

NSF Award @EMBC Flash Slides



Long-term evaluation of sensorimotor control strategies in transradial prostheses



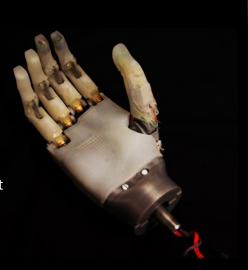
Aadeel Akhtar

Research Problem

- State-of-the-art commercial prostheses lack sensory feedback
- Limited studies available on long-term effectiveness of sensory feedback and sensorimotor prosthesis control strategies

Approach

- Developed a low-cost prosthetic hand capable of sensorimotor control
- Motor control EMG pattern recognition
- Sensory feedback Contact reflexes, Electrotactile stimulation



Results	Visual Feedback	Blind- folded
Eggshells cracked (original myoelectric)	6/10	8/10
Eggshells cracked (our hand)	0/10	0/10
Volume displaced (original myoelectric)	19mL	73mL
Volume displaced (our hand)	12mL	19mL

We designed and implemented a low-cost prosthetic hand that can easily be integrated into standard sockets, facilitating long-term testing of sensorimotor control strategies for people with hand amputations worldwide.









Long-term evaluation of sensorimotor control strategies in transradial prostheses



Aadeel Akhtar

Results (cont.)

Video of eggshell and water cup grasping

Note: The video can be downloaded at https://www.dropbox.com/s/bdmcoj4oxds5edn/Akhtar-Aadeel FlashTalk.pptx?dl=0

To keep the master file size acceptable, I delete it, but feel free to e-mail for the complete file.

Intellectual Merit

- Test EMG pattern recognition algorithms and sensory feedback over 2 weeks to 6 months
- Subjects evaluated on performance in standard occupational therapy tasks
- important to understand usefulness of long-term sensorimotor prosthetic control
- Requires use of prosthesis that can record data from the prosthesis long-term

- 11.4 million people with hand amputations worldwide
- 80% from developing nations, <3% have access to prosthetic care
- Our hand will provide long-term sensorimotor prosthetic control solutions to people with hand amputations worldwide

A. Ozan Bicen, Postdoctoral Fellow, Inan Research Lab, Georgia Institute of Technology

Research Question

"Non-Invasive Monitoring of Left Ventricular (LV) Dysfunction for Heart Failure Patients"

 The responsibility of the LV is to pump oxygenated blood from the heart to the body.

Approach

 Wearable and unobtrusive sensing systems to complement implantable hemodynamic monitors

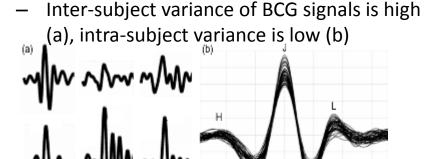


 The timing information for LV events in the cardiac cycle can provide key information regarding the overall health of the heart

Results

 Extraction of timing information from BCG waveform

Additionally, motion of the subjects would significantly distort the measured BCG signals

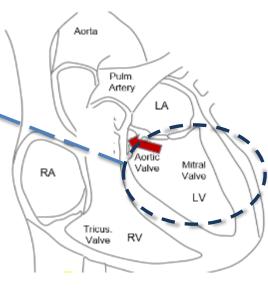








Bicen, A. O.

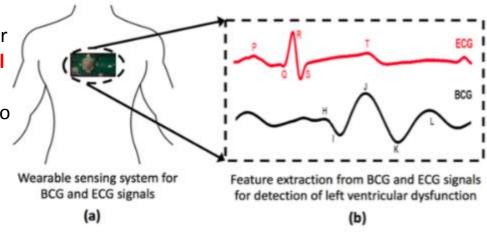






Intellectual Merit

- Objective: To develop robust algorithms for feature extraction by utilizing physiological relations between LV function and BCG signals, and by mitigating distortions due to
 - 1. subject-to-subject variability,
 - 2. motion artifacts,
 - 3. sensor placement errors.
- The data from heart failure patients will be used comparatively with the validated measurements from healthy subjects.







Wearable BCG



- This research effort is expected to bridge an important gap in the area of mobile health with regards to the clinically relevant assessment of the mechanical aspects of cardiovascular system using wearable, unobtrusive, and inexpensive systems.
- Example application for precision medicine: "In Home Monitoring of Heart Failure Patients"
 - Wearable sensing of key parameters in cardiovascular function such as contractility can enable proactive detection of condition worsening and personalized medical therapy for heart failure patients.

 Bicen, A. O.









Research Question

Can closed-loop deep brain stimulation (DBS) based on external sensors provide improved therapy for essential tremor?

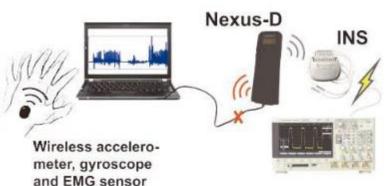
Approach

- Tremor detection from wearable acceleration sensors
- Integration with Medtronic Nexus-D interface to initiate DBS

Preliminary Results

- Real-time tremor detection with delay less than 250ms
- A stand-alone wrist band that can initiate DBS in response to tremor detection

Development of Closed-Loop
DBS Hardware Platform







Future Directions

- Compare clinical effectiveness of tremor detection based closed-loop DBS to open-loop DBS
- Examine improvement of battery life and side-effects

Intellectual Merit

Gathering the first critical information on the effectiveness of closed-loop DBS systems for essential tremor

- Improve the quality of life of essential tremor patients
- Transformative to other movement disorders, such as PD







Research Question



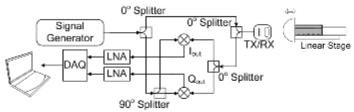
To develop a pulse pressure monitor with same accuracy level as BP device yet exceeds in a non-contact and continuous fashion.

Approach

- Doppler radar based physiological monitoring
- 1) Signal demodulation algorithm (chest wall displacement ≤100μm)
- 2) Integrated prototype design
- 3) Pulse pressure estimation algorithm
- 4) Evaluation and optimization (IRB approval)

Results

- Displacement order of mm
- Range 4-12mm, Error 0.01-2.63% (10μm)
- Range 0.1-1mm, Error 0.13-2.88% (10μm)







Intellectual Merit

- Easiness and comfort to care givers and patient
- Innovative device
 - Continuous monitor pulse pressure non-obstructively
 - Analysis on the trend of value change
 - Necessary judgement or prediction

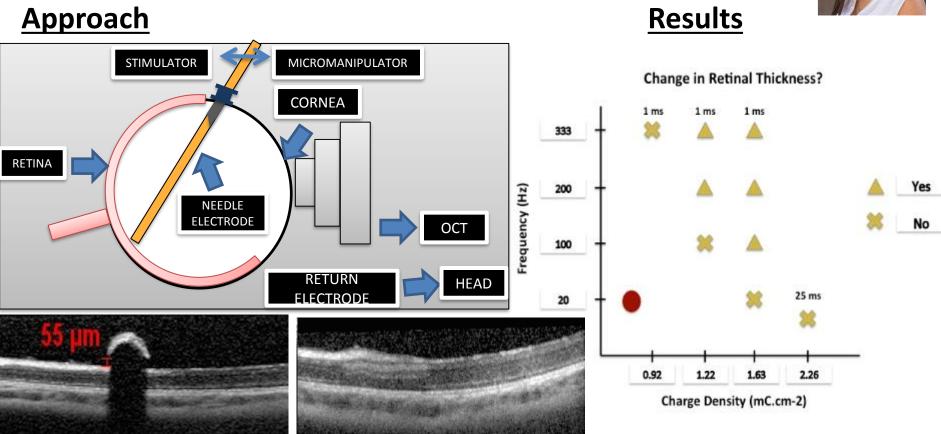
- Interdisciplinary studies (physiol., biomed., eng.)
- BP monitoring device industry
- Wireless and smart sensing (communication, sensor network)
- Remote sensing applications (vital, fall, occupancy, security)

Research Question

Effects of high charge density stimulation in the retina.







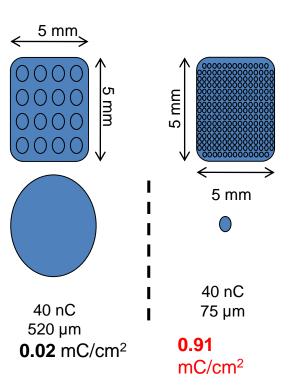
1.63 mC/cm2, 333 Hz for 30 min, 1ms Pulse - Biphasic

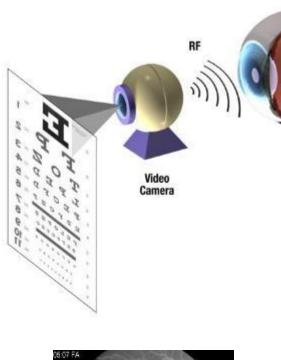


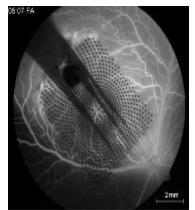


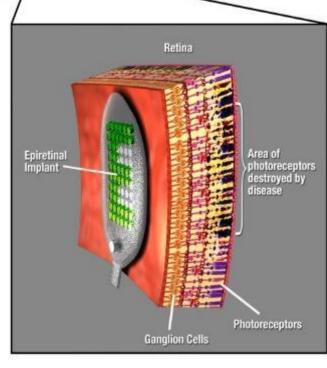
Retinitis pigmentosa (RP)











Implant

Department of Biomedical Engineering

UNIVERSITY of HOUSTON An In silico Model of the Effects of Vitamin D3 on

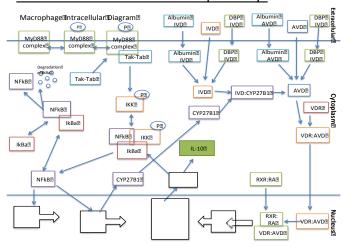
Mycobacterium Infected Macrophage Maya Gough and Elebeoba May*



Research Question: How does nutrient deprivation, specifically vitamin D₃ deficiency, effect the host's ability to defend against mycobacterium infection

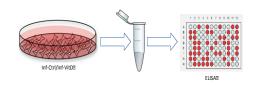
Approach:

Establish known mechanistic pathways

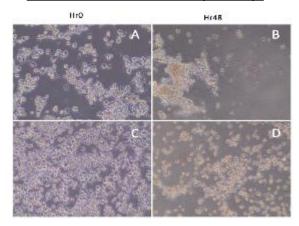


$$v = k_6[f][g] + \frac{vmax_h[h]}{K_7 + [h]}$$

$$v = k_1[a][c] + k_2[b][c] + k_3[a] + k_4[b]$$



Curate known mechanistic pathways



Intellectual Merit:

- Currently there does not exist a dynamic model that captures these interactions
- Previous models were specific to humans and/or limited by the availability of empirical data
- Our intracellular vitamin D₃ model overcomes many of these limitations Gough, M

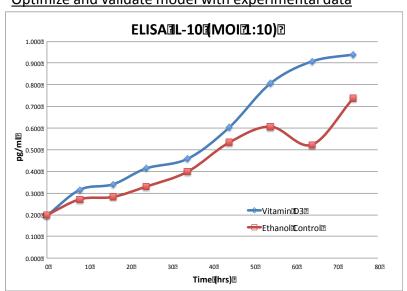
Department of Biomedical Engineering

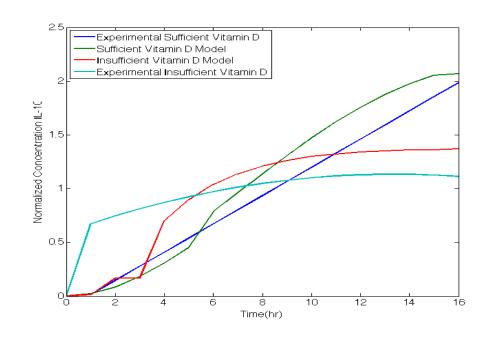
UNIVERSITY of HOUSTON An In silico Model of the Effects of Vitamin D3 on Mycobacterium Infected Macrophage Maya Gough and Elebeoba May*





Optimize and validate model with experimental data





- Mycobacterium tuberculosis: 9 million people infected, 1 million dead
- Many factors pertaining to patient health are overlooked, (ex: age, nutrition level, environment, cultural differences, diet...)
- Vitamin D₃ deficiency is tied to TB susceptibility and poor outcome of infection but is almost never taken into consideration when treating for TB; there is a strong need for more personalized treatment
- The results from our simulation can be used to provide a greater understanding of how vitamin D₃ deficiency can impact the immune system during infection, affording us the ability to create a platform for modulating immune response using nutraceuticles. Gough, M

EMBC'16 Orlando, FL USA

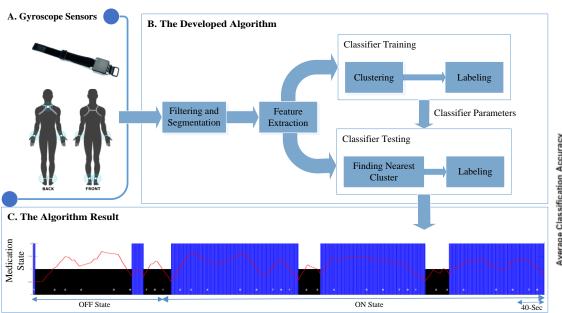






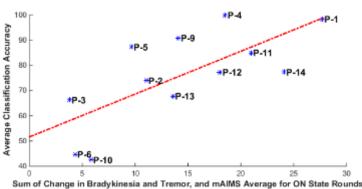
- Automatic assessment of medication states of patients with Parkinson's disease using wearable sensors
 - Patient-specific, activity independent classification approach, and without constraining patient's activities

Approach



Results

The Method	Wrist/T	runk/Leg	Sensors	Trunk/Leg Sensors				
	Acc.	Sens.	Spec.	Acc.	Sens.	Spec.		
Km_F	73.78	68.66	83.66	75.96	70.57	86.93		
Km_H	77.14	71.40	87.26	75.19	68.30	89.02		
$SOTM_F$	73.31	66.41	86.97	74.50	67.26	88.15		
$SOTM_H$	76.00	65.47	93.39	72.47	63.04	90.28		







Intellectual Merit

- The first attempt to develop a patient-specific and activityindependent algorithm to classify medication treatment states.
- Developing a multi-way data analysis approach where time-frequency representations of the ambulatory signals of the gyroscope sensors are simultaneously processed and novel time-frequency features will be extracted using tensor decomposition.

- The developed effective and low-cost algorithm can replace the frequency clinical exams and diary recordings allowing improved and patient-specific treatment of PD.
- It would significantly improve the treatment outcomes for the millions of patients afflicted with this neurological disorder.

Research Question

- Urinary incontinence is a debilitating condition that affects hundreds of millions worldwide.
- Can we develop intelligent algorithms and energy*efficient hardware*^{1,2} to improve diagnosis and treatment options for urinary incontinence, including conditional neuromodulation?

Approach

- Real-time, single-sensor vesicle pressure analysis w/ Context Aware Thresholding (CAT)1
- Implementation on low-power uC for retrospective analysis & prospective study with human subject

Results

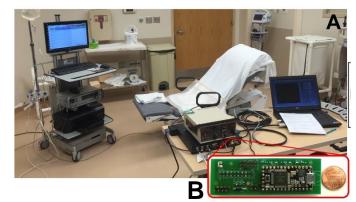
- 92% accuracy on prerecorded data w/ 1.4s lower avg. latency than human experimenter
- Conditional stim, inhibited unwanted bladder contractions & sig. incr. bladder capacity $(320 \pm 78 \text{ ml} \rightarrow 520 \pm 91 \text{ ml})$

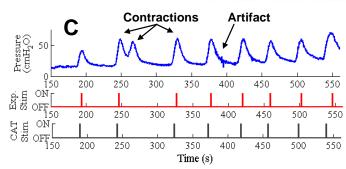












(A) Clinical urodynamics testing, (B) custom SW/HW platform for cond. neuromod. Testing, (C) example retrospective analysis

¹ R. Karam, et al. "Real-Time Classification of Bladder Events for Effective Diagnosis and Treatment of Urinary Incontinence," TBME, 2016.

² R. Karam, et al. "Ultralow-power Data Compression for Implantable Bladder Pressure Monitor: Algorithm and Hardware Implementation," BioCAS, 2016. [to appear]. Karam, R.





Intellectual Merit

- Exploring novel algorithms and hardware for real-time bladder event detection for improved neuromodulation
- Development / validation of a closed-loop neural control framework w/ custom hardware implementation of CAT
- Support for *ambulatory urodynamics* studies (w/ single sensor)
- Can be used for further investigation into the mechanisms of bladder control for different patient populations and to test hypotheses regarding nervous control of organ function

Broader Impacts

- Unique contribution to the field of urology and urodynamics;
 enables precise autonomous detection of meaningful bladder events
- It can have a profound impact on the diagnosis and treatment of LUT dysfunctions
- Data can be used by...
 - <u>physicians</u> → augment or replace existing diagnostic techniques
 - researchers → investigations into bladder physiology, mechanics, and control
 - pharmaceutical → testing new OAB medicines

This has the potential to significantly improve the quality of life for the >250M people with urinary incontinence







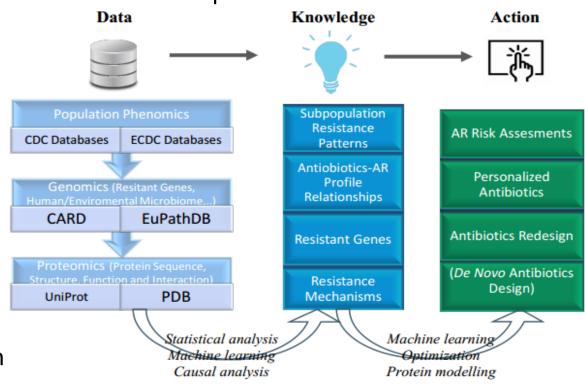
Multiscale Computational Tools for Antibiotic Resistance Big Data:

Patterns, Mechanisms, and Personalized Therapeutics

Approach

Results

- Disparate Data
- Ensemble learner
- Protein/Drug design







Intellectual Merit

- Antibiotic Resistance
 - Mine resistance patterns
 - Unravel resistance mechanisms
 - Suggest and redesign personalized antibiotics
- Big Data Analytics
 - Multiscale and disparate data integration
 - Integrated machine learning and causal analysis
 - Multi-objective and multi-constraint combinatorial optimization

- Prepare for, understand, and control antibiotic resistance
- Lower the direct and indirect cost
- Implications to drug resistance in general
- New applications and curated data for data scientists









How do we perceive speech?

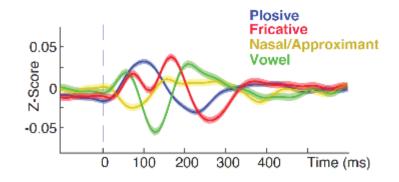
- Identify and model the neural representations of speech.
- Non-invasive methods are required for understanding auditory dysfunctions.

Approach

- Phonemes (e.g., /b/ and /t/ as in bake versus take).
- We use Electroencephalography (scalp EEG).
- Calculating time-aligned neural responses to phoneme instances as subjects listen to continuous speech.

Results

 Each instance of a phoneme in continuous speech produces multiple distinguishable neural events occurring as early as 50 ms, and as late as 400ms







Intellectual Merit

- Quantification of representational properties of speech using EEG.
- Effect of attention on representational properties.
- Comparison between people with auditory verbal hallucinations vs. healthy population.

- Speech development.
- Contexts where a listener learns new acoustic distinctions.
- Second language acquisition.
- Speech processing disorders.

Development of a Disposable Paper Based Ocular Biosensor for Monitoring Post-Surgical and Post-Traumatic Eye Condition

<u>M. S. Khan</u>, S. Misra, A. Duval, E. Daza, F. Ostadhossein, M. Bowman, G. Taylor, D. McDonagh, L. T. Labriola and <u>D. Pan</u>*. *Department of Bioengineering, MatMed Laboratory for Materials in Medicine.** dipanjan@illinois.edu

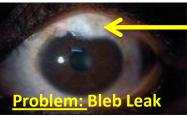


Research Question

- 41-45% of patients who suffer from wound leak infections will have a severe vision loss...
- In 2005, 66,533 of these procedures were performed which cost ~\$1.2 billion as per Medicare database.
- 59% of eyes with filtering surgery resulted in wound leaks and 14% suffered from post-operative infection.











Approach Point-of-Care Label-Free , highly sensitive and low cost handheld Ocular Biosensor to detect

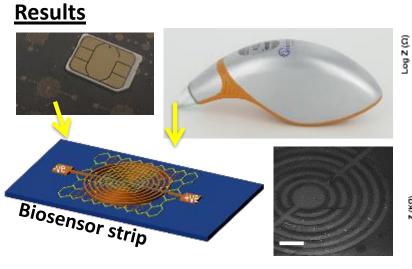
wound leakage using a tiny drop of Tear film.

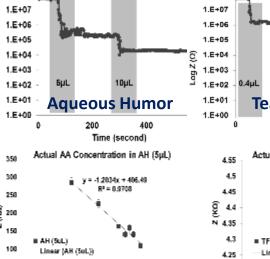
1.E+08

-AH on Blosensor

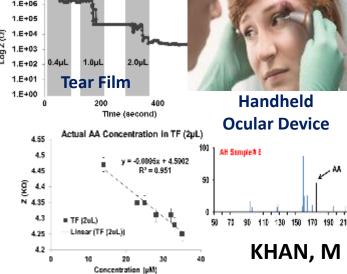
1.E+08

-TF on Blosensor





Concentration (µM)







Intellectual Merit

- To identify problems earlier and more efficiently to prevent further complications from wound leaks, including infection and chronic low pressure in the eye of failed surgery.
- Successfully tested TF samples collected from healthy volunteers and found the efficiency and sensitivity of the Ocular Biosensor device.
- Transformation of current standard of care for eye professionals and enable physicians to have an objective measure that can warn them about possible wound leaks at POC level.
- Future usage at different collaborative locations for data reproducibility.

- To standardize post-wound evaluation, treatment and improve the standard-of-health-care.
- Requirement of the sensor would be high as new sensor strip would be required at each test for a patient required post-operative monitoring visit.
- Estimating seven appointments per year for twenty percent of the surgical market (13,400) would be 93,000 tests for new patients each year with additional 20% for return patients would place the sales for the disposable sensors at \$2.2 million dollars each year.
- Ocular device could also play a significant role to other anterior ocular incisions including monitoring of post-cataract (3.6 million surgeries/year in the US) or post-corneal surgeries (50,000 surgeries/year), which would drastically expand the market.

 KHAN. M















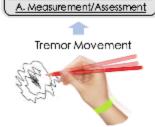
Research Question

- Tremor suppression techniques → invasive, bulky, and lack of efficacy
- Tremor Assessment → qualitative and subjective

Approach

- Develop a *real-time closed-loop* **tremor modulation** using peripheral nerve stimulation
- Analyze tremor movement using a quantitative tremor assessment



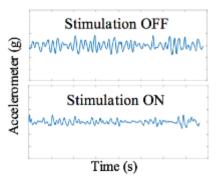


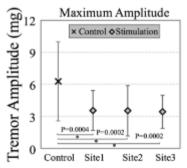


C. Parameter Optimization Stimulation Parameter

Real-time Closed-loop Tremor Modulation & Quantitative Assessment

Results





- Dominant *frequency* & maximum amplitude was significantly reduced by peripheral nerve stimulation

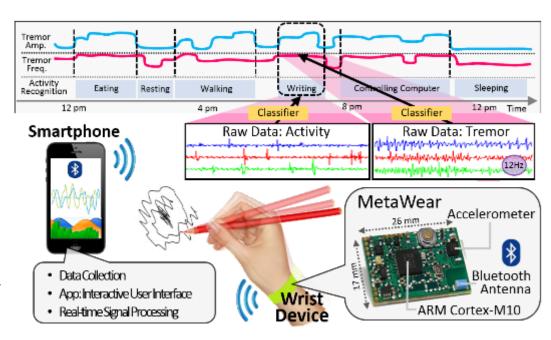




Intellectual Merit

- what kinds of effects can be made by the peripheral electrical stimulation for the physiological tremor pathway
- how the peripheral stimulation can modulate the tremor movement

- Wearable easy-to-use tremor suppression
- Identify the effects of peripheral feedback on tremor
- In-home tremor assessment & tracking system
- Accurate diagnosis
- Determine & track the effects of current treatment/medication regimens



Overview of long-term tremor suppression and assessment

Research Question

- In medicine, *promptly* leveraging massive physiological waveform time series archives (> 10TB) is a key challenge
- Can we do fast, yet accurate "patient like me" retrieval?
- How can waveforms from patient "neighborhoods" be used for prediction?

Approach

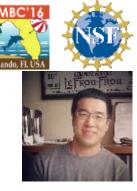
Similar Subset Generation through Locality-Sensitive Hashing (LSH)

- Extremely fast approximate nearest neighbor (NN) search
- Pre-index the data into distance-preserving hash tables
- Query only over the reduced search space within the colliding hash bucket

Results

LSH vs. *k*-nearest neighbors, tree-based exhaustive search:

- Up to two orders of magnitude faster prediction time
- < 1% decrease in accuracy on non-critical false alarms only</p>
- Trivial increase in memory cost (< 10MB)







Intellectual Merit

- Novel end-to-end design and implementation of LSH-based NN search system over multi-dimensional physiological time series
 - New data representation for effective noise removal
 - Hash family design for multiple distance functions
 - Easy-to-use, extensible experimental framework
- Platform for further quantitative evaluation
 - Waveform correlation
 - Multi-class clinical event prediction
 - Binary anomaly detection
 - Automatic cohort sets via LS hash table

- Heterogeneous, high-frequency time series data is continuously acquired at unprecedented volume and velocity
- We provide a "Theory to Practice" exemplar in data-driven, smart healthcare
- Broader applicability to other time series settings such as IoT







t = 180 s

Research Question

To develop a portable point-of-care imaging devices to reliably measure peripheral blood perfusion maps, i.e. the perfusion of blood underneath the skin surface.

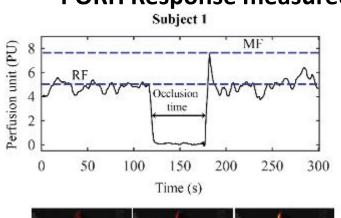
Approach

PulseCam is a new multi-sensor modality which combines a video camera and a pulse-oximeter in a unique way to produce low-noise and high-resolution peripheral blood perfusion maps.

PORH Response measured using PulseCam

Results

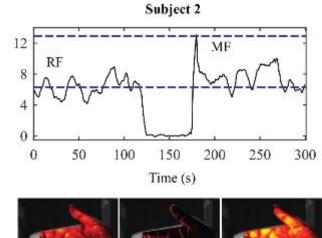
PulseCam produces blood perfusion maps with 0.5 - 3 dB higher SNR per pixel block compared to the state-of-the-art technique that only relies on cameras.



t-150 s

t-50 s

t-180 s



t = 150 s

t=50 s





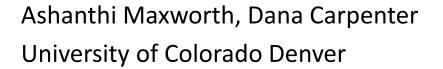
Intellectual Merit

- 1. Algorithmic Innovation: Robust signal recovery, motion tracking, and motion artifact reduction algorithm
- 2. System Evaluation: Evaluate for people having different skin tones, under varying lighting conditions and presence of involuntary motion
- **3. Peripheral perfusion imaging dataset:** Peripheral perfusion imaging dataset of healthy controls and patients suffering from peripheral vascular disease

- 1. POC Device: PulseCam has the potential to become a point-of-care (POC) peripheral perfusion imaging device which can be used to measure blood perfusion in wounds and to diagnose peripheral vascular disease, particularly for disadvantaged and underprivileged population.
- 2. Critical care: Multi-camera PulseCam system can be installed at the bedside in the ICU to access blood perfusion simultaneously in different peripheral organ like palm, foot, face, abdomen etc which can be used to predict shock.

 Kumar, Mayank

Can Texture Predict Bone Fractures?









Methods:

Following methods were considered in this study;

- 1. Bone Mineral Density (BMD)
- 2. Moment of the image about the image center
- 3. Gray scale Shannon and Renyi entropy
- 4. Discrete wavelet transformed image entropies
- 5. Continuous wavelet transformed image entropies.

Research Issue:

- Osteoporosis and fracture are major health issues in the world.
- Currently the quality of a bone is determined most commonly by bone mineral density (BMD).
- Recent results show that the BMD itself is not sufficient in determining bone quality.
- Texture of a bone also plays a major role.
- Hence for accurate prediction of fracture,
 BMD measurements should be combined with a measure of texture.





Decision Making Criterion:

Criterion	Decision
High BMD & even texture	Risk Free
High BMD & uneven texture	Potentially at risk
Low BMD & even texture	Potentially at risk
Low BMD & uneven texture	At risk

Societal impact and scientific merits:

- 1. non-invasive
- 2. Painless
- 3. High in accuracy
- 4. First time hybrid implementation of DWT and CWT and multiple entropies.

Pre	liminary	Results:
1 1 0	iiiiiiiii ai y	itesaits.

Imag e	BMD	Mome nt	Entropy 1	Entropy 2	Entropy 3	Entropy 4	Entropy 5	Entropy 6	Entropy 7	Entropy 8	Entropy 9	Entropy 10	factor	Decision
1	369.107	0.0156	6.2022	5.9531	1.094	1.0346	0.7893	0.6466	1.0838	1.0219	0.9579	0.8421	4 out of 11	High BMD, Uneven texture
2	268.062	0.0119	5.9411	5.7104	1.1121	1.0432	0.8095	0.6755	1.0996	1.0246	0.9237	0.792	4 out of 11	Low BMD, Uneven fexture
3	259.094	0.0145	5.0237	4.7829	1,194	1.0772	0.7684	0.6176	1.0739	1.0193	0.9364	0.8171	8 out of 11	Low BMD, Even texture
4	225.267	0.0146	5.4106	5.1689	1.1211	1.0369	0,7871	0.6435	1.0919	1.0229	0.8742	0.7168	7 out of 11	Low BMD, Even texture
5	301.340	0.0116	5.8782	5.6492	1.1024	1.0362	0.7878	0.6246	1.057	1.015	0.9935	0.9171	7 out of 11	High BMD, Even texture
6	254.409	0.0106	5.5318	5.351	1.1136	1.0399	0.7771	0.628	1.0657	1.0169	1.0025	0.9377	9 out of 11	Low BMD, Even texture
7	317.949	0.0131	5.6797	5.4937	1.1138	1.0391	0.8166	0.6859	1.077	1.0204	0.9531	0.846	6 out of 11	High BMD, Even texture
8	345.213	0.0083	6.121	5.8982	1.0942	1.0333	0.7964	0.6264	1.0615	1.0155	1.007	0.9419	6 out of 11	High BMD, Even Texture
Avg	292.55	0.0125	5.72353	5.50092	1.11815	1.04255	0.79152	0.64351	1.0763	1.01956	0.95603	0.851337		

Future Work:

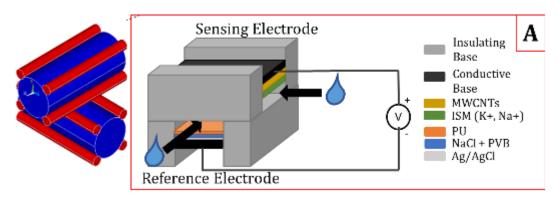
- Suitability in Fracture risk prediction
- Determine critical threshold values based on observations.
- Model optimization

Research Question



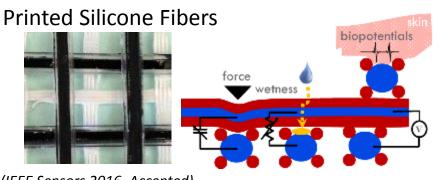
Fiber-based Potentiometric Ion Sensors for Textile Embedded Remote Patient Monitoring

Approach



- Fibers form:
 - Ion Selective Sensing Electrode
 - Reference Electrode
- Electrowetting draws fluid in
- Textile-array Integration

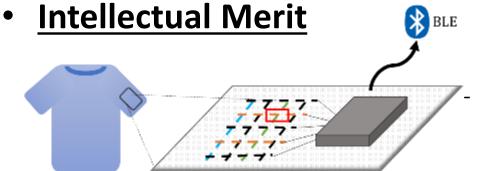
Results



Evaluation of Fibers:

- Electromotive force produced at different ionic concentrations
- Effect of strain/fiber spacing







- New data correlations between multiple factors such as ion concentrations, sweat levels, and heart rate.
- Indicate when urination, bleeding, sweating have occurred and to what extent.
- Enables novel sensor geometries not limited to wearable systems.

Broader Impacts

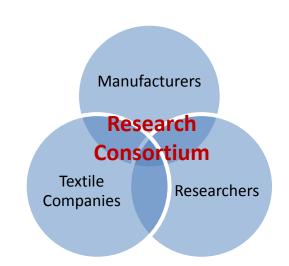
- Uses standard textile integration methods.
- Application-specific textiles

Open-source platform for textile designers, hobbyists, engineers.

Pressure/Wetness Fiber Potentiometric Ref. Fiber

Na+ ISM Fiber K+ ISM Fiber





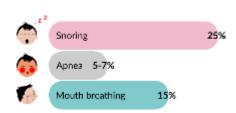
CLEBRE

Advanced system to measure sleep-disordered breathing



Research Question

How **to increase the number** of children and adult properly screened and diagnosed for sleep-disordered breathing **before and after treatment**?



Approach

Convenient and innovative globally set of a **small wireless sensor** with a smartphone and server applications.

Ability to measure various parameters, from **HR** (Heart Rate) to **AHI** (Apnea- Hypopnea Index) or **RDI** (Respiratory Disturbance Index).

Automatic algorithms for segmentation, parameterization and classification to analyze the data **online** and stream the **analysis report** into applications.

O SINHAD PARK



Results

Preliminary measurements were performed in a group of more than 100 participants. We evaluated the breathing episodes from 40 whole-night recordings and obtained 88.2% of overall accuracy.

We also checked fifty 90-second-lasting measurements of oral and nasal breathing and gained 95.76% of accuracy using individual classifiers.

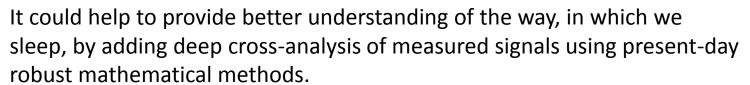


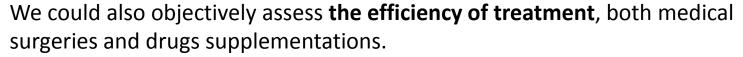




Intellectual Merit

Complex cardiorespiratory solution with motion tracking, intended for **home sleep studies**, which will be qualitatively and functionally similar to **polysomnography**, gold standard.









Broader Impacts

Affordable diagnostic solution for users, with the possibility to detect apneas, snoring and monitoring airways **at home**, with **high accuracy**, with only one sensor, placed in a **comfortable** way, and which is cheaper and more accessible.

Emphasis the need to measure sleep-related signals not once, but using multi-night-recording strategy.

Scientific integrations with other modalities; and/or **commercial fusions** with health services and medical devices.







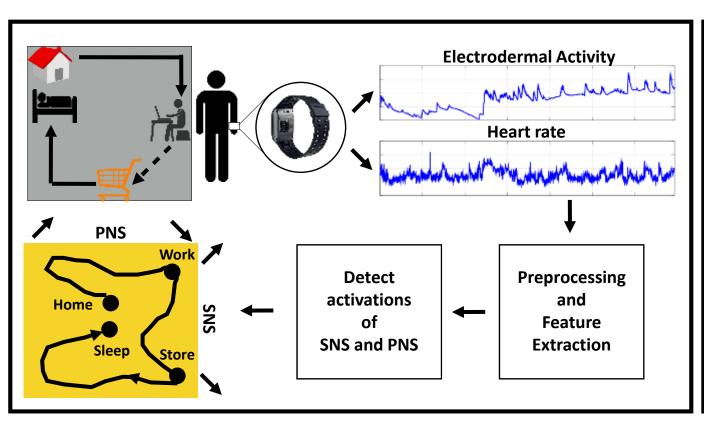
Can we characterize user experiences by studying the contributions of Autonomic Nervous System using Wearable sensors?



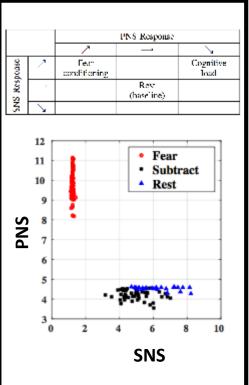




1. Approach



2. Preliminary Results



Significance and Future Impacts



3. Intellectual Merit

- Provide tools and techniques to map everyday experiences onto the 2D SNS-PNS plane
- Mapping user experiences relative to known baseline tasks, similar experiences from same or other users
- Novelty lies in estimating individual contributions of SNS and PNS divisions using machine learning models

4. Broader Impact

- Detect stressful experiences
- Educators use this mapping to track students' status (e.g., cognitive load when solving problems and learning new concepts)
- User responses to content (e.g., individual scenes in films)

Proposal for a non-invasive continuous and real-time device for cardiovascular assessment

Cardiovascular Diseases (CVDs)







Approach

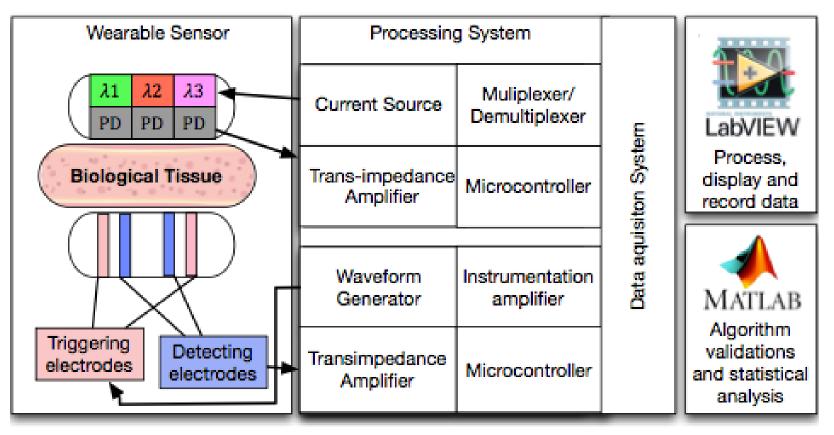
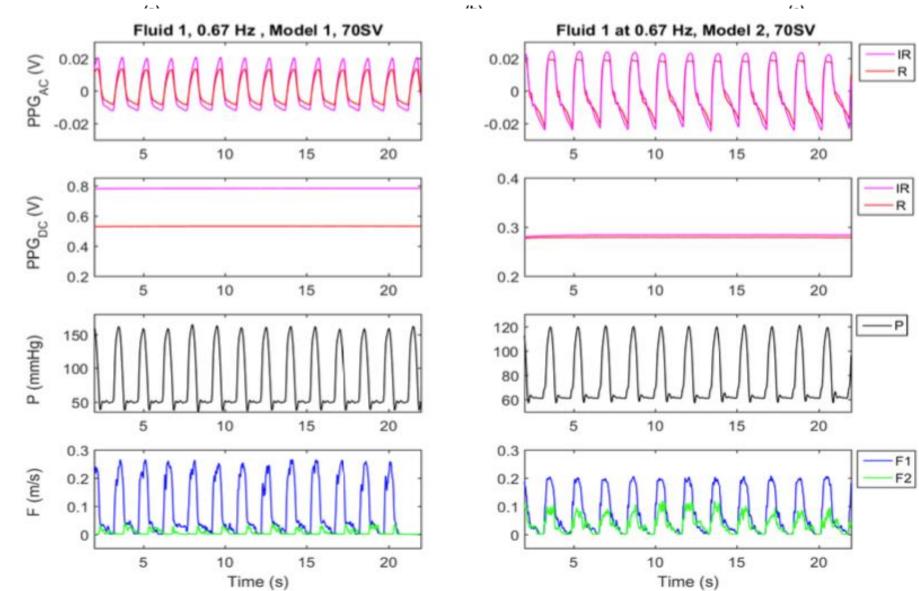


Figure 1. A block diagram of the proposed wearable device system, showing the optical components and electrodes of the wearable sensor, the proposed processing criteria and data flow into a virtual machine.

Results





Njoum, Haneen





Intellectual Merit

Broader Impacts

- Patients: Empower Individuals to monitor their health reliably and accurately and avoid further complications with an early alert.
- Patients: Rid patients and their beloved ones from stress and concerns about the "unpredictable danger".
- Clinicians: Less surgeries and unnecessary checks.
 Pharmacological and non-pharmacological treatment control.
- Governments/Healthcare Providers: Reduce costs associated with further complications of CVDs

Motor Evaluation Database for Parkinson's Disease Research

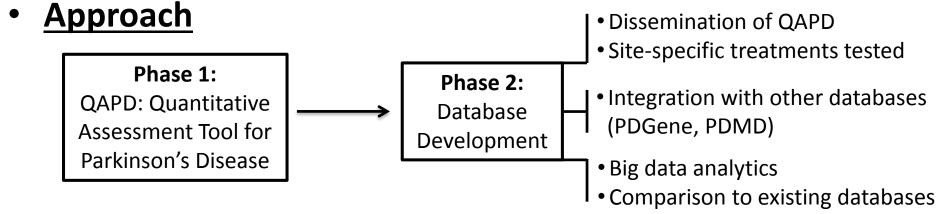






Research Questions:

- 1. Should the database be more versatile (upper limb kinematics + EMG, structured tasks) than existing ones (wrist kinematics, continuous data collection)?
- 2. Can a motor evaluation database, in conjunction with big data analytics, help integrate PD research?



Results

- QAPD: clinically feasible, able to track motor deficits, structured file formats for database
- Preliminary data analysis supports using multiple tasks types and multiple sensors

Patel, V.





Intellectual Merit:

- Structured approach to 'big data'
 - Disease stages characterized by brain scans and/or motor symptoms
 - Success of DBS implanted at varying disease stages
 - Writing samples corresponding to damage in different neural circuits

Broader Impact

- Improvement in diagnostic test (identification of potential biomarkers)
- Improvement in PD treatment plans
 - Which medications are optimal for an individual?
- Understanding neuropathology of PD

Design of a Bio-Inspired Pneumatic Artificial Muscle with Self-Contained Sensing

Onder Erin, Nishant Pol, Luis Valle, Yong-Lae Park; EMBC 2016

Research Question

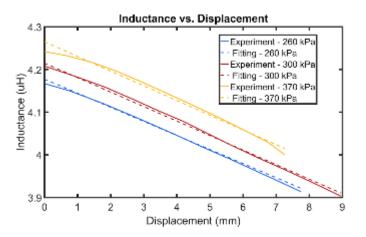
How can the displacement and axial contraction force for a McKibben pneumatic artificial muscle be measured while maintaining the compliance of the actuator?

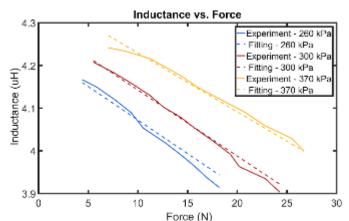
Approach

Inductive Sense Coil:

- Wire wrapped around actuator
- Secured to actuator with silicone

Results





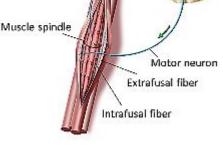












Sensory neuror

Pol, N





Intellectual Merit

- Compliant alternative to rigid pneumatic actuators
- Sense coil can be installed on many PAM implementations
- Linear behavior allows for application of many control methods

Broader Impacts

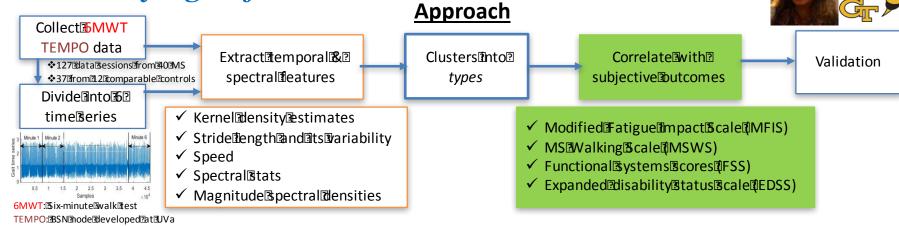
- Improve safety with compliant mechanisms
- Viable actuator+sensor choice for orthotics and prostheses

Future Work

- Dynamic characterization, Closed-loop control
- Improve manufacturing, enhance reliability



Detailed characterization of gait of multiple sclerosis patients using temporal and Hilbert spectral features for identifying objective markers of the disease

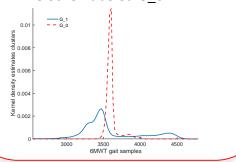


1. GAIT PROBABILITY DENSITY ESTIMATES CLUSTERS

T25FW:@Timed@25-foot@walk

cps:@cycles/second

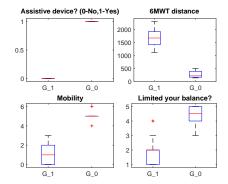
- The two distinguishing features, namely, the height of the first peak, & the sample value at which the first peak occurs
- Two typical clusters found, one labeled
 G 1 while other labeled G 0



Results

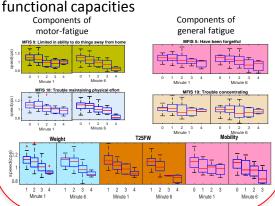
2. CORRELATION OF DENSITY CLUSTERS PEAKS WITH CLINICAL DATA

 Peaks of density estimates correlates with disability measures including MSWS, MFIS and walking-test based clinical measures.



3. RELATIVE ASSESSMENTS

- Variations in speed correlated to physical disability
- More noticeable for patients who reported fatigue had high impact on their functional capacities





Detailed characterization of gait of multiple sclerosis patients using temporal and Hilbert spectral features for identifying objective markers of the disease



Intellectual Merit

- Identifying new objective labels and types
 - Indication of possibly missing information or current labels being insufficient
- Exploiting non-stationary properties and spectral features of the MS-affected gait time series
 - Modified an existing transform, the Hilbert-Huang transform, and used it to extract spectral
- Event-based feature extraction
- Relative assessments to enable personalized studies
- Relationships between gait variables and PROs
- Leverage longitudinal data

Broader Impacts

- Making gait analysis a regular part of health and wellness monitoring
- Possibility of adapting the methodology for other related debilitating conditions
- The advances in personalized signal processing could be applicable to domains that can leverage relative assessments

Research Description



 Research Question: This research aims to explore the connectivity features of the epileptic functional brain networks in order to enhance the disease understanding and improving the diagnosis and treatment.



- Approach: Phase synchronization among scalp electrodes are helped to calculate the functional connectivity networks.
 Extracted connectivity features are utilized to characterize the disease biomarkers or used for classification.
- Results: Functional connectivity networks was successful to differentiate healthy subjects from epileptics with accuracy of 92.8% in the test population of 14 children and it was successfully used to characterize focal epilepsy biomarkers versus generalized.
 Rajaei, H.





- Intellectual Merit: This study will outline a reliable methodology that overcomes the obstacle of subjective epilepsy diagnosis. The functional connectivity analysis will highlight the hidden characteristics of the disease. This method will help physicians to determine a better assessment of various treatments.
- <u>Broader Impacts:</u> The method would help the disease diagnosis in non-invasive, less expensive and in a shorter time while helps more accurate treatment and makes the patient to suffer less in case surgery is prescribed.

Research Description









Research Question

What specific aspects of *non-verbal human-to-human communication signals* are being evaluated by different individuals (e.g. neurotypical and ASD) during emotion perception? How does changing their presence or intensity modulate the perception judgment?

Approach

We employ virtual agents in a VR environment to (1) assess neurotypical individual's semantic evaluations of and physiological reactions to non-verbal affective behaviors, and (2) build an evaluation testbed to explore how different individuals use the different (in type and intensity) non-verbal behavior cues in their emotion perception judgments.

Results

We created a non-dynamic human-computer interaction while manipulating three specific non-verbal channels of communication: gaze pattern, facial expression, and gesture. Assessment of the behavioral data revealed a significant and complex three-way interaction between non-verbal configurations on the affective dimensional scales (pleasure, arousal, and dominance).





Intellectual Merit

This research will advance previous social psychology and affective computing research on interpersonal dynamics and social affective semantic evaluation by:

- (1) capitalizing on several advantages of VR environments;
- (2) building affective state inference models based on the statistical analysis of self assessments and physiological measurements in an active learning framework;
- (3) developing a testbed for evaluating the effect of non-verbal behaviors in emotion perception ability.

Broader Impacts

Health-related societal impacts: (1) increase our understanding of typical human-to-human interactions; (2) eventual rehabilitation of individuals with social disorders, including children with ASD.

STEM education enhancement: (1) summer internships for high school students; (2) undergraduate design projects; (3) interdisciplinary graduate research environment.

Efficient On-Chip Classification for Resource-Constrained Biomedical Applications

Motivation

- On-chip classification is an essential element of implantable biomedical devices
- Power/area constraints limit the integration of conventional algorithms such as SVM, KNN, ANN, etc.
- How to implement simple, yet sufficiently accurate classifiers on chip?

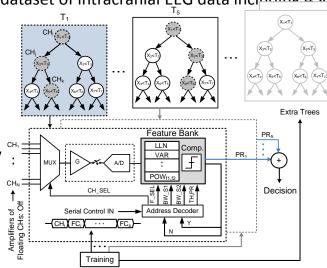
Approach

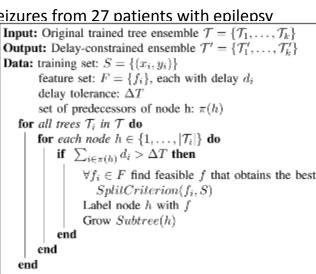
- Gradient-boosted decision trees (DTs) achieve a reasonable trade-off between detection accuracy and hardware cost (EMBC16)
- Only simple comparators form their building blocks, eliminating the multiplication operations

• Proposed method verified on a large dataset of intracranial EEG data including 430 seizures from 27 patients with epilepsy

Results

- Boosted trees are competitive models, with
- A generic decision tree architecture integration
- One feature bank can be sequentially saving
- A greedy algorithm is proposed to constraint





Shoaran, M

Intellectual Merit

- Useful in diagnosis of neurological disorders
 - -- Guide early treatment: biofeedback, medications, or electrical stimulation
- Intersection of electrical engineering, neuroscience and machine learning
- Yield important insights for other scientists engaged in related research activities

Broader Impacts

- Primary focus: neurological disorders such as migraine, dementia, and epilepsy
 - -- Major concerns of the modern world, placing a heavy economic burden on the society
- The results will potentially apply to similar biomedical applications
- The developed circuits and algorithms will be used in ongoing collaborative projects between Caltech, UCLA, and the Huntington Medical Research Institute
- Actively involve other graduate students in research and publication and contribute to their technical training

Shoaran, M

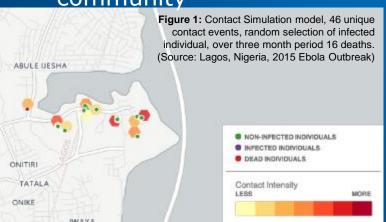
mHealth can improve our ability to predict and prevent emerging diseases

Research Question:

 How can mHealth studies expose neurodevelopment issues from Zika and other emerging diseases, and can engagement be maintained at scale?

Approach:

 Development of an enhanced mHealth application, with symptomology for infectious diseases (including Zika), deployed amongst the CDC pregnancy registry and community



Results:

- Abiola, S. O. et al. Node view: a mHealth real-time infectious disease interface-2014 ebola outbreak case study. UbiComp/ISWC'15 Adjunct Proceedings 297-300 (2015).
- Node: Combating Ebola and Beyond in Real-time Using Smartphones, 1st Annual Rochester Global Health Symposium, Rochester, NY, (2015).

Solomon Abiola (co-PI) http://www.joinnode.com/@eWizard2_0 solomon.abiola@chet.rochester.edu
NSF 1516340 MEDICINE of THE HIGHEST ORDER







The is the ability to engage in real-time preventative and predictive precision medicine

Intellectual merits

- Use retinal images aided by computer vision to asses reports of conjunctivitis
- Use neurodevelopmental questionnaires to asses ZIKV effects on childhood development

Broader impacts:

- mHealth can overcome socioeconomic and geopolitical barriers,
 which hinder larger scale emerging infectious disease surveillance
- Basic science approaches of computer vision and machine learning improve our preventive capabilities to fight disease in realtime

55

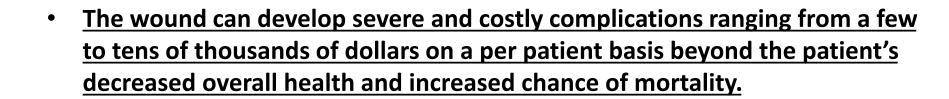


Research Description



 Infections arising in wounds (surgical or pressure sores) are one of the most common problems faced by healthcare patients

- If the patient's wound and dressing are not:
 - Monitored properly
 - Cared for at the right time
 - Given the correct treatments



Particularly stubborn skin ailments







Pressure Ulcers



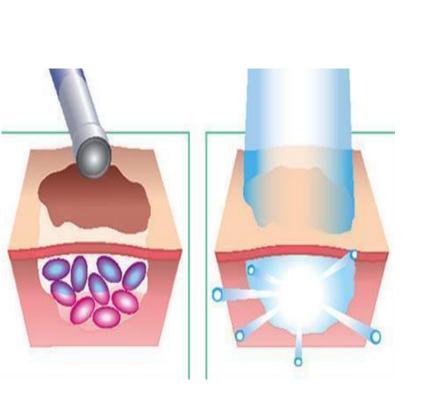
Surgical Wounds

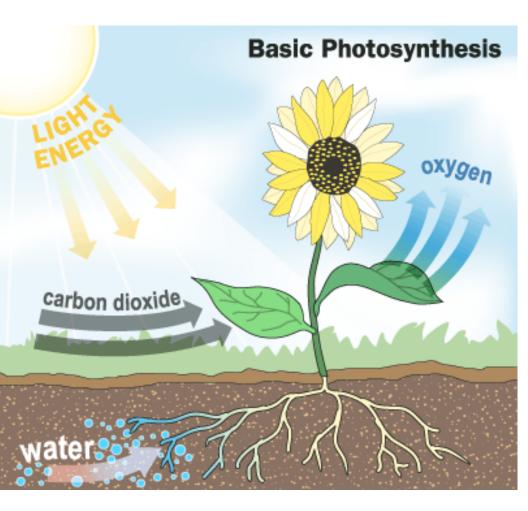


Polarized light therapy









Skin Cell Plants

Light therapy applied





Acne



Pressure Ulcers



Trauma Wounds





Benefits extend to:

- Healing wounds
- Treating pain
- Skin: acne, herpes, allergies
- Wrinkles, skin mistreated
- 1st degree burns
- Infected wounds
- Inflammatory process
- Ulcers
- Healing pathological
- Surgical injuries

Light therapy LIMITATIONS





The DEVICE

- · Large, bulky, rigid
- Preformed by doctor
- No infection detection

The PROCESS

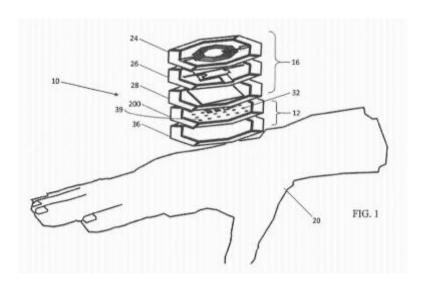
- Long treatment sessions
- Preformed in hospital
- Light source logistics

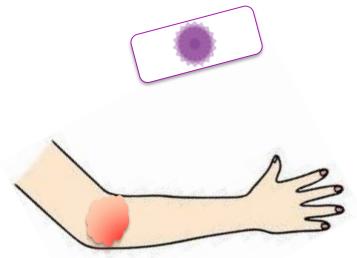


The MicroViolet Patch













Current features

- Re-usable bandage
- Micro LEDs
- Wireless power
- Data Transmission
- Embedded Bio Sensors
- Ultrathin bandage







Intellectual Merit

- 1. Accelerate the wound healing process by providing controlled light exposure
- 2. Monitor the healing process for signs of infection
- 3. Use E-stimulation as an effective adjunctive therapy to reduce bacterial load and clinical infections.
- 4. Eliminate bacterial infections by sanitizing the infected site using UV light.

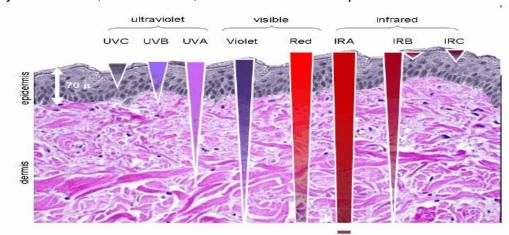
Thus enabling us to realize its mission of making light therapy as easy as putting a bandage.





Broader Impacts

- Light therapy treatments involve constant trips to the hospital
- Hospitalization time is the main cost driver for wound care for the system.
- Reduce the overall hospital stay length and cost.
- By using controlled micro UV/LED therapy we can reverse the appearance of aging skin, enlarged pores and crow's feet with a light wave that penetrates far beneath the surface of our skin without causing any damage. It also pulls collagen to the surface to fill-in lines and wrinkles.
- Sanitizing process
 - UV light itself wound sanitizing self- adhesive bandage
- Improve healing process
 - Light treatments at various wavelengths have been shown to increase significantly cell growth in a diversity of cell lines, muscle cells, and normal human epithelial cells.



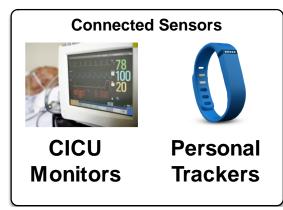
A smart & connected system for early cardiac arrest detection

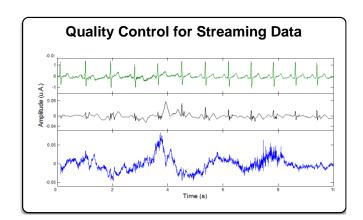


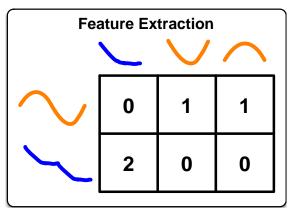




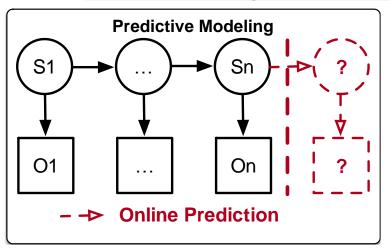
Approach

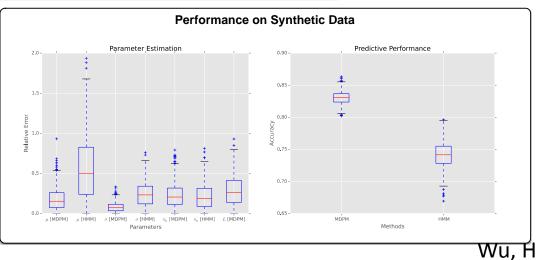






Preliminary Results: HMM and its variants





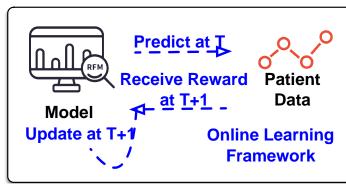




Intellectual Merit



System Design: building an integrated monitoring system for continuous recording **Application scenarios:** both alert at home, and in CICU – training with integrations of data



Data Analysis:

- Novel and interpretable feature extraction
- An online learning framework, useful for constant and personalized monitoring

Broader Impacts

- Can help transform current cardiac disease treatment to more preventive and more evidence-based
- Can be applied to other monitoring scenarios seamlessly

Research Description









Research Question

Wearable, Wireless Vital-Signs Monitor for Athletes

Approach

- Seismocardiograph (SCG) based on MEMS IMU sensor
- Blood Pressure from PTT measurement based on SCG and inear sensor

Results

- Motion artifact cancellation of SCG (EMBC'16, J. Sensors'16)
- ECG-free annotation of SCG (BioCAS'16)
- PTT measurement from proof-of-concept set up (BioCAS'16)







Intellectual Merit

- SCG signal acquisition and processing with motion noise reduction of SCG during extreme movements
- Standardization and ECG-free auto-annotation of SCG
- Cuff-less blood pressure assessment from PTT using SCG to in-ear sensor signals
- Specific cardiac disease detection/screening based on SCG and BP metrics

Broader Impacts

- Reduce sudden deaths of athletes during or after competitive sports
- A low-cost pre-screening method prior to using expensive techniques for detecting cardiac diseases
- Low-cost, wearable, daily monitoring system for high-risk patients
- Cardiac monitoring system for low-resource areas such as developing countries

Research Description



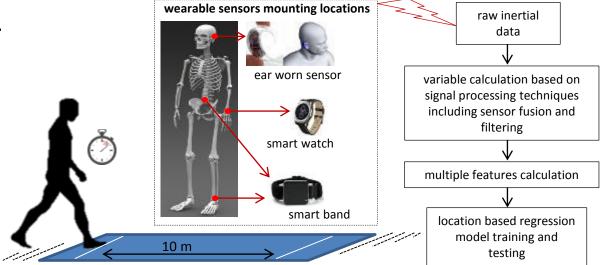


Research Question

 Free-Living walking speed estimation in older adults using a single body-worn sensor



Approach



Results

 When using Gaussian process regression, walking speed estimation accuracy for the ankle and waist positions is about 5 cm/s.





Intellectual Merit

- Development of a technology for longitudinal measurement of the walking speed in older adults
 - Based on signal processing and machine learning
 - Using a single inertial sensor
 - Optimized for various mounting locations
- Helps doctors to predict neurodegenerative disorders

Broader Impacts

- Benefit the society of older adults by a cost-effective tool for early detection and timely intervention of neurodegenerative disorders
- Fostering independent living
- Improving quality of life