

Ozgur Ege Aydogan

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PROPOSED THESIS TITLE

Multimodal, Context-Aware Brain–Computer Interface for Real-Time Shared Control of a Robotic Arm Using Minimally Invasive Neural Signals

RESEARCH PROJECT SUMMARY

This research project proposes a multimodal brain–computer interface (BCI) system for real-time shared control of a robotic arm. By fusing EEG, EOG, in-ear EEG, and contextual signals from the META API, it aims to improve intent decoding, reduce user effort, and enhance autonomy in neuroprosthetic control. A hybrid control pipeline will intelligently modulate assistance based on decoder confidence and gaze-based context. Future development will incorporate advanced, minimally invasive interfaces such as the Stentrode. The system will be validated through robotic simulations and physical testing using metrics including classification accuracy, latency, task success, cognitive workload, and embodiment.

TERTIARY EDUCATION HISTORY

Osaka University

Master of Engineering (Research) in Systems Innovation (Robotics Engineering)

Osaka, Japan
September 2023

GPA: 3.78/4.00

- **Scholarship:** Japanese Government (Monbukagakusho: MEXT, full merit-based)
- **Thesis:** "*3D Walking of a Bio-Inspired Musculoskeletal Quadruped Robot*" – Advisor: Professor Kensuke Harada

Yildiz Technical University

Bachelor of Science in Mechatronics Engineering

Istanbul, Turkey
July 2020

Graduated with Honors

- **Thesis:** "*Design and Development of a 4-DOF Impedance-Controlled Upper Limb Exoskeleton for Shoulder and Elbow Rehabilitation*" – Advisor: Professor Erhan Akdogan

Istanbul Commerce University

Bachelor of Science in Mechatronics Engineering (Transferred)

Istanbul, Turkey
November 2017

GPA: 3.60/4.00 (Full Merit Scholarship)

- Completed the first year of coursework before transferring to Yildiz Technical University

RESEARCH AND RELEVANT PROFESSIONAL EXPERIENCE

Osaka University, Department of Neuroinformatics, Yanagisawa Lab

Neuroengineering Research Assistant (Part-time)

Osaka, Japan
November 2023 – July 2025

Advisor: Professor Takufumi Yanagisawa | Average hours per week: 30

- Developed a real-time EEG-based BCI system for robotic arm control in post-stroke rehabilitation, decoding motor imagery using PCA-reduced spectral features and SVM classifiers; achieved ~82% accuracy with ~1.2s latency across 80 trials
- Integrated Kalman filtering and adaptive thresholding to enhance decoding stability and reduce actuation latency by ~15%, improving responsiveness in volitional motor intent detection
- Designed a multimodal hybrid control pipeline combining SSVEP (robot selection) and P300 (object selection), enabling sequential shared-control of multi-agent robotic systems
- Deployed the BCI decoder in a closed-loop neuroprosthetic system using WebSocket and LSL, reducing neural-to-actuation delay by 22% and enabling stable multi-step grasp-and-place tasks
- Collaborated with clinical partners to design rehab protocols and conduct usability evaluations, resulting in a 20% increase in user satisfaction and stronger clinical workflow integration

Osaka University, Adaptive Robotics Lab
Graduate Research Assistant (Part-time)

Osaka, Japan
October 2021 – September 2023

Advisor: Professor Koh Hosoda | Average hours per week: 30

- Engineered a bio-inspired soft quadruped robot actuated by 30 McKibben-type pneumatic muscles, modeling musculoskeletal anatomy to mimic biologically realistic joint movement
- Developed real-time embedded valve control and CAN-based actuation pipelines, improving muscle activation precision by 30% and enabling closed-loop biomechanical control

Neuromatch Academy

Remote
July 2022

Team Lead, Deep Learning Research (Full-time)

Advisor: Dr. Bradley Baker | Average hours per week: 35

- Developed time-resolved SVM pipelines to decode volitional motor planning from 64-channel ECoG data (Miller et al., PNAS, 2010), achieving 92% within-subject accuracy for predicting movement intention up to 1 second before onset
- Modeled spectrotemporal features to enhance early intent detection, outperforming baseline classifiers by ~18% and enabling high-fidelity neural decoding in pre-movement conditions

Yildiz Technical University, Biomechatronics Research Lab
Post-Baccalaureate Research Assistant (Part-time)

Istanbul, Turkey
March – September 2021

Advisor: Professor Erhan Akdogan | Average hours per week: 30

- Led the design and control of a 5-DOF upper-limb robotic exoskeleton, implementing a real-time impedance-based control strategy driven by surface EMG to enable intent-adaptive assistance; improved responsiveness by 95% and reduced actuation effort by 56%
- Integrated low-cost EMG sensors for real-time muscle activation decoding, enabling biosignal-driven human-in-the-loop control and improving motor intention interpretation under low SNR
- Developed and validated a dynamic load suspension system that reduced user muscle fatigue by 30% during extended use, informing design principles for prolonged exoskeleton-assisted mobility

Neuromatch Academy

Remote
August 2021

Team Lead, Deep Learning Research (Full-time)

Advisor: Dr. Samin Nili Ahmadabadi | Average hours per week: 35

- Led development of voxel-wise fMRI decoding models, mapping visual cortex activity to DCNN feature embeddings of natural images
- Trained regularized regression models (Ridge/Lasso), achieving up to 85% voxel-wise R^2 on held-out BOLD responses and improving decoding robustness and spatial interpretability

Neuromatch Academy

Remote
July 2021

Team Lead, Computational Neuroscience Research (Full-time)

Advisor: Dr. Tom Rhys Marshall | Average hours per week: 35

- Developed cross-subject ECoG-based classifiers to distinguish real vs. imagined limb and orofacial movements, achieving ~72% accuracy with 5-fold cross-validation
- Designed high-SNR preprocessing pipelines (1–200 Hz bandpass filtering, baseline correction, temporal smoothing), enhancing decoder generalization and improving robustness across sessions

Yildiz Technical University, Biomechatronics Research Lab
Undergraduate Research Assistant (Part-time)

Istanbul, Turkey
September 2019 – July 2020

Advisor: Professor Erhan Akdogan | Average hours per week: 20

- Led the development of a 4-DOF upper-limb robotic exoskeleton for shoulder and elbow neurorehabilitation, achieving ~95% joint trajectory fidelity across passive, active-assistive, isotonic, and isometric exercise modes through detailed kinematic and dynamic modeling

- Designed and integrated a low-cost EMG sensor module to enable real-time biosignal-driven control, improving signal reliability by ~20% and supporting adaptive estimation of motor intent

RELEVANT PUBLICATIONS

1. Dikbas, F. E. H. M., **Aydogan, O. E.**, Aydin, I., Cetin, D., Aktan, M. E., & Akdogan, E. (2023). Development of a 5-DOF impedance-controlled wearable upper limb exoskeletal robot. *Journal of Mechanics in Medicine and Biology*. Published online: July 15, 2023. <https://doi.org/10.1142/S0219519423500574>
2. Karadeniz, F., **Aydogan, O. E.**, Kazanci, E. A., & Akdogan, E. (2020). Design of a 4-DOF grounded exoskeletal robot for shoulder and elbow rehabilitation. *Sustainable Engineering and Innovation*, 2(1), 41–65. Published online: July 6, 2020. <https://doi.org/10.37868/sei.v2i1.106>

GRADUATE AWARDS AND SCHOLARSHIPS

1. **Japanese Government (Monbukagakusho: MEXT) Scholarship**
Osaka University, Japan
October 2021 – September 2023 | Annual value: ~\$40,000 AUD
Awarded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) (<4% acceptance rate) to support full-time Master's research in Robotics Engineering, focused on bio-inspired soft quadruped robots using pneumatic muscle actuation and biomechanical control
2. **Recipient, MEXT-Funded Special Robotics Training Program**
Osaka University, Japan
January 2021 | Non-monetary, competitive training award
Selected as one of only four international Master's students for a MEXT-sponsored robotics innovation program at the Graduate School of Engineering Science. Successful completion enabled full MEXT scholarship eligibility for Master's admission

CONFERENCE PRESENTATIONS

1. **Aydogan, O. E.**, Changhao, D., Yanagisawa, T. (July 2025). *Real-Time EEG-Based Brain–Machine Interface for Robotic Arm Control Using Motor Imagery*. Poster presentation at the 1st International Symposium on Decoded Neurofeedback (DecNef 2025), Nara, Japan.
2. **Aydogan, O. E.** (September 2024). *Advancing Brain-Computer Interfaces (BCI): Overcoming Challenges in Transfer Learning*. 2024 IEEE EMBS SAC Summer Camp (virtual).
3. Changhao D., Huixiang, Y., **Aydogan O. E.**, Ryohei, F., Yanagisawa, T. (September 2024). *Augmented Reality Brain-Computer Interface Using Slow Cortical Potentials for Phantom Limb Pain*. JST CREST Final Results Report International Symposium, Tokyo, Japan.
4. **Aydogan, O. E.**, Ceylan, G., Yilmaz, F., Ertekin, S. N., Tekerek, O. E. (September 2022). *Transfer Learning from Real to Imagined Motor Actions in ECoG Data*. Neuromatch Conference 5.0
5. **Aydogan, O. E.**, Zhang, Y., Barry, B., Haram, L., Mishra, U. (December 2021). *Classification of motor planning into overt or imagery using an ECoG signal*. Neuromatch Conference 4.0 (virtual).

HONORS AND AWARDS

1. **1st Prize (among 894 projects)**, TEKNOFEST Aerospace and Technology Festival 2020, Technology for Humanity Competition, Health and First Aid Category, September 2020
2. **2nd Prize (among 204 projects)**, TUBITAK 2242 University Students Research Projects Competitions, Health Category, The Scientific and Technological Research Council of Turkey (TUBITAK), September 2020

3. **1st Prize (among 20 finalist projects)**, 8th University Students Research Project Competitions, Istanbul-Asian Side, Health Category, TUBITAK, August 2020
4. **Full Merit Scholarship** (OSYM, 100% merit-based, top 0.1% of 2 million applicants) 2015 – 2017

RESEARCH GRANTS

1. **TUBITAK 2209-B Industry-Oriented Research Projects Grant** January – December 2020
Robotic Exoskeleton for Shoulder Rehabilitation, TUBITAK BIDEB, 1000 AUD
2. **TEKNOFEST 2020 Technology for Humanity Competition Grant** July – September 2020
Robotic Exoskeleton for Shoulder Rehabilitation, Turkish Technology Team Foundation, 650 AUD

TEACHING EXPERIENCE

Neuromatch Academy Remote
Teaching Assistant, "Deep Learning" course July 2025

- Mentored 11 PhD students on core and advanced deep learning topics, including CNNs, VAEs, Transformers, reinforcement learning, and multimodal architectures, using PyTorch and real neuroscience datasets
- Supervised two final research projects, "Modeling Decision-Making in Mice and Machines" and "Reinforcement Learning to Imitate Mouse Behavior", focusing on biologically grounded RL, behavior prediction, and CNN-RL integration for decoding animal decision strategies

Neuromatch Academy Remote
Teaching Assistant, "Deep Learning" course July 2023

- Mentored 13 graduate students on deep learning applications in neuroscience, focusing on neural signal modeling, BCI-relevant decoding tasks, and translational neurotechnology
- Supervised two final research projects, "Using LSTMs to Model Naturalistic fMRI Data" and "LSTM Prediction of Behavioral Outputs from Preparatory Neural Activity", on temporal decoding of neural signals using ECoG and fMRI datasets

LEADERSHIP AND MENTORSHIP

Mentor, IEEE EMBS SAC Student Mentoring Program 2024 August 2024 – February 2025

- Supervised a mentee developing a wearable assistive device integrating sensor fusion and machine learning for real-time motor intent decoding, with a focus on adaptive control strategies

Research Mentor, IEEE YTU EMBS January – March 2021

- Guided 36 undergraduate students in designing a biosignal-driven bionic arm, emphasizing real-time EMG signal processing, low-cost sensor integration, and functional control strategies

SKILLS

- **BCI & Neural Signal Processing:** EEG, EMG, and ECoG signal processing; real-time feature extraction and decoding (Motor Imagery, P300, SSVEP); Kalman filtering and SVM; BCI pipeline development for translational neuroprosthetics; real-time BMI system implementation
- **Neural Interfaces & Embedded Systems:** Embedded AI for neurotechnology; edge computing and low-latency neural decoding; biosignal acquisition hardware; adaptive and impedance-based control; electrophysiology integration; human-in-the-loop BCI systems
- **Programming & Software Tools:** Python, C/C++, MATLAB, Git, ROS, Linux; signal decoding algorithms; data analysis and visualization for BCI experiments; real-time system deployment
- **Language:** English (Advanced, TOEFL IBT: 95), Turkish (Native), Japanese (Intermediate)

PROFESSIONAL MEMBERSHIPS

- IEEE Engineering in Medicine and Biology Society (EMBS) April 2023 – present
- IEEE Robotics and Automation Society (RAS) April 2023 – present