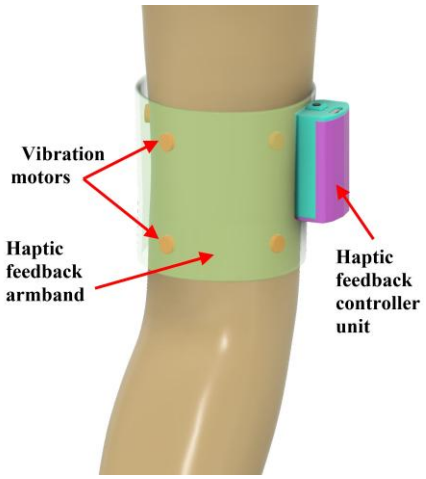
(1) Journal paper publication: Bishay, P.L.; Funes Alfaro, G.; Sherrill, I.; McMahon, E.; Carter, C.; Valdez, C.; Riyaz, N. M.; Ali, S.; Lima, A.; Reoyo, I.; Nieto, N.; Tirone, J. (2025): ***"The foot can do it": Controlling the "Persistence" prosthetic arm using an enhanced "Infinity" foot controller***. *Technologies*, vol. 13(3), 98. https://doi.org/10.3390/technologies13030098.

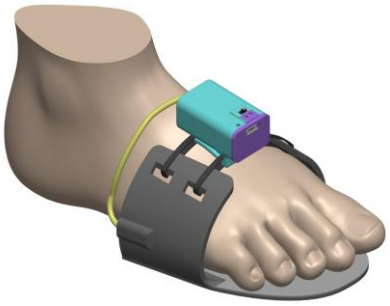
(2) "**Crowd Favorite Poster Award**" at the 36th Annual CSU Biotechnology Conference (Santa Clara, CA, Jan. 11-13, 2024). Poster title: "*Foot Controller and Haptic Feedback Systems for Below-the-Elbow Prosthetic Arms*".

(3) **First place** (Award certificates and $300) at the 3-minute presentation and poster competitions of CSUN's 28th annual research and creative works symposium (CSUNposium). Presentation title: "*Biomimicry: Recreating the complexity of the human hand*". Poster title: *"Persistence" and "Precision" prosthetic hand designs with a haptic feedback system and an advanced foot controller*.

(4) Oral presentation and project display at CSUN's 2024 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).







technologies

MDPI

Article

"The Foot Can Do It": Controlling the "Persistence" Prosthetic Arm Using the "Infinity-2" Foot Controller

Peter L. Bishay *, Gerbert Funes Alfaro, Ian Sherrill, Isaiah Reoyo, Elihu McMahon, Camron Carter, Cristian Valdez, Naweeth M. Riyaz, Sara Ali, Adrian Lima, Abel Nieto and Jared Tirone

Department of Mechanical Engineering, California State University, Northridge, CA 91330, USA
* Correspondence: peter.bishay@csun.edu

The eighth cohort (2024-25) designed a below-the-shoulder prosthetic arm with two degrees-of-freedom per finger, two wrist degrees of freedom and an elbow joint. The finger design features rolling contact joints. The forearm and upper arm core structures were generatively designed, and the outer shells were made of composite laminates. The foot controller was extended to become a sleeve securely surrounding the foot with embedded sensor and wireless transmission electronics. A Machine Learning (ML) model was used to translate foot gestures to hand gestures. The haptic feedback system was divided into two subsystems: (1) texture identification subsystem that can detect the texture, based a trained image classification ML model, using a tiny camera in the hand, and fingertip surface topography sensors (electret microphones), and (2) texture application subsystem that applies representative textures, via servomotors that hold texture applicator units, and vibrations, based on the roughness of the surface the fingers touch, using vibration motors. Achievements:

(1) Poster presentation at the 37th Annual CSU Biotechnology Conference (Garden Grove, Jan. 9-11, 2025). Poster title: "*A Below-the-Shoulder Prosthetic Arm with a Texture Detection and Application Haptic Feedback System and a Gesture Recognizing Foot Controller*".

(2) **First place** (Award certificates and $300) at the poster presentation competition of CSUN's 29th annual research and creative works symposium (CSUNposium).

(3) Oral presentation and project display at CSUN's 2025 College of Engineering and Computer Science Senior Design Project Showcase (SDPS).

The ninth cohort (2025-26) will focus on designing, building, and testing a robotic arm that can be used by individuals who have permanent or temporary arm immobility due to stroke, injury, or rotator cuff surgery. The foot controller would be further improved and tested. The haptic feedback system will also be extended and tested.

Table 2: SP achievements table

Cohort	CSUNposium		Other
	10-min	3-min	
First (2017-18): MataPro-1	1st place	1st place	- 1st place in oral presentation & project display competitions as well as the Grand Prize at SDPS - Posters in RMASB and NWASB symposia - Paper in ***Engineering Research Express*** journal
Second (2018-19): MataPro-2	1st place	-	- 1st place in oral presentation competition at SDPS - 3rd place in CSUN's Bull Ring competition - Poster in RMASB symposia - Paper in ***ASME-SMASIS*** conference proceedings
Third (2019-20): MyOwn & Hall & Oates	-	-	
Fourth (2020-21): Hercules Arm	-	-	
Fifth (2021-2022): Infinity Arm & Foot Controller	1st place	-	- Only representative of CSUN's CECS in the 2022 CSU-statewide competition. - **Patent application**. - Paper in ***Prosthesis*** journal.
Sixth (2022-2023): Clock Arm	2nd place	-	- Design details were featured in the 5th cohort's *Prosthesis* journal paper.
Seventh (2023-2024): Persistence Arm & Infinity-2 foot controller	-	1st place	- Crowd Favorite Poster Award at the CSU Biotechnology Conference. - 1st place: CSUNposium Poster. - Paper in ***Technologies*** journal.
Eighth (2024-2025): SoleSync foot controller; Texture detection and application system	-	-	- Poster presentation at the CSU Biotechnology Conference. - 1st place: CSUNposium Poster.

For more details, visit: http://www.csun.edu/~pbishay/projects.php .

2 Enrollment

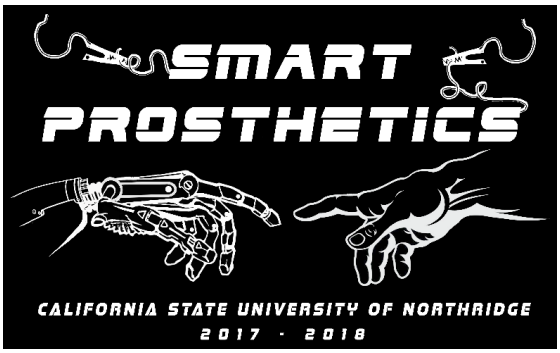
In order for any student to join "Smart Morphing Wing" or "Smart Prosthetics" SDPs, the following two documents should be sent to Dr. Bishay (peter.bishay@csun.edu) by the **end of May**:

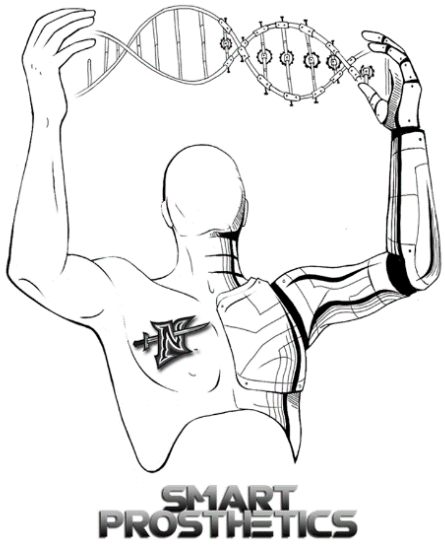
1- Resume (including current GPA, internships, job experience, any projects that the student was part of, special skills, computer software skills, etc.)
2- Cover letter describing (a) why the student is interested in this SDP specifically, and (b) how does the student qualifies to be a part of this research-based SDP.

Around the second week of the summer, Dr. Bishay will inform the selected students by email and will introduce the summer reading assignment (research papers and last year's technical report). Students are expected to write a report on the assigned readings, and the due date is usually in the first week of the Fall semester. Permission numbers will be given to the selected students once they are selected.

3 Volunteering

Both senior design projects accept volunteers starting in the winter break and through the spring semester. Volunteers will be given the opportunity to select the sub-team they are most interested in. Volunteers who perform their assigned tasks as expected will be given preference for enrolment in the following year. Because of the experience volunteers get, they usually lead their senior design projects in the following year. For volunteering, please contact Dr. Bishay or the project leader.





CALIFORNIA STATE UNIVERSITY NORTHRIDGE
2018-2019