

The Diné College Library and its Fruitful Relationship with Mathematics

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<http://lib.dinecollege.edu/>

<http://mealab.dinecollege.edu/>

Tribal College Librarians Institute (TCLI), June 8th, 2023



Introduction

- A unique relationship between Diné College Libraries and School of STEM faculty which yielded results that could be replicated at other TCUs:
 - It began with NSF funded Mathematics for Engineering Applications (MEA) laboratory, with student research assistants and an attendant tutoring service, being located in the Tsaile Campus library.
 - It eventually blossomed into a Technology Transfer Center, the first of its kind at a TCU, with Congressional funding to be located in the Tsaile Campus library.
 - This presentation goes from the MEA lab to the Technology Transfer Center highlighting the vital role that library played in making them happen.



NSF Org:	HRD Division Of Human Resource Development
Recipient:	NAVAJO NATION TRIBAL GOVERNMENT, THE
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Program Manager:	Lura Chase lchase@nsf.gov (703)292-5173 HRD Division Of Human Resource Development EHR Direct For Education and Human Resources
Start Date:	September 15, 2016
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History of Investigator:	Oleksandr Makeyev (Principal Investigator) omakeyev@dinecollege.edu
Recipient Sponsored Research Office:	Dine College P O Box 126 tsaile AZ US 86556-0067 (928)724-6670



September 21, 2016



Old computer lab, equipment, peculiarities.

October 11, 2016



Networking equipment, more peculiarities.

November 14, 2016

All the old
equipment
gone.



December
14-15, 2016



Putting in partition wall.

January 13-17, 2017



Paint, carpet, and furniture.

January 13-17, 2017



March 22, 2017



MEA lab's original equipment

- MEA lab's cluster has four Intel® Xeon® E5-1650 v4 3.6 GHz based machines with a total of 24 cores and 128 Gb of DRAM.
 - Still the fastest computer cluster at Diné College and is available to other faculty for their research projects.
- 1 Gbps network
 - At that time first network faster than 100 Mbps at Diné College which came in handy both during our first NSF project and the second one for which we still needed a fast network and a lot of computational power but did not depend on anyone in terms of datasets.



NSF Org:	EES Div. of Equity for Excellence in STEM
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Award Number:	1914787
Award Instrument:	Standard Grant
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History of Investigator:	Oleksandr Makeyev (Principal Investigator) omakeyev@dinecollege.edu
Recipient Sponsored Research Office:	Dine College 1 CIRCLE DR TSAILE AZ US 86556-9998 (928)724-6670



MEA lab products since 2016

- 3 NSF research awards total (\$600,000+);
- 3 patents (one issued and two pending);
- 8 journal and 9 conference proceedings papers;
- 7 undergraduate Research Assistants published their research including journal papers;
- Awards, tutoring for Diné College students, running activities for local school students at STEM festivals, etc.



Papers

Article

Comprehensive Optimization of the Triplar Concentric Ring Electrode Based on Its Finite Dimensions Model and Confirmed by Finite Element Method Modeling

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Abstract: The optimization performed in this study is based on the finite dimensions model of the concentric ring electrode as opposed to the negligible dimensions model used in the past. This makes the optimization problem comprehensive, as all of the electrode parameters including, for the first time, the radius of the central disc and individual widths of concentric rings, are optimized simultaneously. The optimization criterion used to maximize the accuracy of surface Laplacian estimation, as the ability to estimate the Laplacian at each electrode constitutes primary biophysical significance of concentric ring electrodes. For triplar concentric ring electrodes, the optimal configuration was compared to previously proposed linearly increasing inter-ring distances and constant inter-ring distance configurations of the same size and based on the same finite dimensions model. The obtained analytic results suggest that previously proposed configurations correspond to almost two-fold and more than three-fold increases in the Laplacian estimation error compared with the optimal configuration proposed in this study, respectively. These analytic results are confirmed using finite element method modeling, which was adapted to the finite dimensions model of the concentric ring electrode for the first time. Moreover, the finite element method modeling results suggest that optimal electrode configuration may also offer improved sensitivity and spatial resolution.



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Research Article Improved Spatial Resolution of Electroencephalogram Using Triplar Concentric Ring Electrode Sensors

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The electroencephalogram (EEG) is broadly used for research of brain activities and diagnosis of brain diseases and disorders. Although EEG provides good temporal resolution of milliseconds or less, it does not provide good spatial resolution. There are two main reasons for the poor spatial resolution: the blurring effects of the head volume conductor and poor signal-to-noise ratio. We have developed a triplar concentric ring electrode (TCRE) Laplacian sensor and now report on computer simulations comparing spatial resolution between conventional EEG disc electrode sensors and TCRE Laplacian sensors. We also performed visual evoked stimulus experiments and acquired visual evoked potentials (VEPs) from healthy human subjects. From the simulations, we found that TCRE Laplacian sensors can provide approximately a twofold improvement in spatial resolution and pass signals from specific volumes. Placing TCRE sensors near the brain region of interest will allow passage of the wanted signals and rejection of distant interference signals. We were also able to detect VEPs on the scalp surface and show that TCREs separated VEP sources better than conventional disc electrodes.

1. Introduction

Electroencephalography (EEG) is widely used in diagnosis of brain-related disorders and research. However, EEG suffers from poor spatial resolution due to the blurring effects primarily from different conductivities of the volume conductor [1].

To improve the spatial resolution, the surface Laplacian has been applied to EEG [1, 2]. The surface Laplacian is a high-pass spatial filter, which sharpens the blurred potential distribution on the surface [2] and produces an image proportional to the cortical potentials [3].

Two approaches have been used to calculate the surface Laplacian. The global surface Laplacian approach is based on the potential interpolation on the surface [4–6]. A drawback of this approach is that building the potential interpolation equations requires a significant number of electrodes [7]. The local surface Laplacian approach approximates the surface Laplacian based on potentials from neighboring electrodes only [8]. This approach also has significant drawbacks:

(1) when the neighboring electrodes are too sparse, which is usually the case with the 10–20 system configuration, the resulting local surface Laplacian might not be a good estimation of the surface Laplacian [7], and (2) the locations where the surface Laplacian could be estimated are limited.

This paper assesses a local Laplacian that overcomes the drawback of sparse electrode distribution by employing the triplar concentric ring electrode (TCRE; Figure 1) introduced by Imita et al. [9]. Instead of using neighboring electrodes to estimate the surface Laplacian, the three recording surfaces of a single TCRE (outer ring, middle ring, and the central disc) are used. The second drawback can also be alleviated by interpolation of the TCRE local surface Laplacian. To illustrate these points, the global surface Laplacian and local surface Laplacian are compared using a four-layer concentric inhomogeneous spherical head model [10]. This model has been selected for this study to ensure consistency with previous results of others having used it to compare Laplacian estimation methods [11]. Moreover, unlike most of the more realistic head models, it allows straightforward modeling of



applied sciences

Article

Validating the Comparison Framework for the Finite Dimensions Model of Concentric Ring Electrodes Using Human Electrocardiogram Data

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Abstract: While progress has been made in design optimization of concentric ring electrodes maximizing the accuracy of the surface Laplacian estimation, it was based exclusively on the negligible dimensions model of the electrode. Recent proof of concept of the new finite dimensions model that adds the radius of the central disc and the widths of concentric rings to the previously included number of rings and inter-ring distances provides an opportunity for more comprehensive design optimization. In this study, the aforementioned proof of concept was developed into a framework allowing direct comparison of any two concentric ring electrodes of the same size and with the same number of rings. The proposed framework is illustrated on constant and linearly increasing inter-ring distances triplar concentric ring electrode configurations and validated on electrocardiogram data from 20 human subjects. In particular, ratios of transition term coefficients between the two electrode configurations were used to demonstrate the similarity between the negligible and the finite dimensions models analytically ($p < 0.077$). Laplacian estimates based on the two models were calculated using ECG data for a constant and linearly increasing inter-ring distances triplar concentric ring electrode. The differences between the estimates was not statistically significant ($p >> 0.05$) which is consistent with the analytic result.

Keywords: electrocardiography; electrophysiology; biopotentials; measurement; wearable sensors; noninvasive; concentric ring electrodes; Laplacian; estimation; modeling

1. Introduction

Surface biometric signals, such as an electrocardiogram (ECG) or electroencephalogram (EEG) are essential tool in clinical diagnosis. When recorded with conventional disc electrodes surface biometric signals have an outstandingly poor spatial resolution but poor spatial resolution is a blurring effect. It is due to the configuration of conventional disc electrodes and different conductivities of the body volume conductor [1, 2]. To overcome this drawback, surface Laplacian estimation was proposed. Surface Laplacian is the second spatial derivative of the surface potentials that acts as a high-pass spatial filter [3] and allows diminishing the blurring effect of the volume conductor [4, 5]. Laplacian estimation allows an improvement in picking up the biometric signals closest to the electrodes and rejection of distant biometric disc sources when compared to bipolar signals from conventional disc electrodes [1].

Initially, Laplacian was estimated based on the surface potentials recorded via multiple single pole electrodes and the application of discretization techniques such as the five-point method [7]. Laplacian

Improving the accuracy of Laplacian estimation with novel multipolar concentric ring electrodes

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ABSTRACT

Conventional electroencephalography with disc electrodes has major drawbacks including poor spatial resolution, selectivity and low signal-to-noise ratios that are critically limiting its use. Concentric ring electrodes, consisting of several elements including the central disc and a number of concentric rings, are a promising alternative with potential to improve all of the aforementioned aspects significantly. In our previous work, the triplar concentric ring electrode was successfully used in a wide range of applications demonstrating its superiority to conventional disc electrode, in particular, in accuracy of Laplacian estimation. This paper takes the next step toward further improving the Laplacian estimation with novel multipolar concentric ring electrodes by comparing and validating a general approach to estimation of the Laplacian for an $(n + 1)$ -pole electrode with n rings using the $(4n + 1)$ -point method for $n > 2$ that allows cancellation of all the truncation terms up to the order of $2n$. An explicit formula based on inversion of a square Vandermonde matrix is derived to make computation of multipolar Laplacian more efficient. To confirm the analytic result of the accuracy of Laplacian estimate increasing with the increase of n and to assess the significance of this gain in accuracy for practical applications finite element method model analysis has been performed. Multipolar concentric ring electrode configurations with n ranging from 1 ring (bipolar electrode configuration) to 6 rings (septapolar electrode configuration) were directly compared and obtained results suggest the significance of the increase in Laplacian accuracy caused by increase of n .

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1. Introduction

Electroencephalography (EEG) is an essential tool for brain and behavioral research and is used extensively in neuroscience, cognitive science, cognitive psychology, and psychophysiology. EEG is also one of the mainstays of hospital diagnostic procedures and pre-surgical planning. Despite scalp EEG's many advantages and uses, it suffers from its poor spatial resolution, selectivity and

low signal-to-noise ratio, which are EEG's biggest drawbacks critically limiting the research discovery and diagnosis [1–3].

EEG's poor spatial resolution is primarily due to (1) the blurring effects of the volume conductor with disc electrodes; and (2) EEG signals having reference electrode problems as idealized references are not available with EEG [2]. Interference on the reference electrode contaminates all other electrode signals [2]. The application of the surface Laplacian (the second spatial derivative of the potentials on the body surface) to EEG has been shown to alleviate the blurring effects enhancing the spatial resolution and selectivity, and reduce the reference problem [4–6].

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RESEARCH

Solving the general inter-ring distances optimization problem for concentric ring electrodes to improve Laplacian estimation

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Abstract

Background: Superiority of noninvasive triplar concentric ring electrodes over conventional disc electrodes in accuracy of surface Laplacian estimation has been demonstrated in a range of electrophysiological measurement applications. Recently, a general approach to Laplacian estimation for an $(n + 1)$ -pole electrode with n rings using the $(4n + 1)$ -point method has been proposed and used to introduce novel multipolar and variable inter-ring distances electrode configurations. While only linearly increasing and linearly decreasing inter-ring distances have been considered previously, this paper defines and solves the general inter-ring distances optimization problem for the $(4n + 1)$ -point method.

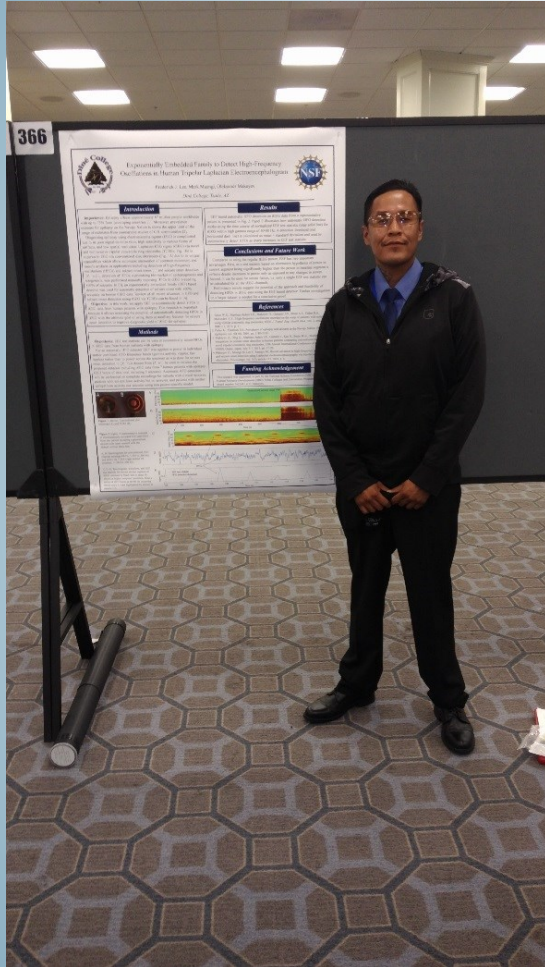
Results: General inter-ring distances optimization problem is solved for triplar ($n = 2$) and quadripolar ($n = 3$) concentric ring electrode configurations through minimizing the truncation error of Laplacian estimation. For triplar configuration with middle ring radius r and outer ring radius R the optimal range of values for r was determined to be $0 < r < 0.22$ while for quadripolar configuration with an additional middle ring and radius β the optimal range of values for β and R was determined by inequalities $0 < \beta < \beta < 1$ and $0.5 < R < 1$. Finite element method modeling and full factorial analysis of variance were used to confirm statistical significance of Laplacian estimation accuracy improvement due to optimization of inter-ring distances ($p < 0.0001$).

Conclusions: Obtained results suggest the potential of using optimization of inter-ring distances to improve the accuracy of surface Laplacian estimation via concentric ring electrodes. Identical approach can be applied to solving corresponding inter-ring distances optimization problems for electrode configurations with higher numbers of concentric rings. Solutions of the proposed inter-ring distances optimization problem define the class of the optimized inter-ring distances electrode designs. These designs may result in improved noninvasive sensors for measurement systems that use concentric ring electrodes to acquire electrical signals such as from the brain, intestines, heart or chest for diagnostic purposes.

Keywords: Electroencephalography; Electroencephalography; Wearable sensors; Concentric ring electrodes; Laplacian; Optimization; Inter-ring distances; Finite element method; Modeling

Awards

Elevation in
professional



research
competitions



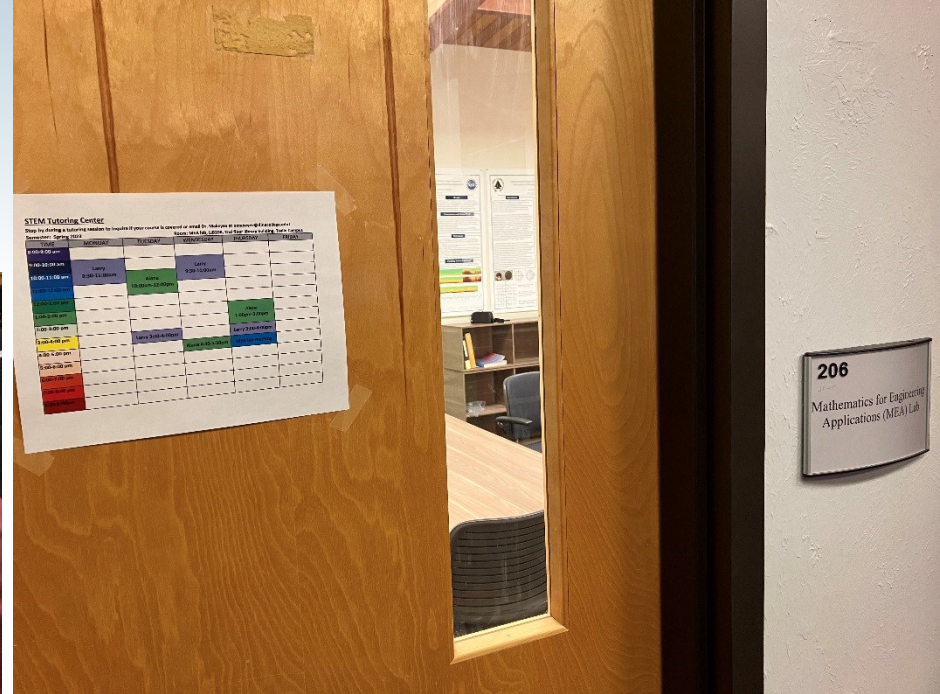
Competitive
travel awards.



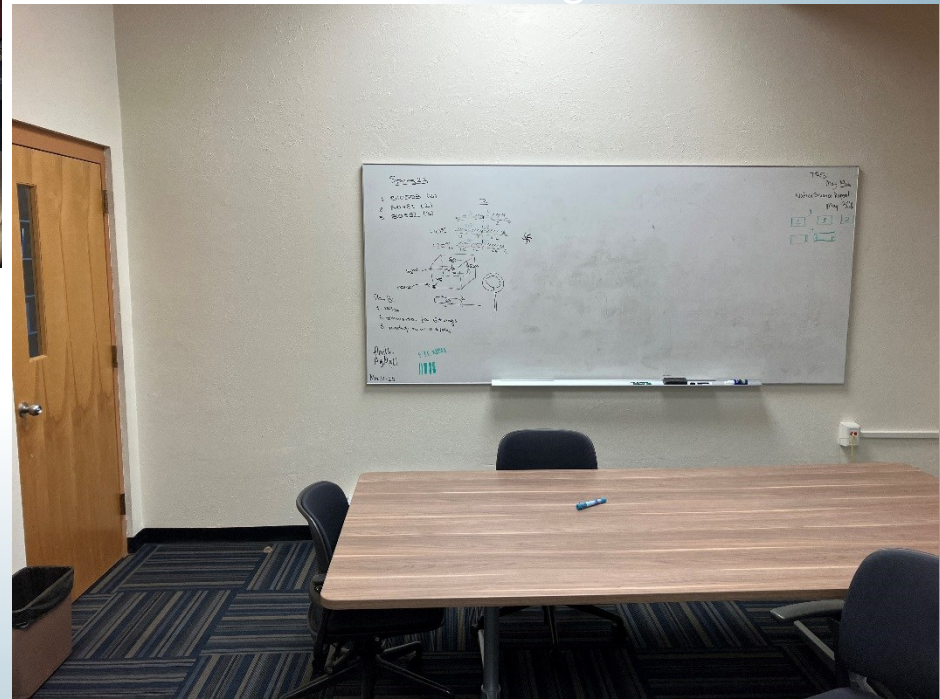
Outreach



Fall 2019 STEM festival



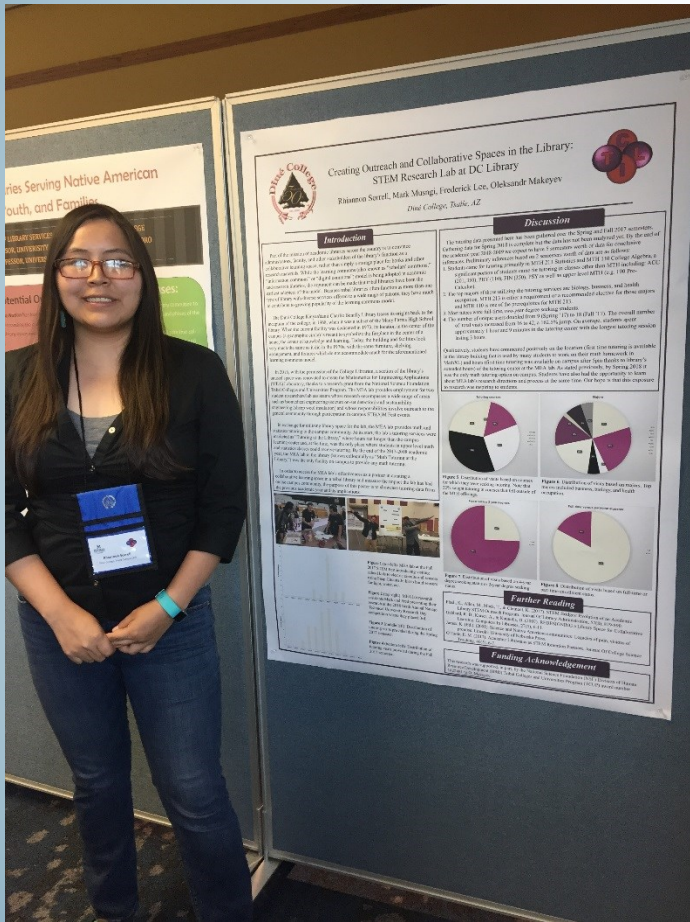
tutoring schedule.



2019 NSF
TCUP TRS.



Tutoring



Creating Outreach and Collaborative Spaces in the Library: STEM Research Lab at DC Library

Rhiannon Sorrell, Mark Musngi, Frederick Lee, Oleksandr Makeyev
Diné College, Tsaile, AZ



Introduction

Part of the mission of academic libraries across the country is to convince administrators, faculty, and other stakeholders of the library's function as a collaborative learning space, rather than simply a storage place for books and other research materials. While the learning commons (also known as "scholars' commons," "information commons" or "digital commons") model is being adopted in academic and research libraries, the argument can be made that tribal libraries have been the earliest adopters of this model. Because tribal libraries often function as more than one type of library with diverse services offered to a wide range of patrons, they have much to contribute to growing popularity of the learning commons model.

The Diné College Kinyaa'naani Charlie Bonally Library traces its origins back to the inception of the college, in 1968, when it was a subset of the Many Farms High School library. When the current facility was dedicated in 1973, its location in the center of the campus (a geographic circle) is meant to symbolize the fireplace in the center of a home; the center of knowledge and learning. Today, the building and facilities look very much the same as it did in the 1970s, with the same furniture, shelving arrangement, and fixtures which do not accommodate much for the aforementioned learning commons model.

In 2016, with the permission of the College Librarian, a section of the library's unused space was renovated to create the Mathematics for Engineering Applications (MEA) Laboratory, thanks to a research grant from the National Science Foundation Tribal College and Universities Program. The MEA lab provides employment for two student researchers/lab assistants whose research encompasses a wide range of areas such as biomedical engineering (seismic on-set detection) and sustainability engineering (sheep wool insulation) and whose responsibilities involve outreach to the general community through participation in campus STE(A)M Fest events.

In exchange for utilizing library space for the lab, the MEA lab provides math and statistics tutoring to the campus community. At its start, the lab's tutoring services were marketed as "Tutoring at the Library," where hours ran longer than the campus learning center and, at the time, was the only place where students in upper level math and statistics classes could receive tutoring. By the end of the 2017-2018 academic year, the MEA lab in the library (known colloquially as "Math Tutoring at the Library,") was the only facility on campus to provide any math tutoring.

In order to access the MEA lab's effectiveness as a partner in creating a collaborative learning space in a tribal library and measure the impact the lab has had on the campus community, the purpose of this poster is to showcase tutoring data from the previous academic year and its implications.

Discussion

The tutoring data presented here has been gathered over the Spring and Fall 2017 semesters. Gathering data for Spring 2018 is complete but the data has not been analyzed yet. By the end of the academic year 2018-2019 we expect to have 5 semesters worth of data for conclusive inferences. Preliminary inferences based on 2 semesters worth of data are as follows:

1. Students came for tutoring primarily in MTH 213 Statistics and MTH 110 College Algebra, a significant portion of students came for tutoring in classes other than MTH including: ACC (201, 350), PHY (110), FIN (350), PSY as well as upper level MTH (e.g. 190 Pre-Calculus).
2. The top majors of those utilizing the tutoring services are biology, business, and health occupation. MTH 213 is either a requirement or a recommended elective for those majors and MTH 110 is one of the prerequisites for MTH 213.
3. Most tutored were full-time, 2-year degree seeking students.
4. The number of unique users doubled from 9 (Spring '17) to 18 (Fall '17). The overall number of total visits increased from 16 to 42, a 162.5% jump. On average, students spent approximately 1 hour and 9 minutes in the tutoring center with the longest tutoring session lasting 3 hours.

Qualitatively, students have commented positively on the location (first time tutoring is available in the library building that is used by many students to work on their math homework in MathXL) and hours (first time tutoring was available on campus after 5pm thanks to library's extended hours) of the tutoring center at the MEA lab. As stated previously, by Spring 2018 it was the only math tutoring option on campus. Students have also had the opportunity to learn about MEA lab's research directions and process at the same time. Our hope is that this exposure to research was inspiring to students.

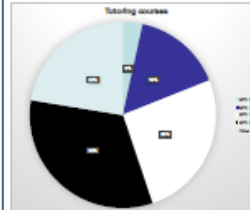


Figure 5. Distribution of visits based on courses for which they were seeking tutoring. Note that 22% sought tutoring in courses that fell outside of the MTH offerings.

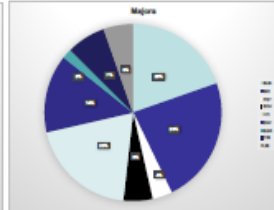


Figure 6. Distribution of visits based on majors. Top majors included business, biology, and health occupation.



Figure 7. Distribution of visits based on 4-year or degree seeking status or 2-year degree seeking status.

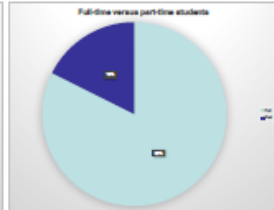


Figure 8. Distribution of visits based on full-time or part-time enrollment status.



Figure 1 (top left). MEA lab at the Fall 2017 STEM Fest introducing visiting school kids to electric circuits and sensors using Smart Circuits Jr. kit to build sensors for light, water, etc.

Figure 2 (top right). MEA lab research assistants Mark and Fred presenting their research at the 2018 Sixth Annual Navajo Technical University Research Day competition where they placed 3rd.

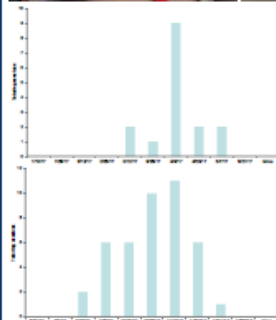


Figure 3 (middle left). Distribution of tutoring visits provided during the Spring 2017 semester.

Figure 4 (bottom left). Distribution of tutoring visits provided during the Fall 2017 semester.

Further Reading

- Flash, K., Allen, M., Mack, T., & Clement, K. (2017). STEM Bridges: Evolution of an Academic Library STEM Outreach Program. *Journal Of Library Administration*, 57(8), 879-890.
- Gabband, R. B., Kaiser, A., & Kannelis, D. (2007). REDESIGNING A LIBRARY SPACE FOR COLLABORATIVE LEARNING. *Computers In Libraries*, 27(5), 6-11.
- James, K. (Ed.). (2001). *Science and Native American communities: Legacies of pain, visions of promise*. Lincoln: University of Nebraska Press.
- O'Toole, E. M. (2017). Academic Librarians as STEM Retention Partners. *Journal Of College Science Teaching*, 46(5), 6-7.

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2018 TCLI.



Nowadays



Newest toys.



NSF Org:	EES Div. of Equity for Excellence in STEM
Recipient:	NAVAJO NATION TRIBAL GOVERNMENT, THE
Initial Amendment Date:	May 15, 2022
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History of Investigator:	Oleksandr Makeyev (Principal Investigator) omakeyev@dinecollege.edu
Recipient Sponsored Research Office:	Dine College 1 CIRCLE DR TSAILE AZ US 86556-9998 (928)724-6670



Some other firsts along the way

- Pursuing intellectual property required a respective set of policies and procedures which had to be created (mostly) from scratch first;
- Same goes for getting legal counsel on board, funding patent related costs and fees with soft money, dealing with USPTO, Bayh–Dole Act reporting, etc;
- MEA lab's web page showcased at <http://mealab.dinecollege.edu/>
- Certain aspects of international collaborations;
- Patents and the most important first yet...



Patents

- First patent issued to a Tribal College or University.
- Two more patents are currently pending.
- Other STEM faculty are ready to apply for patents but current process is not easy and how about other inventors?



(12) **United States Patent**
Makeyev

(10) **Patent No.:** **US 11,045,132 B1**
(45) **Date of Patent:** **Jun. 29, 2021**

(54) **CONCENTRIC RING ELECTRODES FOR IMPROVED ACCURACY OF LAPLACIAN ESTIMATION**

(71) Applicant: **Diné College**, Tsile, AZ (US)

(72) Inventor: **Oleksandr Makeyev**, Tsile, AZ (US)

(73) Assignee: **Diné College**, Tsile, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/067,480**

(22) Filed: **Oct. 9, 2020**

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(52) U.S. Cl. **A61B 5/291** (2021.01); **A61B 2562/0209** (2013.01); **A61B 2562/0215** (2017.08); **A61B 2562/04** (2013.01)

(58) **Field of Classification Search**
CPC **A61B 5/291**; **A61B 2562/0215**; **A61B 2562/0209**; **A61B 2562/04**
See application file for complete search history.

FOREIGN PATENT DOCUMENTS

ES 2425692 * 10/2013 A61B 5/04
WO 201315931 A1 9/2013

OTHER PUBLICATIONS

Pras Betada, Gerns, Translation of ES2425692A1, "Device for Measuring Bioelectric Signals on the Surface of the Body, Based on Adjustable Ring Sensors", (Year: 2013), translated on Jun. 7, 2021.*
Oleksandr Makeyev et. al., "Proof of concept Laplacian estimate derived for noninvasive tripolar concentric ring electrode with incorporated radius of the central disc and the widths of the concentric rings", retrieved: Jan. 7, 2021., (Year: 2017).*

(Continued)

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(57) **ABSTRACT**

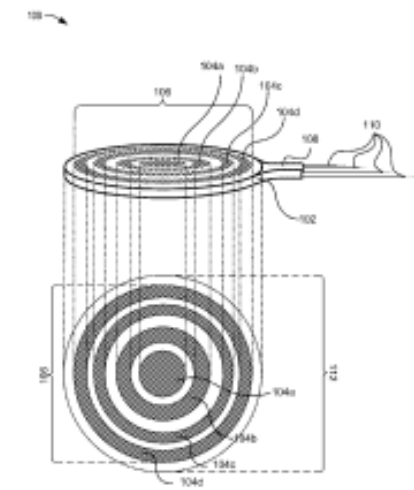
An electrode device for electrophysiological measurement may include an electrode substrate having a surface area. The electrode device may include a central electrode disposed on the electrode substrate around a central portion of the surface area. The electrode device may include a plurality of electrodes disposed on the electrode substrate concentric with the central electrode. The plurality of electrodes may include a first electrode covering a first portion of the surface area of the electrode substrate and a second electrode covering a second portion of the surface area of the electrode substrate. The second portion may be greater than a combined surface area of the first portion and the central portion.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,043,292 B2 5/2006 Tarjan et al.
8,190,248 B2 5/2012 Besio et al.
8,352,612 B2 1/2013 Besio
8,615,283 B2 12/2013 Besio
8,636,259 B2 1/2014 Besio
2012/0159011 A1* 6/2012 Besio A61N 1/0502
600/388

20 Claims, 10 Drawing Sheets



Technology transfer center

- Current state of the art: who has them and why?
- What services are usually provided?
 - Protecting IP;
 - Licensing IP;
 - Creating small businesses around IP.



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The mission of the Technology Transfer Office at Montana State University

- Commercialize MSU innovations
- Spur entrepreneurship based on MSU technology
- Provide a gateway for industry partners to access MSU technologies and capabilities

The Technology Transfer Office at MSU has collaborated with faculty, researchers, and universities, and partnered with industry to achieve the following:

- 600+ technologies managed;
- 400+ patents, PVP's, trademarks, and copyrights issued;
- 700+ IP agreements completed; and
- 60+ company start ups and spin-outs.



Diné College journey so far

- Several funding proposals were prepared and submitted with varying degrees of success:
 - NSF TCUP TEA Center proposal was not funded but revision was invited;
 - That revision has been resubmitted on June 1st, 2023.
 - SBA earmark for over \$1M was funded thanks to the Senator Mark Kelly.
- Technology Transfer Center as well as its computer lab and maker space will be located in the Tsaile Campus library.



What has been funded already

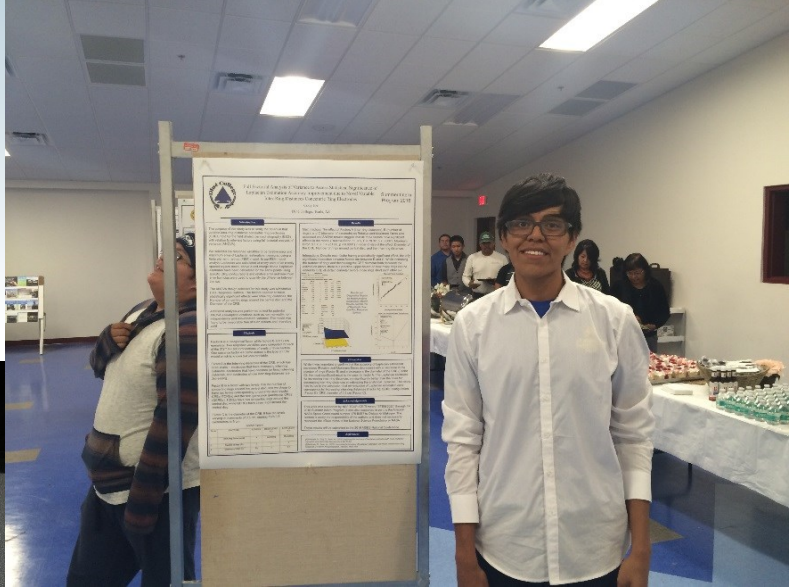
- Already funded via the SBA earmark:
 - Setting up and operations (including legal costs and fees) of the center during its first year;
 - Renovations (center and computer lab/maker space);
 - Computer lab/maker space hardware and software;
- Not funded yet:
 - Comprehensive suite of database subscriptions;
 - Years two through six of operations (crucial to its self-sustainability plan).



Conclusions

- It's doable.
 - More of our research labs are now located elsewhere.
- Not spending hard money is possible:
 - NSF TCUP SGR awards are great for setting up research labs;
 - NSF TCUP TEA Center awards may be a fit for technology transfer centers;
 - Do as much as possible in house and don't forget about the earmarks.
- Please, consider collaborating with a research laboratory at your Tribal College or University library.





Thanks You!



Questions?

