Recent Advances in Technology Transfer and Intellectual Property at Diné College

Dr. Oleksandr Makeyev[1] and Darwyn Clyde Henderson[2]

[1]Associate Professor with School of STEM, Head of the Mathematics for Engineering Applications (MEA) Laboratory

[2]Acting College Librarian, Kinyaa'áanii Charlie Benally Library, Diné College Libraries

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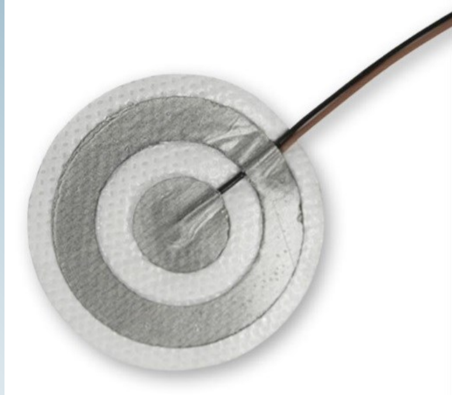
Tribal College Librarians Institute (TCLI), June 2nd, 2026

Outline

- Research
  - General overview since 2023
- Tech transfer and patents
  - Latest developments
    - Second and third patents issued
    - Fourth patent pending
  - What our four patents are about
- Patenting experience
  - Before tech transfer center
  - After tech transfer center

CODE401526 electrode from Spes Medica



t-Interface pre-amplifiers from CREmedical

Research: MEA lab since 2023

- Fourth NSF TCUP SGR award ($200,000);
- Second and third patents issued and fourth one pending;
- Two graduate students defended their MS theses with two and three first author manuscripts respectively;
- Awards, tutoring for Diné College students, running activities for local school students at STEM festivals, etc.

Award Abstract # 2415867

SGR: Comparing the Optimal Tripolar Concentric Ring Electrode to Commercial Configurations on Phantom Data

NSF Org:	DUE Division Of Undergraduate Education
Recipient:	DINE COLLEGE
Initial Amendment Date:	January 16, 2025
Latest Amendment Date:	January 16, 2025
Award Number:	2415867
Award Instrument:	Standard Grant
Program Manager:	Regina Sievert rsievert@nsf.gov (703)292-2808 DUE Division Of Undergraduate Education EDU Directorate for STEM Education
Start Date:	February 1, 2025
End Date:	January 31, 2027 (Estimated)
Total Intended Award Amount:	$200,000.00
Total Awarded Amount to Date:	$200,000.00
Funds Obligated to Date:	FY 2025 = $200,000.00
History of Investigator:	Oleksandr Makeyev (Principal Investigator) omakeyev@dinecollege.edu
Recipient Sponsored Research Office:	Dine College 1 CIRCLE DR TSAILE

Tech transfer and patents

- Both tech transfer center and maker space are located in the Kinyaa'áanii Charlie Benally library building.
- Tech transfer center

- former audio/visual

room, second floor.

- Audio and visual

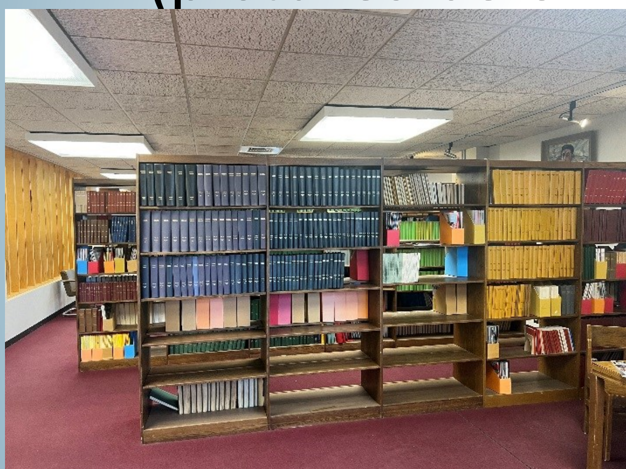
materials now on the

first floor (near desk).

Diné College

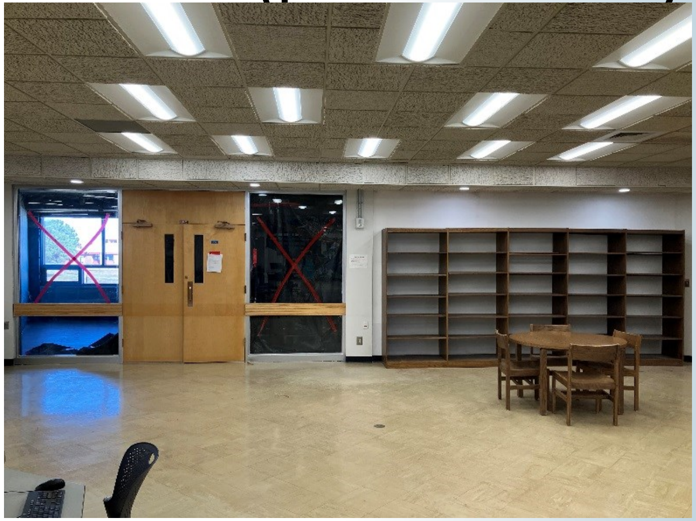
Maker space

- Maker space - former periodicals room, first floor (pictures below from April 11, 2025).



Maker space (continued)

- Now in final stages of renovation (pics from July 2025)



Item	Quantity
Desktop Vacuum Forming Machine	2
Laser Engraving Cutter Machine	2
Multi Process Welding Machine	1
Desktop Extruder	1
CNC Machine Lathe	2
CNC Milling Machine	2
Wireless 3D Printer	2
AutoDesk AutoCAD 2022	2
Computer(s) 2 HP laptops	2
HP Printing Plotter	1

Patents

- Our patenting efforts are still centered around novel concentric ring electrode technology for noninvasive electrophysiological measurement capable of improving medical signal processing significantly thus offering better diagnostic value via better detection of relevant biomarkers for a range of disorders and conditions.
- Diné College now holds three out of three first patents ever issued to a Tribal College or University (TCU) with 100% success rate well above national average thanks to Kilpatrick Townsend & Stockton LLP.

Patents (continued)

- What our patents (in filing order) are all about
  - First: optimization of distances between recording surfaces of equal widths and/or radii to maximize the Laplacian estimation accuracy (12,144,630; issued November 19, 2024).
  - Second: optimization of variable widths and/or radii of recording surfaces to maximize the Laplacian estimation accuracy (11,045,132; issued June 29, 2021).
  - Third: design of pre-amplifiers that allow inputting optimal Laplacian estimation coefficients for specific electrode geometries (12,419,562; issued September 23, 2025; continuation application to the second one).
  - Fourth: calculation of the optimal Laplacian estimation coefficients for a specific electrode geometry (18/911,107; published on February 13, 2025; divisional application to the first one).

Patenting experience

- Before tech transfer center
  - Funding patent related costs and fees via inventor's external awards;
  - Individual Board of Regents resolutions supporting each patent application;
  - Dealing with USPTO with help from legal counsel (if any) only;
  - Bayh-Dole Act reporting.

- After tech transfer center
  - Assistance with costs and fees associated with issuance of the most recent patents even before reaching its full capacity.

Graduate advisees

MASTER THESIS DEFENSE

ASSESSING THE IMPORTANCE OF OPTIMAL LAPLACIAN ESTIMATION COEFFICIENTS FOR COMMERCIALLY AVAILABLE CONCENTRIC RING ELECTRODES ON HUMAN DATA AND VIA FINITE ELEMENT METHOD MODELING

PRESENTED BY:
ALANA BENALLY

THESIS ADVISOR:
OLEKSANDR MAKEYEV, PHD

JOIN US!

Tuesday, May 6, 2025
9:00am MDT
LIB-206, MEA Lab
Kinyaa'áanii Library, Tsaile Campus
Zoom Link: https://dinecollege.zoom.us/j/99617172850
Meeting ID: 996 1717 2850

Very limited seating is reserved for thesis committee members, MEA lab employees, and college faculty and staff on first come, first serve basis.

MASTER THESIS DEFENSE

LINEAR AND NONLINEAR SIGNAL SYNCHRONY MEASURES TO ASSESS SALT BRIDGE SHORTING AND CONVENTIONAL DISC ELECTRODE EMULATION VIA TRIPOLAR CONCENTRIC RING ELECTRODE ON HUMAN ELECTROENCEPHALOGRAM DATA

PRESENTED BY:
SHELDON N. CHEE

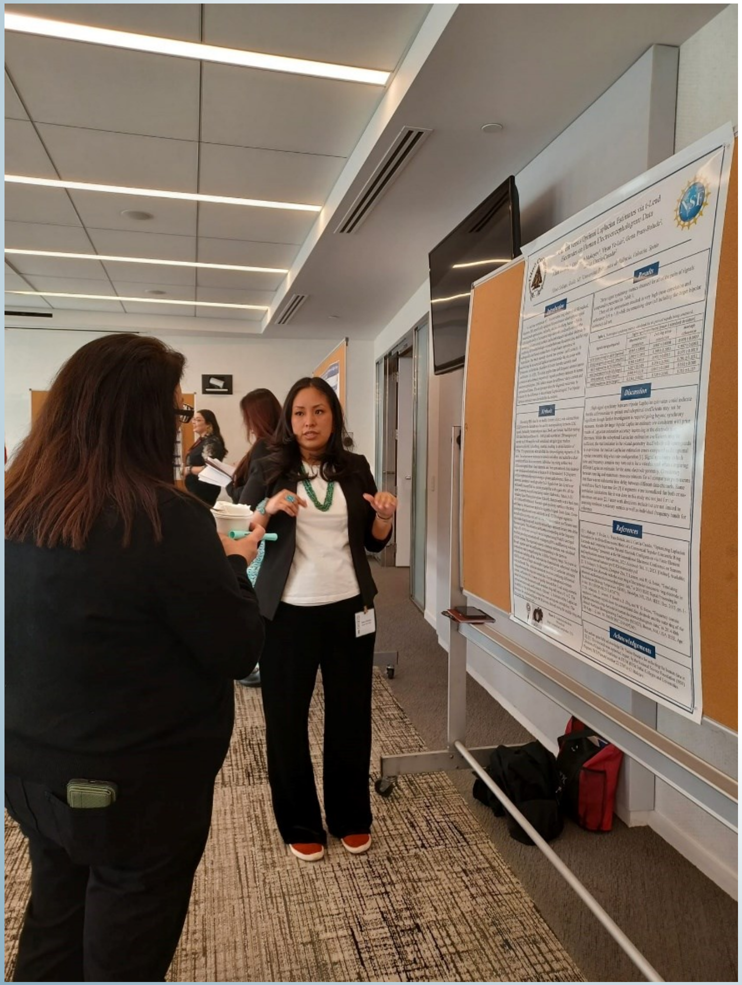
THESIS ADVISOR:
OLEKSANDR MAKEYEV, PHD

JOIN US!

Monday, May 4, 2026
9:00am MDT
LIB-206, MEA Lab
Kinyaa'áanii Library, Tsaile Campus
Zoom Link: https://dinecollege.zoom.us/j/99469960701
Meeting ID: 994 6996 0701

Very limited seating is reserved for thesis committee members, MEA lab employees, and college faculty and staff on first come, first serve basis.

2024 Tribal Colleges and Universities Program Research Symposium
February 28-29, 2024
Alexandria, VA



Current Versus Optimal Laplacian Estimates via t-Lead Electrodes on Human Electroencephalogram Data

Alana Benally[1], Oleksandr Makeyev[1], Yiyao Ye-Lin[2], Gema Prats-Boluda[2], Javier Garcia-Casado[2]

[1]*Diné College, Tsaile, AZ;* [2]*Universitat Politècnica de València, Valencia, Spain*

Introduction

t-Lead is a commercial tripolar concentric ring electrode (CREmedical, Kingston, RI), specifically designed for noninvasive electrophysiological measurement applications, including studies involving human subjects. Utilizing the ability of concentric ring electrodes to directly estimate the second spatial derivative (surface Laplacian) at each individual electrode by combining differential voltages recorded between the central disc and the rings with specific coefficients makes them of significant importance in biomedicine. Our recent research showed that optimal coefficients (6,-1) maximizing the accuracy of Laplacian estimation for the electrodes with dimensions similar to the t-Lead are different from the currently used coefficients (16,-1) [1]. This study applies time and frequency domain (cross-correlation and coherence respectively) signal synchrony measures to human electroencephalogram (EEG) data to access the difference due to current and optimal coefficients. This is important since the diagnostic value may be impacted by the differences in the estimated Laplacian signal. Two bipolar Laplacian estimates were also added to the analysis.

Methods

The resting EEG data for six healthy human subjects was adopted from [2], [3] where this dataset was also used to asses synchrony between EEG signals. Six healthy human subjects (ages 24-40, one female) had their resting EEG data band pass filtered (0.1-100Hz) and recorded at 1200 samples per second via gUSB amplifier with normalized unit gain (g.tec medical engineering GmbH, Schiedlberg, Austria), resulting in a total duration of 1730s, 173 segments total when divided into non-overlapping segments of 10s each. The subjects were instructed to remain motionless and seated in a chair to reduce artifacts due to movement. Individual (recording surface) and differential signals from t-Lead electrode and from conventional disc electrode were simultaneously monitored at location P4 of the standard 10-20 system with the right mastoid process serving as ground and reference. Skin-to-electrode impedances were kept under 5kΩ. Signals from the t-Lead were additionally preamplified via custom preamplifier with a gain of 6. All the signal processing was performed using Matlab (Mathworks, Natick, MA) including digital filtering (zero-phase fifth-order Butterworth) with a band pass of 1-100Hz and 60Hz notch. Neuronal signal synchrony metrics in the time and frequency domains were applied to six pairs of signals from t-Lead. Cross-correlation and coherence were calculated for all 173 10s signal segments normalized to zero mean and unit variance. Cross-correlation coefficients were calculated at lag zero as well as at the optimal lag to account for any time delay between signals. The coherence coefficients corresponding to the frequency range of 1-100Hz were averaged for each segment using Welch's averaged modified periodogram method with overlapping (50%) and Hanning window of 1024 samples. The magnitude squared coherence estimate was calculated for each segment and the coefficients corresponding to the pairwise comparisons were averaged using the 1-100Hz frequency range. Six pairwise comparisons including all the combinations of optimal and suboptimal tripolar (tEEG) as well as of larger and smaller bipolar (bEEG) Laplacian estimates were performed. The Laplacian estimation involves combining differential voltages between the rings and central disc. For the suboptimal estimate current coefficients (16,-1) were originally derived for t-Lead using a simple model of electrode dimensions with a median ring radii ratio of 1 to 2. The optimal estimate used coefficients (6,-1) from [1]. Estimate of the Laplacian via BCREs is the differential voltage between a ring and central disc. The estimates for smaller and larger BCREs were derived using the middle ring and the outer ring, respectively.

Figure 1. t-Lead electrodes from CREmedical (https://cremedical.com/product-2-2/).

Results

Three signal synchrony metrics obtained for all of the pairs of signals compared is presented in Table 1.

Three of the comparisons resulted in very high cross-correlation and coherence (0.9 to 1.0) while the remaining three (all including the larger bipolar estimate) did not.

Table 1. Three signal synchrony metrics calculated for six pairs of signals being compared.

Signals being compared	Signal synchrony metric (mean ± standard deviation)		
	Maximum cross-correlation	Zero lag cross-correlation	Average coherence
tEEG (suboptimal) vs tEEG (optimal)	0.997 ± 0.0008	0.997 ± 0.0008	0.991 ± 0.0007
tEEG (suboptimal) vs bEEG (smaller)	0.999 ± 0.0003	0.999 ± 0.0003	0.997 ± 0.0003
tEEG (optimal) vs bEEG (smaller)	0.992 ± 0.0019	0.992 ± 0.0019	0.979 ± 0.0019
tEEG (suboptimal) vs bEEG (larger)	0.707 ± 0.0939	0.706 ± 0.0941	0.281 ± 0.1011
tEEG (optimal) vs bEEG (larger)	0.648 ± 0.1078	0.647 ± 0.1086	0.231 ± 0.088
bEEG (smaller) vs bEEG (larger)	0.736 ± 0.0859	0.736 ± 0.086	0.313 ± 0.107

Discussion

High signal synchrony between tripolar Laplacian estimates could indicate that the difference due to optimal and suboptimal coefficients may not be significant though further investigation is required going beyond synchrony measures. Results for larger bipolar Laplacian estimate are consistent with prior results of Laplacian estimation accuracy increasing as the electrode size decreases. While the suboptimal Laplacian estimation coefficients may be sufficient, the real limitation is the t-Lead geometry itself which still corresponds to over 4 times the median Laplacian estimation errors compared to the optimal tripolar concentric ring electrode configuration [1]. Signal synchrony in both time and frequency domains may turn out to be a valuable tool when comparing different Laplacian estimates for the same electrode geometry. Consistency between zero lag and maximum cross-correlations for all comparison pairs means that there was no substantial time delay between different data channels. Same would have likely been true for [2] if segments were normalized for both cross-correlation calculations like it was done in this study and not just for the maximum one as in [2]. Future work directions include but are not limited to assessing nonlinear synchrony metrics as well as individual frequency bands for coherence.

References

[1] O. Makeyev, Y. Ye-Lin, G. Prats-Boluda, and J. Garcia-Casado, "Optimizing Laplacian Estimation for the Finite Dimensions Model of a Commercial Tripolar Concentric Ring Electrode and Comparing It to the Optimal Electrode Configuration via Finite Element Method Modeling," presented at the 9th International Electronic Conference on Sensors and Applications session Applications, 2022. Accessed: Oct. 11, 2023. [Online]. Available: https://sciforum.net/manuscripts/13324/manuscript.pdf

[2] O. Makeyev, Y. Boudria, Zhenghan Zhu, T. Lennon, and W. G. Besio, "Emulating conventional disc electrode with the outer ring of the tripolar concentric ring electrode in phantom and human electroencephalogram data," in 2013 IEEE Signal Processing in Medicine and Biology Symposium (SPMB), Brooklyn, NY, USA: IEEE, Dec. 2013, pp. 1–4. doi: 10.1109/SPMB.2013.6736778.

[3] O. Makeyev, T. Lennon, Y. Boudria, Z. Zhu, and W. G. Besio, "Frequency domain synchrony between signals from the conventional disc electrode and the outer ring of the tripolar concentric ring electrode in human electroencephalogram data," in 2014 40th Annual Northeast Bioengineering Conference (NEBEC), Boston, MA, USA: IEEE, Apr. 2014, pp. 1–2. doi: 10.1109/NEBEC.2014.6972865.

Acknowledgements

The authors gratefully acknowledge Dr. Yacine Boudria for collecting the human data in [2], [3]. This research was supported, in part, by the National Science Foundation (NSF) Division of Equity for Excellence in STEM (EES) Tribal Colleges and Universities Program (TCUP) award number 2212707 to O. Makeyev.

2024 Emerging Researchers National (ERN) Conference in STEM
March 14-16, 2024
Washington, DC

Current Versus Optimal Laplacian Estimates For t-Lead Concentric Ring Electrodes Via Finite Element Method Modeling

Alana Benally[1], Oleksandr Makeyev[1], Yiyao Ye-Lin[2], Gema Prats-Boluda[2], Javier Garcia-Casado[2]

[1]*Diné College, Tsaile, AZ;* [2]*Universitat Politècnica de València, Valencia, Spain*

Introduction

t-Lead (Fig. 1) is a commercial tripolar concentric ring electrode (TCRE; CREmedical, Kingston, RI), specifically designed for noninvasive electrophysiological measurement applications, including studies involving human subjects. Utilizing the ability of concentric ring electrodes to directly estimate the second spatial derivative (Laplacian) of surface potential at each individual electrode by linearly combining differential voltages recorded between the central disc and the rings with specific coefficients used as weights makes them of significant importance in biomedicine. Our recent research showed that optimal coefficients (6,-1) maximizing the accuracy of Laplacian estimation for TCRE with dimensions similar to those of the t-Lead are different from the currently used coefficients (16,-1) [1]. This study assesses the difference between optimal and current coefficients via finite element method modeling. This is important since significant difference in Laplacian estimate signal may affect its diagnostic value.

Methods

Finite element method modeling was used to compare the performance of two realistic finite dimensions models approximating the dimensions of the commercially available t-Lead electrodes (Fig. 2A and 2B) determined in [1]. First set of dimensions was patented in [2]. Second set of dimensions was published in [3]. Both sets of dimensions were scaled to the size of the optimal TCRE configuration from [4] with the outer radius of the outer ring subdivided into 9 equal intervals. To derive the suboptimal coefficients from them, additional electrode configuration was considered with a ratio of median radii of 1 to 2 (Fig. 2C). Since current coefficients (16, -1) were originally derived for t-Lead using simplistic negligible dimensions model of an electrode with the same ratio, a modified version of these coefficients (13.8, -1) was derived using finite dimensions model from Fig. 2C to be used as suboptimal coefficients (23/60, -1/36) for configurations approximating t-Lead from Figs. 2A and 2B. Optimal Laplacian estimate coefficients for Fig. 2A (17/63, -1/21) and Fig. 2B (51938/159159, -1202/22737) were adopted from [1]. Second set of suboptimal coefficients was derived from the optimal set by scaling the first coefficient by 16/6 followed by scaling the resulting estimate by 6/16 to avoid a substantial increase in amplitude. Finite element method model was adopted from [1, 4]. Errors of Laplacian estimation corresponding to the optimal and two suboptimal estimates for finite dimensions models from Figs. 2A and 2B served as primary outcomes for comparison.

Figure 1. t-Lead electrodes from CREmedical (https://cremedical.com/product-2-2/).

Figure 2. Three finite dimensions models corresponding to: two approximations of t-Lead dimensions (panels A and B) and TCRE configuration with one to two ratio of median ring radii (panel C).

Results

Obtained finite element method modeling results (Fig. 3) indicate median ratio of normalized relative errors corresponding to suboptimal over optimal coefficients for two finite dimensions models approximating t-Lead electrodes to range between 479 and 644 times. Respective ratio of maximum errors ranges from 278 to 375 times.

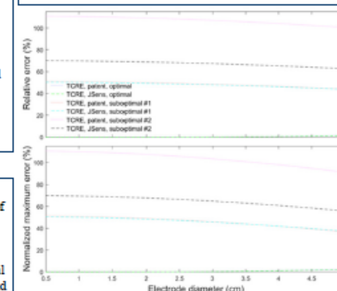


Figure 3. Relative (top panel) and normalized maximum (bottom panel) errors of surface Laplacian estimation corresponding to two tripolar concentric ring electrode configurations approximating t-Lead dimensions with three sets of coefficients for each including the optimal and two suboptimal ones respectively.

Discussion

While aforementioned preliminary error ratios suggest a significant difference in Laplacian estimation accuracy further investigation is needed to address the following. First, at this point of time difference in amplitudes of resulting Laplacian estimate signals corresponding to optimal and suboptimal coefficients has not been studied and difference in amplitudes may affect respective estimation errors. Addressing this is the first step of envisioned future work. Second, other approaches of determining suboptimal coefficients may result in closer fit to currently used (16, -1). Finally, any modeling based results need to be validated on real life phantom or human data using physical electrode prototypes.

References

[1] O. Makeyev, Y. Ye-Lin, G. Prats-Boluda, and J. Garcia-Casado, "Optimizing Laplacian Estimation for the Finite Dimensions Model of a Commercial Tripolar Concentric Ring Electrode and Comparing It to the Optimal Electrode Configuration via Finite Element Method Model-ing," presented at the 9th International Electronic Conference on Sensors and Applications session Applications, 2022. Accessed: Oct. 11, 2023. [Online]. Available: https://sciforum.net/manuscripts/13324/manuscript.pdf

[2] W. G. Besio, "Biomedical electrode system and method for detecting localized electrical signals and providing electrical stimulation," US8615283B2, Dec. 24, 2013 Accessed: Nov. 01, 2023. [Online]. Available: https://patents.google.com/patent/US8615283B2/en

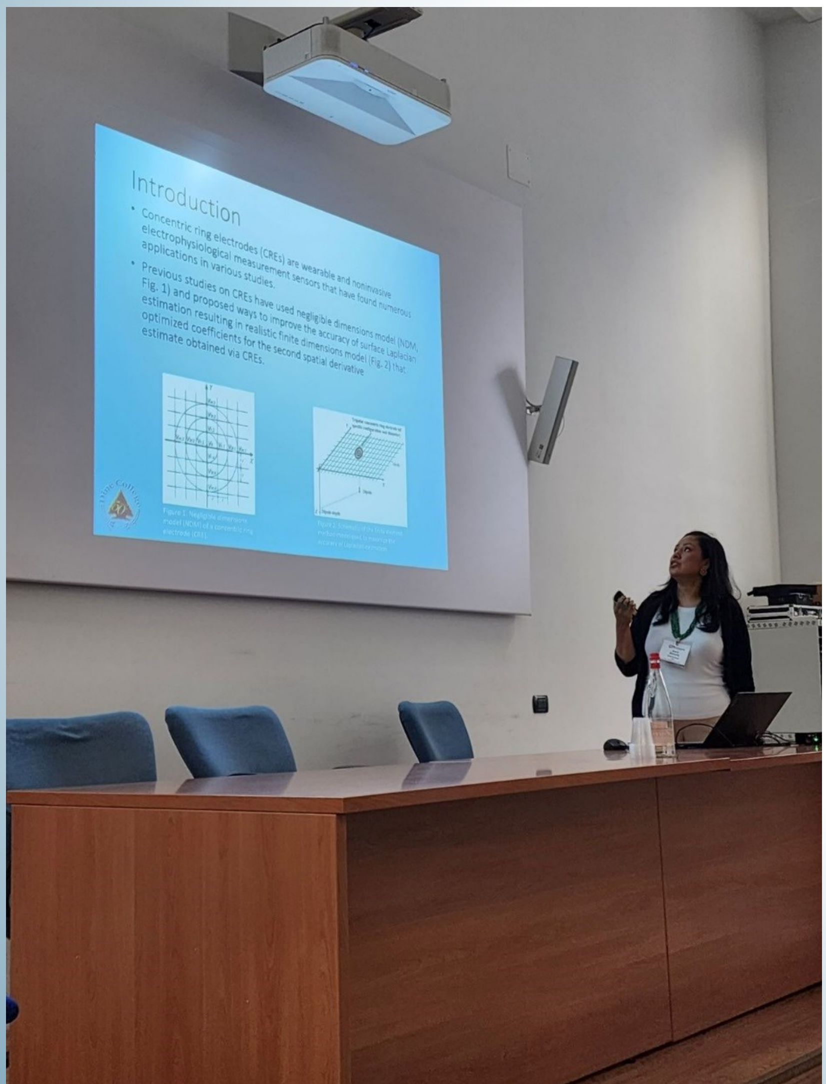
[3] X. Liu, O. Makeyev, and W. Besio, "Improved Spatial Resolution of Electroencephalogram Using Tripolar Concentric Ring Electrode Sensors," *Journal of Sensors*, vol. 2020, pp. 1–9, Jun. 2020, doi: 10.1155/2020/6269394.

[4] O. Makeyev, Y. Ye-Lin, G. Prats-Boluda, and J. Garcia-Casado, "Comprehensive Optimization of the Tripolar Concentric Ring Electrode Based on Its Finite Dimensions Model and Confirmed by Finite Element Method Modeling," *Sensors*, vol. 21, no. 17, Art. no. 17, Jan. 2021, doi: 10.3390/s21175881.

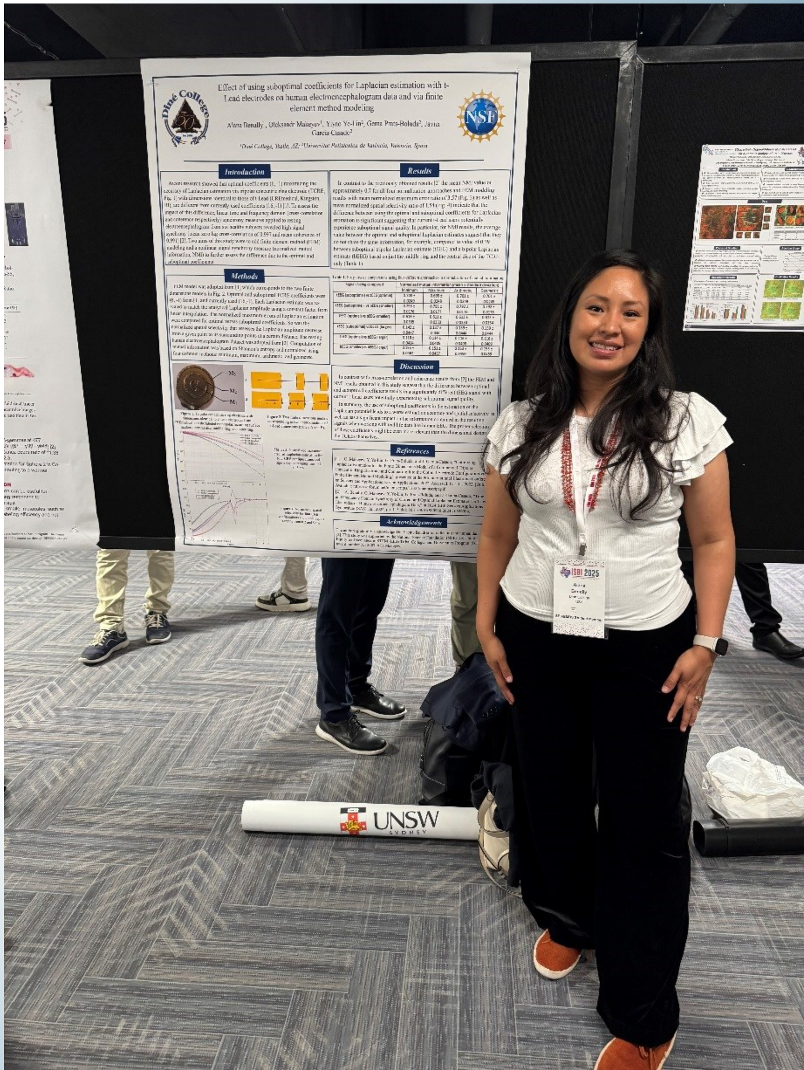
Acknowledgements

This research was supported, in part, by the National Science Foundation (NSF) Division of Equity for Excellence in STEM (EES) Tribal Colleges and Universities Program (TCUP) award number 2212707 to O. Makeyev.

2024 IEEE Sensors Applications Symposium
Naples, Italy
July 23-25, 2024



22nd IEEE International Symposium on Biomedical Imaging (ISBI 2025)
Houston, TX
April 14-17, 2025



MS Thesis Defense
May 6, 2025

Public MS thesis defenses

- Alana: https://www.youtube.com/watch?v=AAQjUdrXAJM
- Sheldon: https://www.youtube.com/watch?v=RhaNh-uA8eg

2026 Emerging Researchers National (ERN) Conference in STEM
March 19-21, 2026
Atlanta, GA

Linear Synchrony to Emulate Disc Electrode with Middle Ring or Central Disc of a Concentric Ring One

Sheldon Chee[1], Alana Benally[1], Oleksandr Makeyev[1], Yiyao Ye-Lin[2], Gema Prats-Boluda[2], Javier Garcia-Casado[2]

[1]*Diné College, Tsaile, AZ;* [2]*Universitat Politècnica de València, Valencia, Spain*

Introduction

Some noninvasive electrophysiological measurement applications benefit from simultaneous collection of data via both conventional disc electrodes and via tripolar concentric ring electrodes (TCREs), so an emulation of the former by the outer ring of the latter was previously proposed and since adopted widely [1], [2]. Its effectiveness was validated using linear time and frequency domain signal synchrony measures (cross-correlation and coherence, respectively) [1], [2]. This approach represents an alternative to recording from both electrode modalities concurrently, which may involve two recording systems and potential synchronization issues with signals not recorded at the exact same locations. However, recent application of a nonlinear signal synchrony measure, normalized mutual information, resulted in mean values of less than 0.7 between the outer ring of a TCRE and the disc electrode on both phantom model and human electroencephalogram (EEG) datasets [3], indicating that the outer ring of a TCRE may not be as suitable as an emulation of the disc electrode as previously suggested. Therefore, in this study, alternative options such as middle ring and central disc of a TCRE were assessed on the resting EEG data from six human subjects [1], [2].

Methods

Resting EEG data for six human subjects were adopted from [1], [2]. To record resting EEG, six human subjects (ages 24-40, one female) were instructed to remain seated motionless, thereby reducing movement related artifacts. The TCRE signals were preamplified using a custom preamplifier with a gain of 6 and both signals were band pass filtered (0.1-100Hz) and recorded at 1200 samples per second using a gUSB amplifier with a normalized unit gain (g.tec medical engineering GmbH, Schiedlberg, Austria). The resulting data was segmented into non overlapping 10s segments yielding 173 segments total with a total duration of 1730s. Some of the monopolar/recording surface (e.g. from the outer ring) and differential (middle ring minus central disc and outer ring minus central disc) signals from both the TCREs and conventional disc electrodes were simultaneously recorded using the standard 10-20 system at location P4 with the right mastoid process being the reference and ground. Central disc and middle ring channels were not recorded directly in this dataset, and were obtained through subtraction and addition of other monopolar and bipolar channels (e.g. subtraction of the outer ring monopolar channel and the bipolar channel corresponding to the outer ring minus the central disc allowed assessing the data corresponding to the central disc) with all resulting channels normalized to zero mean and unit standard deviation. The same two linear signal synchrony measures were used as in [1], [2].

Figure 1. Tripolar concentric ring electrode (A) and conventional disc electrode (B).

Table 1. Signal comparison using cross-correlation with zero and optimal lag on human EEG data

Cross-correlation	Signal comparison pairs (mean ± standard deviation)	
	Middle ring versus conventional disc electrode	Central disc versus conventional disc electrode
Zero lag	0.984 ± 0.012	0.986 ± 0.01
Maximum	0.984 ± 0.012	0.986 ± 0.01

Results

Average cross-correlation values for middle ring and central disc versus disc electrode were 0.984 ± 0.012 and 0.986 ± 0.01, respectively (Table 1). Average coherence values for middle ring and central disc versus disc electrode were 0.969 ± 0.0245 and 0.979 ± 0.0164, respectively (Table 2). These are comparable to previously obtained outer ring values: average cross-correlation of 0.9905 ± 0.0065 and average coherence of 0.9818 ± 0.0133 on the same human EEG dataset [1], [2].

Discussion

For both time- and frequency-domain measures, this comparison shows that middle ring and central disc are lower than outer ring but the difference is small enough to provide viable alternative emulation options if needed. Research significance of this study stems from assessing central disc and middle ring as emulations of disc electrode using linear synchrony measures for the very first time.

References

[1] O. Makeyev, Y. Boudria, Zhenghan Zhu, T. Lennon, and W. G. Besio, "Emulating conventional disc electrode with the outer ring of the tripolar concentric ring electrode in phantom and human electroencephalogram data," in *2013 IEEE Signal Processing in Medicine and Biology Symposium (SPMB)*, Brooklyn, NY, USA: IEEE, Dec. 2013, pp. 1–4. doi: 10.1109/SPMB.2013.6736778.

[2] O. Makeyev, T. Lennon, Y. Boudria, Z. Zhu, and W. G. Besio, "Frequency domain synchrony between signals from the conventional disc electrode and the outer ring of the tripolar concentric ring electrode in human electroencephalogram data," in *2014 40th Annual Northeast Bioengineering Conference (NEBEC)*, Boston, MA, USA: IEEE, Apr. 2014, pp. 1–2. doi: 10.1109/NEBEC.2014.6972865.

[3] S. Chee, A. Benally, O. Makeyev, Y. Ye-Lin, G. Prats-Boluda, and J. Garcia-Casado, "Normalized Mutual Information in Phantom Model and Human Electroencephalogram Data for Emulation of Conventional Disc Electrode via the Outer Ring of Tripolar Concentric Ring Electrode," in *2025 IEEE 22nd International Symposium on Biomedical Imaging (ISBI)*, Apr. 2025, pp. 1–4. doi: 10.1109/ISBI60581.2025.10980659.

Acknowledgements

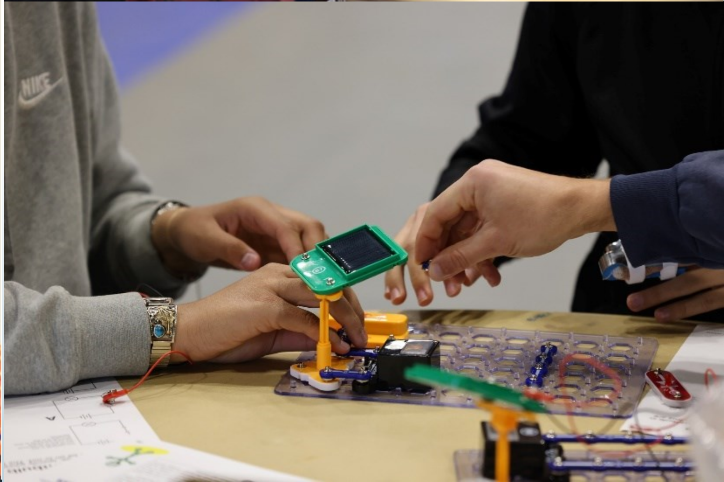
The authors gratefully acknowledge Dr. Yacine Boudria for collecting the human data in [1], [2]. This research was supported, in part, by the National Science Foundation (NSF) Division of Undergraduate Education (DUE) Tribal Colleges and Universities Program (TCUP) award number 2415867 to O. Makeyev.

Table 2. Signal comparison using coherence with spectral frequency bands on human EEG data

Coherence	Signal comparison pairs (mean ± standard deviation)	
	Middle ring versus conventional disc electrode	Central disc versus conventional disc electrode
Full spectrum	0.969 ± 0.0245	0.979 ± 0.0164
Delta	0.941 ± 0.0557	0.958 ± 0.0169
Theta	0.951 ± 0.0517	0.975 ± 0.0126
Alpha	0.977 ± 0.0127	0.984 ± 0.0113
Beta	0.976 ± 0.0206	0.985 ± 0.0124
Gamma	0.969 ± 0.0263	0.978 ± 0.0195

MS Thesis Defense
May 4, 2026

STEAM Festival, March 25-26, 2024 Tsaile, AZ



STEAM Festival, October 21-22, 2025 Tsaile, AZ

Diné College
Land Grant Office
Extension and Outreach

STEAM Festival

Dine College-Tsaile GYM

Agenda

October 21 & 22, 2024

Oct. 21, for grades 5th-8th (Max of 300 participants)		Oct. 22, for grades 9th-12th (Max of 300 participants)
	8:00 - 9:15 a.m.	**Registration Check-in** All participants must be registered for the event & Must wear a face mask.
	9:15 – 9:30 a.m	**Welcome Address** STEM Coordinator
Session 1	*9:30 – 10:30 a.m.* *10:30-10:40 a.m.*	**Session 1 (open sessions)** **Break (10mins)**
Session 2	*10:40 – 11:40a.m.*	**Session 2 (open sessions)**
Lunch	*11:40 – 1:00 p.m.*	**Lunch break for Facilitators** Schools can bring sack lunches or Call the DC cafeteria to arrange with Elizabeth Tso 928-724-6747 etso@dinecollege.edu Alternative contact Tivona Endischee tendischee@dinecollege.edu
Session 4	*1:00 – 2:00 p.m.*	**Session 3 (open sessions)**
Closing	*2:00 – 2:30 p.m.*	**Closing & Clean-up**
	2:30 p.m.	**End event**

MEA lab tutoring schedules for AY24-25

STEM Tutoring Center

Stop by during a tutoring session to inquire if your course is covered or email Dr. Makeyev at omakeyev@dinecollege.edu!

Semester: Spring 2025 — **Room: MEA lab, LIB206, 2nd floor library building, Tsaile Campus**

TIME	MONDAY	TUESDAY	WENDESDAY	THURSDAY	FRIDAY
8:00-9:00 am					
9:00-10:00 am		Alana 9:00am-11:00am		Alana 9:00am-11:00am	
10:00-11:00 am					
11:00-12:00 pm		Sheldon 11:00am-12:30pm		Sheldon 11:00am-12:30pm	
12:00-1:00 pm					
1:00-2:00 pm	Sheldon 1:30-3:30pm				
2:00-3:00 pm			MEA lab meeting 2:00pm-3:00pm		
3:00-4:00 pm			Alana 3:00pm-4:00pm		
4:00-5:00 pm					
5:00-6:00 pm					
6:00-7:00 pm					
7:00-8:00 pm					
8:00-9:00pm					

STEM Tutoring Center

Stop by during a tutoring session to inquire if your course is covered or email Dr. Makeyev at omakeyev@dinecollege.edu!

Semester: Fall 2024 — **Room: MEA lab, LIB206, 2nd floor library building, Tsaile Campus**

TIME	MONDAY	TUESDAY	WENDESDAY	THURSDAY	FRIDAY
8:00-9:00 am					
9:00-10:00 am	Sheldon 9:00-11:00pm	Alana 9:00am-10:30am	Alana 9:00am-10:30am	Alana 9:00am-11:00am	
10:00-11:00 am					
11:00-12:00 pm		Sheldon 11:00am-12:00pm	MEA lab meeting 11:00am-12:00pm		
12:00-1:00 pm					
1:00-2:00 pm				Sheldon 1:00-3:00pm	
2:00-3:00 pm					
3:00-4:00 pm					
4:00-5:00 pm					
5:00-6:00 pm					
6:00-7:00 pm					
7:00-8:00 pm					
8:00-9:00pm					

MEA lab tutoring schedules for AY25-26

STEM Tutoring Center

Stop by during a tutoring session to inquire if your course is covered or email Dr. Makeyev at omakeyev@dinecollege.edu!

Semester: Fall 2025 Room: MEA lab, LIB206, 2nd floor library building, Tsaile Campus

TIME	MONDAY	TUESDAY	WENDESDAY	THURSDAY	FRIDAY
8:00-9:00 am					
9:00-10:00 am					
10:00-11:00 am		MEA lab meeting 10:00am-11:00am	Sheldon 10:00am-12:00pm		
11:00-12:00 pm					
12:00-1:00 pm					
1:00-2:00 pm				Sheldon 1:00pm-2:30pm	
2:00-3:00 pm		Sheldon 2:00pm-3:30pm			
3:00-4:00 pm					
4:00-5:00 pm					
5:00-6:00 pm					
6:00-7:00 pm					
7:00-8:00 pm					
8:00-9:00pm					

STEM Tutoring Center

Stop by during a tutoring session to inquire if your course is covered or email Dr. Makeyev at omakeyev@dinecollege.edu!

Semester: Spring 2026 Room: MEA lab, LIB206, 2nd floor library building, Tsaile Campus

TIME	MONDAY	TUESDAY	WENDESDAY	THURSDAY	FRIDAY
8:00-9:00 am					
9:00-10:00 am					
10:00-11:00 am		Sheldon 10:00am-11:30am		Sheldon 10:00am-11:30am	
11:00-12:00 pm					
12:00-1:00 pm			Sheldon 12:30pm-2:30pm		
1:00-2:00 pm					
2:00-3:00 pm					
3:00-4:00 pm					
4:00-5:00 pm					
5:00-6:00 pm					
6:00-7:00 pm					
7:00-8:00 pm					
8:00-9:00pm					

MEA lab in 2024

Diné College

Acknowledgements and Conclusions

- Acknowledgements

  - National Science Foundation’s TCU Program for their support from the very beginning, Senator Mark Kelly, Small Business Administration, Economic Development Administration, and all of the Diné College staff involved in patenting and technology transfer endeavors.

- We hope that
  - Our lessons learned might be helpful to other TCUs that embark on similar journeys of their own;
  - Other TCUs will center their intellectual property and tech transfer efforts at their libraries as well;
  - Another update in 3 years or so would have even better news on licensing/tech transfer, maker space, etc.

Thank you!
Questions?