

# CWSPI'20



<https://cwspi.cs.ucy.ac.cy/>

## 13<sup>th</sup> Cyprus Workshop on Signal Processing and Informatics

### FINAL PROGRAM AND BOOK OF ABSTRACTS

via Google Meet at the following link:

<https://meet.google.com/ger-mtbz-xrr>

18:45-22:00, September 21<sup>st</sup>, 2020

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## 13<sup>th</sup> Cyprus Workshop on Signal Processing and Informatics (CWSPI)- 2020

### **Preface:**

Following the successful one-day workshop hosted over the past 12 years, we would like to cordially invite you to participate in the upcoming 13<sup>th</sup> Cyprus Workshop on Signal Processing and Informatics (CWSPI 2020).

The overall objective of CWSPI 2020 is to disseminate new research findings in the areas of signal processing, image processing, analysis and informatics. Over the years, CWSPI has grown to become the primary forum of Cyprus' graduate students to present their latest research endeavors. Moreover, this one-day workshop hosts presentations by faculty and industry researchers serving a key mission of CWSPI, towards establishing strong industry – academia and multi – university collaborations. This year's efforts are further embraced by Cyprus' newly founded Research Centers of Excellence, namely RISE CoE and KIOS CoE, constituting CWSPI an ideal event for sharing new knowledge while building effective research networks.

We would like to express our sincere thanks to IEEE Cyprus Section, the IEEE Engineering in Medicine Biology and Signal Processing Societies (EMBS & SPS) Cyprus Chapters, the IEEE CIS Cyprus Chapter and the IET Cyprus Network for their support and sponsorship.

This year the event will be carried out via Google Meet, given the current situation with the pandemic.

Wishing you a fruitful and joyful event.

*M. Neofytou, A. Panayides*  
September 2020

### **Topics:**

- Digital signal and image processing
- Interactive Media, Virtual Reality and Augmented Reality Systems and Applications
- Speech, and audio, processing
- Intelligent and Cognitive systems
- Sensor networks and signal analysis
- Biomedical signal, image, and video analysis
- Wireless communications and signal processing
- FPGAS in signal, image and video processing.

Workshop Organizing Committee	
<b>Chair</b>	A. S. Panayides, University of Cyprus, Cyprus
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<b>Program Chair</b>	C. P. Loizou, Cyprus University of Technology, Cyprus
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<b>Webpage:</b>	<a href="http://cwspi.cs.ucy.ac.cy">http://cwspi.cs.ucy.ac.cy</a>
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## Technical Program

TIME	SESSIONS
18:45	<b>Introductions</b>
18:55-19:00	<b>Welcome</b> <i>Andreas Spanias</i> Arizona State University, USA
	<b>SESSION 1: IoT and Sensing</b> <i>Andreas Spanias</i> Arizona State University, USA
19:00-19:10	<b>Energy Efficient Reuse of Mobile Nodes for Congestion Control in Wireless Sensor Networks</b> Natalie Temene, Charalampos Sergiou, chryssis Georgiou, Vasos Vasiliou Department of Computer Science, University of Cyprus, Nicosia, Cyprus
19:10-19:20	<b>Sensor Synchronization for Android Spatial Applications</b> <i>Andreas Spanias<sup>1</sup></i> <sup>1</sup> Maria Christofi, <sup>2,3</sup> George Plastiras, <sup>2,3</sup> Rafaella Elia, <sup>2</sup> Vaggelis Tsiourtis, <sup>2,3</sup> Theocharis Theocharides, <sup>1</sup> Miltiadis Katsaros <sup>1</sup> National Technical University of Athens, Athens, Greece <sup>2</sup> University of Cyprus, Nicosia, Cyprus <sup>3</sup> KIOS Research and Innovation Centre of Excellence, Nicosia, Cyprus
19:20-19:30	<b>The Navarchos Fleet Management Platform</b> I.Constantinou <sup>1</sup> , C. Constantinou <sup>1</sup> , P. Gouvas <sup>2</sup> , T. Bouras <sup>2</sup> <sup>1</sup> Istognosis Ltd Cyprus, <sup>2</sup> UBITECH Limited Cyprus
	<b>SESSION 2: Machine Learning and Signal Processing</b> <b>Chair: Marios Neofytou</b> <i>3AeHealth LTD</i>
19:30-19:40	<b>Machine Learning based MEMS Sensor Calibration</b> Gowtham Muniraju, Andreas Spanias, SenSIP Center, ECEE, ASU
19:40-19:50	<b>Unsupervised Audio Source Separation using Generative Priors</b> Vivek Narayanaswamy <sup>1</sup> , Jayaraman, Thiagarajan <sup>2</sup> , Rushil Anirudh <sup>2</sup> , Andreas Spanias <sup>1</sup> <sup>1</sup> SenSIP Center, ASU, <sup>2</sup> Lawrence Livermore National Labs
19:50-20:00	<b>Graph Representation Learning using Deep Neural Networks</b> Uday Shankar <sup>1</sup> , Jayaraman Thiagarajan <sup>2</sup> , Andreas Spanias <sup>1</sup> <sup>1</sup> SenSIP Center, ASU, <sup>2</sup> Lawrence Livermore National Labs
	<b>SESSION 3: Computer Vision</b> <b>Chair: Andreas Panayides</b> <i>University of Cyprus</i>
20:00-20:10	<b>Cognitive Swarm of UAVs for Search and Rescue</b> Guillaume Voirin, Loizos Michael Open University of Cyprus & Research Center on Interactive Media, Smart Systems, and Emerging Technologies
20:10-20:20	<b>Detecting Obstacles for Pedestrians' Safety</b> Marios Thoma <sup>1</sup> , Zenonas Theodosiou <sup>1</sup> , Harris Partaourides <sup>1</sup> , Charalambos Tylliros <sup>1</sup> , Demetris Antoniadis <sup>1</sup> , Andreas Lanitis <sup>1,2</sup> <sup>1</sup> RISE, Nicosia, Cyprus, <sup>2</sup> Cyprus University of Technology, Limassol, Cyprus
20:20-20:30	<b>Machine Learning Methods for PV Array Soilage Detection on the Cyprus Solar Dataset</b> Kristen Jaskie <sup>1</sup> and Joshua Martin <sup>1</sup> , Yiannis Tofis <sup>2</sup> Andreas Spanias <sup>1</sup> <sup>1</sup> SenSIP Center, ECEE, ASU, <sup>2</sup> KIOS Center, University of Cyprus
20:30-20:40	<b>Cloud Segmentation and Movement Prediction</b> Sameeksha Katoch, Pavan Turaga, Cihan Tepedelenioglu, Andreas Spanias SenSIP Center, ECEE, ASU
	<b>SESSION 4: Medical Imaging</b> <b>Chair: Efthymou Kyriacou</b>

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	<i>Frederick University</i>
20:40-20:50	<b>Detection of Breast Cancer with Mammography: Use of temporal subtraction of sequential mammograms</b> Kosmia Loizidou, Galatea Skouroumouni, Christos Nikolaou and Costas Pitris <i>KIOS, University of Cyprus</i>
20:50-21:00	Machine Learning Techniques Comparison for Classification of Barrett's and Dysplasia from <i>In Vivo</i> Esophagus Optical Coherence Tomography Images <b>Christos Photiou<sup>1</sup>, George Plastiras<sup>1</sup>, Guillermo Tearney<sup>2</sup>, Costas Pitris<sup>1</sup></b> <sup>1</sup> KIOS Center of Excellence for Intelligent System and Networks, Dept. of Electrical and Computer Engineering, University of Cyprus, <sup>2</sup> Massachusetts General Hospital and Harvard medical school 55 Fruit Street, Boston, USA
	<b>SESSION 5: PhD Presentations – 5 min. (2 to 3 slides)</b> <b>Costas Pitris</b> <i>University of Cyprus</i>
21:00-21:05	<b>Extracting Explainable Assessments of Alzheimer's disease via Machine Learning on brain MRI imaging data</b> Kleo Achilleos, Nicoletta Prentza, Antonis C. Kakas, Constantinos S. Pattichis Department of Computer Science, University of Cyprus, Nicosia, Cyprus
21:05-21:10	<b>Argumentation-based framework for Explainable Machine Learning (ARGEML)</b> Nicoletta Prentzas, Antonis Kakas, Constantinos S. Pattichis Department of Computer Science, University of Cyprus
21:10-21:15	<b>A Review of Brain MRI Multiple Sclerosis Disease Image Analysis Studies</b> Andria Nicolaou, Department of Computer Science, University of Cyprus, Nicosia, Cyprus
21:15-21:20	<b>Intelligent Virtual Reality Systems for pain management in cancer patients</b> Melpo Pittara Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligent, University of Groningen, Department of Computer Science, University of Cyprus
	<b>SESSION 6: Elevator Speech Presentations – 2 min (1 to 2 slides)</b> <b>Constantinos S. Pattichis</b> <i>University of Cyprus</i>
21:20-21:23	<b>AI for Power Converters</b> Mohit Malu, Andreas Spanias and Gautam Dasarathy ECEE, SenSIP, ASU
21:23-21:26	<b>RET Project: Solar Fault Detection and Classification using Machine Learning</b> Milton Johnson Bioscience High School, Phoenix Advisors: Kristen Jaskie and Andreas Spanias, ECEE, SenSIP, ASU
21:26-21:29	<b>Fault Classification in PV Arrays using Pruned Neural Networks</b> Sunil Rao, Cihan Tepedelenlioglu and Andreas Spanias SenSIP, ECEE, ASU
21:29-21:32	<b>Using Machine Learning and Audio Spectral Features For COVID-19 Testing</b> Michael Esposito Advisors: Sunil Rao, Vivek Narayanaswami and Andreas Spanias ECEE, SenSIP, ASU
21:32-21:35	<b>Semi-Supervised Classification via Graph Filtering</b> Jie Fan, Cihan Tepedelenlioglu and Andreas Spanias SenSIP Center, ECEE, ASU
21:35-21:38	<b>Space-Based Computational Imaging Systems</b> Drika Iqbal, Suren Jayasuriya, Andreas Spanias ASU ECEE, SenSIP
21:38-22:00	<b>CLOSING REMARKS</b>

Abstracts

SESSION 1: IoT and Sensing

**Energy Efficient Reuse of Mobile Nodes for Congestion Control in Wireless Sensor Networks**

**Natalie Temene, Charalampos Sergiou, Chryssis Georgiou, Vasos Vasiliou**  
**Department of Computer Science, University of Cyprus, Nicosia, Cyprus**

The energy consumption of the sensor nodes in Wireless Sensor Networks (WSNs) is known to be affected by congestion. To deal with the combination of these two challenges, recently developed algorithms have introduced mobility to improve the lifetime of the network with a general goal to maximizing it. In this work, we present an extension of the Mobile Congestion Control (MobileCC) mechanism and propose the MobileCC+ mechanism. The new version improves the algorithm by considering the energy used by the mobile node to move around the network.

*See also one-page extended abstract in page 14.*

**Sensor Synchronization for Android Spatial Applications**

**<sup>1</sup>Maria Christofi, <sup>2,3</sup>George Plastiras, <sup>2,3</sup>Rafaella Elia, <sup>2</sup>Vaggelis Tsiourtis, <sup>2,3</sup>Theocharis Theocharides,**  
**<sup>1</sup>Miltiadis Katsaros**  
**<sup>1</sup>National Technical University of Athens, Athens, Greece**  
**<sup>2</sup>University of Cyprus, Nicosia, Cyprus**  
**<sup>3</sup>KIOS Research and Innovation Centre of Excellence, Nicosia, Cyprus**

This work illustrates a computational approach in urban stimuli. The concept is showcased via multiple sensors and synchronization for an android spatial application, namely FUMapp (Fragmented Urban Mobility application). It then reviews the spatial application structure and quantitative measures related to the real environment that the application collects. The production of FUMapp aims to analyze specific urban forms through multidisciplinary data that will feedback on the urban design process.

*See also one-page extended abstract in page 14.*

**The Navarchos Fleet Management Platform**

**I.Constantinou<sup>1</sup>, C. Constantinou<sup>1</sup>, P. Gouvas<sup>2</sup>, T. Bouras<sup>2</sup>**  
**<sup>1</sup>Istognosis Ltd Cyprus**  
**<sup>2</sup>UBITECH Limited Cyprus**

Navarchos is a world-class Fleet Management Platform (FMP), which supports a) real-time driver-centric notification and recommendations algorithms for promoting eco-driving behavior, b) intelligent metrics and analytics for empowering fleet managers to have a more comprehensive overview and complete control of their fleet, c) routing optimization and scheduling tools for increased fleet productivity, and d) scalable, highly available and high-performance cloud-based infrastructure to support (a), (b) and (c). Navarchos is already installed in 30 small fleets in Cyprus supporting 180 vehicles, with plan to be installed abroad in Greece, Romania and Equator in the near future.

**SESSION 2: Machine Learning and Signal Processing**

**Machine Learning based MEMS Sensor Calibration**

**Gowtham Muniraju, Andreas Spanias,  
SenSIP Center, ECEE, ASU**

Microelectromechanical systems (MEMS) sensors are an essential unit of all integrated circuits and are widely used for their high precision and reliable performance. Any MEMS sensor produced from the manufacturing unit has to be calibrated to the appropriate specifications of the datasheet, prior to packaging. The calibration process ensures that the MEMS sensor always performs within the specified offset and sensitivity range across temperature ranging from -40 (degree Celsius) C to 125 C. However, the initial sensor reading across these temperatures has a nonlinear behavior and varies randomly when tested each time. Moreover, sweeping temperatures from -40 C to 125 C with an interval of 5 C for a batch of sensor, repeated for 4 different orientations, is time- consuming and expensive. In this work, we develop machine learning (ML) techniques to find a cost effective and reliable solution to improve MEMS sensor validation and testing process.

**Unsupervised Audio Source Separation using Generative Priors**

**Vivek Narayanaswamy<sup>1</sup>, Jayaraman, Thiagarajan<sup>2</sup>, Rushil Anirudh<sup>2</sup>, Andreas Spanias<sup>1</sup>  
<sup>1</sup>SenSIP Center, ASU, <sup>2</sup>Lawrence Livermore National Labs**

State-of-the-art under-determined audio source separation systems rely on supervised end-end training of carefully tailored neural network architectures operating either in the time or the spectral domain. However, these methods are severely challenged in terms of requiring access to expensive source level labeled data and being specific to a given set of sources and the mixing process, which demands complete re-training

when those assumptions change. This strongly emphasizes the need for unsupervised methods that can leverage the recent advances in data-driven modeling, and compensate for the lack of labeled data through meaningful priors. To this end, we propose a novel approach for audio source separation based on generative priors trained on individual sources. Through the use of projected gradient descent optimization, our approach simultaneously searches in the source-specific latent spaces to effectively recover the constituent sources. Though the generative priors can be defined in the time domain directly, e.g. WaveGAN, we find that using spectral domain loss functions for our optimization leads to good-quality source estimates. Our empirical studies on standard spoken digit and instrument datasets clearly demonstrate the effectiveness of our approach over classical as well as state-of-the-art unsupervised baselines.

**Graph Representation Learning using Deep Neural Networks**

**Uday Shankar<sup>1</sup>, Jayaraman Thiagarajan<sup>2</sup>, Andreas Spanias<sup>1</sup>  
<sup>1</sup>SenSIP Center, ASU, <sup>2</sup>Lawrence Livermore National Labs**

Deep Neural Networks (DNNs) are the main workhorse for many scientific and non-scientific applications. DNNs have enjoyed unprecedented success in the past decade, even surpassing human-level performance in various fields including image and vision, speech processing, and natural language processing. Graph neural networks (GNNs), a generalization of neural networks to graph-structured data have recently gained a lot of prominence due to their expressive power. In this presentation, I will provide an overview of the message passing formalisms in GNNs. I will address some of the inherent challenges and applications of GNNs. Finally, I will conclude with an application of GNNs to human brain connectomes.

**SESSION 3: Digital Image Processing**

**Cognitive Swarm of UAVs for Search and Rescue**

**Guillaume Voirin, Loizos Michael**

**Open University of Cyprus & Research Center on Interactive Media, Smart Systems, and Emerging Technologies**

We present a cognitively-inspired architecture for a swarm of unmanned aerial vehicles tailored for search and rescue operations, and evaluate it through a custom-built simulator.

*See also one-page extended abstract in page 14.*

**Detecting Obstacles for Pedestrians' Safety**

**Marios Thoma<sup>1</sup>, Zenonas Theodosiou<sup>1</sup>, Harris Partaourides<sup>1</sup>, Charalambos Tylliros<sup>1</sup>, Demetris Antoniadis<sup>1</sup>, Andreas Lanitis<sup>1,2</sup>**

**<sup>1</sup>RISE, Nicosia, Cyprus**

**<sup>2</sup>Cyprus University of Technology, Limassol, Cyprus**

Walking is directly related to the quality of life, both as a form of exercise, and by helping reduce car traffic, air pollution and traffic noise. City walking, however, is often dangerous—according to the World Health Organization, 26% of all road traffic deaths in 2016 involved pedestrians and cyclists [1].

A major cause of such accidents is the many forms of obstructions blocking pedestrian paths, forcing pedestrians to use less safe walking routes. Keeping pedestrian routes clear of any obstacles should therefore be a top priority for the authorities; this however is often a difficult task, since new obstacles often go unreported for considerable amounts of time.

*See also one-page extended abstract in page 14.*

**Machine Learning Methods for PV Array Soilage Detection on the Cyprus Solar Dataset**

**Kristen Jaskie<sup>1</sup> and Joshua Martin<sup>1</sup>, Yiannis Tofis<sup>2</sup> Andreas Spanias<sup>1</sup>**

**<sup>1</sup>SenSIP Center, ECEE, ASU, <sup>2</sup>KIOS Center, University of Cyprus**

Solar panel soilage detection is an important problem as soiled panels produce significantly less energy than clean ones. In this presentation, we present two new methods for identifying soiling in residential solar installations. The first method aims to calculate a daily energy-lost-due-to-soilage value by comparing two calculated power curves: the expected best case scenario curve (after taking degradation into account) and a weather corrected curve, which estimates what the day's power curve would be in the absence of cloud cover. Our second method takes a different approach and compares sites in the same weather region to each other using a multi-level k-means clustering strategy. The key takeaway being that these new methods do not need feature rich datasets, which are often unavailable, rather they operate solely on time-series power values.

**Cloud Segmentation and Movement Prediction**

**Sameeksha Katoch, Pavan Turaga, Cihan Tepedelenlioglu, Andreas Spanias**

**SenSIP Center, ECEE, ASU**

Cloud cover is one of the major reasons that hampers the widespread penetration of photovoltaic in power grids. Since power output is based on the sun's irradiance there is high uncertainty and intermittency due to variable weather conditions. In this work, we elaborate on cloud identification and segmentation which is the first step in climate research and photovoltaic power generation forecast. We propose a training-

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free cloud/sky segmentation based on a threshold that adapts to the cloud formation conditions. Furthermore, we present a novel cloud movement prediction method which views the cloud videos as dynamic textures and can be utilized to manage photovoltaic power output.

**SESSION 4: Machine Learning and Signal Processing**

**Detection of Breast Cancer with Mammography: Use of temporal subtraction of sequential mammograms**

**Kosmia Loizidou, Galateia Skouroumouni, Christos Nikolaou and Costas Pitris  
KIOS, University of Cyprus**

Breast cancer is one of the deadliest malignancies worldwide. In this retrospective study, a new technique for the detection and classification of breast Micro-Calcifications (MCs), using subtraction of temporal pairs of mammograms is proposed. Screening digital mammographic examinations from 100 women were included. These examinations had precisely markings at MC locations in order to be used as a reference. The classification performance was evaluated with and without the use of temporal subtraction. Various features were extracted, and eight classifiers were tested in a Leave-One-Patient-Out (LOPO) and k-Fold cross-validation. The best classification accuracy was 90.22% with temporal subtraction and 83.88% without temporal subtraction (p-value = 0.01).

*See also one-page extended abstract in page 14.*

**Machine Learning Techniques Comparison for Classification of Barrett's and Dysplasia from *In Vivo* Esophagus Optical Coherence Tomography Images**

**Christos Photiou<sup>1</sup>, George Plastiras<sup>1</sup>, Guillermo Tearney<sup>2</sup>, Costas Pitris<sup>1</sup>**

**<sup>1</sup>KIOS Center of Excellence for Intelligent System and Networks, Dept. of Electrical and Computer Engineering, University of Cyprus,**

**<sup>2</sup>Massachusetts General Hospital and Harvard medical school 55 Fruit Street, Boston, USA**

Endoscopic Optical Coherence Tomography (EOCT) systems can perform *in vivo*, real-time, high-resolution imaging of the human esophagus and, thus, play an important role in the early diagnosis and improved prognosis of esophageal diseases such as Barrett's, dysplasia and adenocarcinoma.

However, the massive data volumes produced make manual evaluation of the generated information extremely difficult. The algorithms, developed thus far, have not been able to provide effective computer-aided diagnosis. In this study, we evaluated different machine learning methods for the classification of esophageal tissue from *in vivo* EOCT images. An automated algorithm is presented, capable of discriminating normal tissue from Barrett's Esophagus (BE) and dysplasia. The classification was based on a wide range of features extracted from EOCT images, including intensity-based statistics, group velocity dispersion (GVD) and the average scatterer size (SS) of each A-Scan. The areas of the epithelium were annotated as normal, BE or dysplasia by an expert. The comparison and evaluation of various machine learning (ML) techniques has shown that a neural network based approach provided the best performance, separating BE from dysplasia, for individual A-Scans, with an accuracy of 89%.

*See also one-page extended abstract in page 14.*

**SESSION 5: PhD Presentations**

**Extracting Explainable Assessments of Alzheimer's disease via Machine Learning on brain MRI imaging data**

**Kleo Achilleos, Nicoletta Prentza, Antonis C. Kakas, Constantinos S. Pattichis**  
**Department of Computer Science, University of Cyprus, Nicosia, Cyprus**

Decision tree (DT) induction and an argumentation-based reasoning framework were used to assess Alzheimer's Disease (AD) from brain structural changes as seen in Magnetic Resonance Imaging (MRI). The objective was to demonstrate that our methodology produced accurate but simultaneously explainable assessments. The DT and Random Forest algorithms were applied on brain MRI images acquired from normal controls (NC) and AD subjects. The KNIME analytics platform was used to compute the DT and the R project was used for the RF. The argumentation model implemented in the Gorgias framework. The overall performance was consistent to current research with the added advantage of providing the reasoning in support of the assessment.

**Argumentation-based framework for Explainable Machine Learning (ARGEML)**

**Nicoletta Prentzas , Antonis Kakas, Constantinos S. Pattichis**  
**Department of Computer Science, University of Cyprus**

Artificial intelligence (AI) research in the medical domain is accelerating rapidly, with potential applications being demonstrated across various areas of medicine. The problem with many state-of-the-art AI models is a lack of transparency and interpretability, and their inability to explain their results in a way that humans can understand. Explainable AI (XAI) is an emerging field in AI that aims to address these challenges and the key innovation of the argumentation-based framework. The proposed ARGEML framework is a novel approach to Machine Learning that integrates sub-symbolic methods with logical (symbolic) methods of argumentation to provide explainable solutions to learning problems. The ultimate goal is to provide the community with a formal and practical framework for the development of Explainable solutions for decision support, in the medical and other critical domains.

**A Review of Brain MRI Multiple Sclerosis Disease Image Analysis Studies**

**Andria Nicolaou**  
**Department of Computer Science, University of Cyprus, Nicosia, Cyprus**

Multiple Sclerosis (MS) is an unpredictable disease of the central nervous system that disrupts the flow of information within the brain and between the brain and body. It is caused by inflammation that comes from the immune system which attacks the myelin and produces lesions. In order to analyze, preprocess, segment and predict these lesions, researchers based on methods of Image Analysis and some of them used Deep Learning (DL) methods. The datasets were collected by public databases of biomedical imaging challenges (ISBI 2015, MICCAI 2008, MICCAI 2016) and by clinical MS databases. The datasets include MRI Images 2D/3D (TW1, TW2, PDW, Flair). Most of the studies have pre-processing methods of images and some of them have post-processing methods. Segmentation methods are categorized into manual delineation, semi-automated and automated, with the last one being in the first line as includes DL methods.

**Intelligent Virtual Reality Systems for pain management in cancer patients**

**Melipo Pittara**

**Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligent, University of Groningen, Department of Computer Science, University of Cyprus**

Recent advances in Virtual Reality (VR) immersive technologies provide new methods and tools for the development of novel and promising applications mainly for different disease conditions. However, the full potential of VR applications in healthcare still remains to be explored. The purpose of this research work is to develop an innovative methodological framework for the development of emerging VR applications based on user interaction integration and tracking, biosignal analysis and intelligent decision making and personalization. It is expected that this framework will be exploited in the development and evaluation of VR applications in cancer patients suffering with chronic pain management.

**SESSION 6: Elevator Speech Presentations**

**AI for Power Converters**  
**Mohit Malu, Andreas Spanias and Gautam Dasarathy**  
**ECEE, SenSIP, ASU**

The efficiency of the power converters can be improved by finding an optimal point of operation for the given circuit parameters like input voltage, output voltage, inductance, capacitance etc. but finding this optimal point of operation in a complex power converter circuit on the chip is not an easy task as many of the parameters cannot be accurately measured. In this project we aim to develop a machine learning algorithm that can help improve the efficiency of the power converters under various circuit parameters and load conditions, and implement this algorithm in an M-arm core processor using tensor flow lite.

**RET Project: Solar Fault Detection and Classification using Machine Learning**  
**Milton Johnson, Bioscience High School, Phoenix**  
**Advisors: Kristen Jaskie and Andreas Spanias**  
**ECEE, SenSIP, ASU**

Solar energy is becoming more affordable and more common in local businesses and residential use. We propose to create classification models using labeled data for solar arrays that are affected by soiling, weather, ground leakage and short circuits. We then plan to evaluate these models and use our assessments to create new methods that can be used for unlabeled solar array data sets. If successful, these new methods or algorithms can be used to inform customers of deficiencies within their rooftop systems and the probable cause. Our studies will enable improved system power output and better management of the solar array. We will compare several supervised learning algorithms including logistic regression, support vector machines, neural net classifiers. We will also simulate semi-supervised positive unlabeled algorithm to evaluate its effectiveness for PV faults.

**Fault Classification in PV Arrays using Pruned Neural Networks**  
**Sunil Rao, Cihan Tepedelenlioglu**  
**Andreas Spanias, SenSIP, ECEE, ASU**

Automatic detection of solar array faults leads to reduced maintenance costs and increased efficiencies. In this work, we address the problem of fault detection, localization, and classification in utility-scale photovoltaic (PV) arrays. More specifically, we examine and assess the use of neural networks for fault classification, trained using dropout regularizers and compare our results with other classification algorithms. We perform neural network pruning experiments and illustrate the trade-off between model accuracy and complexity. Our approach promises to improve the accuracy of fault classification and elevate the efficiency of PV arrays.

**Using Machine Learning and Audio Spectral Features For COVID-19 Testing**  
**Michael Esposito**  
**Advisors: Sunil Rao, Vivek Narayanaswami and Andreas Spanias**  
**ECEE, SenSIP, ASU**

As the COVID-19 pandemic continues, it has become necessary to develop rapid testing to identify infected individuals in order to restrict the spread of the virus. We propose to determine appropriate audio data features and use machine learning for COVID-19 testing. The expected benefits compared to traditional nose swab, saliva, or blood testing are expedited results, lower cost, and ease of implementation (e.g. via a smartphone app). Challenges include possible distorted or low-quality audio samples, availability of reliable labeled (ground truth) data, and lack of baseline (healthy) audio recordings for comparison to suspected pathological recordings.

**Semi-Supervised Classification via Graph Filtering**

**Jie Fan, Cihan Tepedelenlioglu**

**Andreas Spanias, SenSIP Center, ECEE, ASU**

For datasets that reside on irregular and complex domains, using graphical models to represent them can bring advantages. Graph signal processing offers several tools for such data sets and combines graph theory with traditional digital signal processing theory. We propose a novel graph filter design method for use in semi-supervised data classification. The proposed design uses multiple graph shift matrices, one for each feature, and is shown to provide improved performance when the feature qualities are uneven. We introduce three methods to optimize for the graph filter coefficients and the graph combining coefficients. The first method uses the alternating minimization approach. In the second method we optimize our objective function by convex relaxation that can theoretically achieve a global optimum. The third method adopts the genetic algorithm, which is computationally efficient and better at dealing with overfitting. In our simulation experiments, we use both synthetic and real datasets with informative and non-informative features.

**Space-Based Computational Imaging Systems**

**Odrika Iqbal, Suren Jayasuriya, Andreas Spanias**

**ASU ECEE, SenSIP**

Fast object tracking is useful for a variety of applications in surveillance, autonomous vehicles, and remote sensing. In particular, there is a need to have these algorithms embedded on specialized hardware such as FPGAs or ASICs to ensure energy-efficient operation while saving on latency, bandwidth, memory access/storage. However, one of the main challenges is accounting for motion blur that can occur due to sensor exposure times. We want to present an algorithm to perform tracking-based motion deblurring, that is designed to be lightweight and resource utilization friendly. We show the effectiveness of this method when coupled with an object tracker. We further show an FPGA implementation of this algorithm and achieve 29 frames per second real-time performance with approximately 17 times speed-up in clock cycles as compared to software. This work points to future avenues for hardware-software optimization in computational imaging platforms in the future.

One Page Extended Abstracts

# Energy Efficient Reuse of Mobile Nodes for Congestion Control in Wireless Sensor Networks

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**Abstract**—The energy consumption of the sensor nodes in Wireless Sensor Networks (WSNs) is known to be affected by congestion. To deal with the combination of these two challenges, recently developed algorithms have introduced mobility to improve the lifetime of the network with a general goal to maximizing it. In this work, we present an extension of the Mobile Congestion Control (MobileCC) mechanism and propose the MobileCC+ mechanism. The new version improves the algorithm by considering the energy used by the mobile node to move around the network.

**Index Terms**—Wireless Sensor Networks, WSNs, Mobility, Mobile Nodes, Energy Consumption, Reuse

## I. INTRODUCTION

Significant challenges have risen based on the limitations of Wireless Sensor Networks (WSNs). One of the most known and researched challenges in WSNs is congestion control. Existing congestion control algorithms monitor and adjust the traffic of the network by either controlling the load or increasing the resources. For the latter, in addition to creating alternative paths using unused nodes [1], another way to mitigate congestion is to increase the capacity of the network by utilizing mobile nodes. These nodes can either be inserted in the network when help is needed, or are part of it from the beginning. In both scenarios, the mobile nodes reduce congestion by facilitating new paths for data transmission.

## II. DYNAMIC MOBILECC ALGORITHM

The Dynamic Node Placement algorithm [2] is a variation of the MobileCC mechanism that solves the congestion problem locally by placing a mobile node in such a position so that it can receive the traffic intended for the congested node. Initially, the Dynamic MobileCC algorithm calculates the average number of packets per time unit that the congested node receives and cannot forward due to lack of buffer space. Then, it discovers the nodes that transmit their packets to the congested nodes and calculates the best position that the mobile node(s) should move to in order to receive data from

a number of them. Ideally, the best position is the position where the maximum number of nodes in the neighborhood of the congested node can divert their traffic through the mobile node(s), whereas at the same time their total sending rate should be equal or more than the amount of the excess traffic of the congestion node.

## III. ENERGY EFFICIENT ALGORITHMIC SOLUTION

The Dynamic Node Placement algorithm stops when the mobile node is placed in the needed position. However, at some point the congestion problem may be solved and the mobile node may no longer be needed. For this reason we extended the previously mentioned algorithm in order to reuse the mobile nodes that are placed in the network.

When a new congestion problem occurs in the network, there is a need to use a mobile node to solve it. The first thing to do is to check if one of the in-use mobile nodes, meaning the mobile nodes already placed in the network, can be reused. An in-use mobile node can be reused if and only if: 1. The mobile node is not needed any more, which means that the congestion problem occurred has been solved. 2. All nodes, that send packets to the mobile node, can find an alternative path. 3. The energy needed for the mobile node to move from its current to its new position, and from there to its initial position, does not exceed a certain threshold.

We plan to perform simulations in the COOJA simulator of Contiki OS and evaluate the algorithmic solution on various parameters.

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# Sensor Synchronization for Android Spatial Applications

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**Abstract**—This work illustrates a computational approach in urban stimuli. The concept is showcased via multiple sensors and synchronization for an android spatial application, namely FUMapp (Fragmented Urban Mobility application). It then reviews the spatial application structure and quantitative measures related to the real environment that the application collects. The production of FUMapp aims to analyze specific urban forms through multidisciplinary data that will feedback on the urban design process.

**Index Terms**—sensors synchronization, multidisciplinary data, urban stimuli, spatial application

## I. INTRODUCTION

Although digital computation appeared in architecture in the late 1940s, scientific applications related to spatial problems took shape by the mid-1950s. The substantial progress in digital computation during the last two decades has been connected to the quantification and analysis of urban spatial characteristics. However, the produced spatial systems and applications had little focus on how every kind of sensory input might be incorporated. The rapid advances in spatial applications led to a gap between design and cognitive architecture.

In this work, we present FUMapp (Fragmented Urban Mobility application), an android application that works as a coordinator between several devices for data acquisition. FUMapp offers paperless experiments and eliminates manual synchronization between the data and the manual marking of regions on a 3D environment. In this way, there is a significant speed-up on the time needed before and after an experiment. The production of a spatial application like FUMapp will be useful for a human-centric, explicit representation of urban space suitable for filling the gap between cognition and design.

## II. FUMAPP

### A. Implementation of Application

FUMapp is a mobile (Android OS) application for data synchronization and acquisition from various devices (smartwatch, eye-tracking glasses, android device). The application was used in a navigation experiment in Copenhagen's urban path to capture the optical response in urban stimuli of 20 subjects

[1]. FUMapp supports the selection of multiple paths that are pre-loaded by the researcher, e-signing of a consent form which is updated based on the current city, collection of data such as GPS for speed estimation and position (from both smartwatch and android device), eye-tracking data from pupil labs glasses that are exported using iMotions software and importing/exporting/grouping data for each subject into the correct folder.

### B. Data collection Protocol

The protocol for data collection is the same as the one presented in [1]. The app supports predefined paths of different cities, where the subjects have to navigate from point A to point B while they are wearing eye-tracking glasses, smartwatch, and sensors helping the collection of multidisciplinary data. At the end of the navigation process (point B), the recalling process starts. Every subject needs to answer a path questionnaire directly in FUMapp. All data collected will be saved in the app for further analysis. Moreover, FUMapp supports navigation through a 3D environment where the subjects have to mark highlighted recalled spatial stimuli (objects/sidewalks/buildings) of the path which can recall easier. The whole experiment lasts from 27 to 31 minutes.

## III. SPATIAL FILE ORGANISATION

FUMapp provides the following collected data that a researcher can extract for further analysis: personal information of a subject with its corresponding ID, consent form of a subject, eye-tracking data, smartwatch data, path questionnaire and lastly recalling 3D stimuli data.

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# Cognitive Swarm of UAVs for Search and Rescue (Extended Abstract)

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**Abstract**—We present a cognitively-inspired architecture for a swarm of unmanned aerial vehicles tailored for search and rescue operations, and evaluate it through a custom-built simulator.

## I. INTRODUCTION AND MOTIVATION

The success of search-and-rescue (SAR) operations directly depends on the *rescue time*, with the first 72 hours following an event being crucial. This makes the use of robotic systems — including unmanned aerial vehicles (UAVs) — a fitting addition on the SAR field due to their ability for continuous operation, speed, and agility, and with their limited autonomy being compensated by their interaction with human operators.

This required interaction highlights, however, a major drawback of UAVs for SAR. A recent survey report [1] has outlined UAVs’ insufficient ability to learn, whereas a meta-analysis review [2] has shown that current UAV swarm approaches pose human-factor challenges by incurring high cognitive demands for operators due to the swarm’s unpredictable behavior.

## II. PROPOSED SAR ARCHITECTURE

To mitigate those problems, we introduce a *cognitive* swarm of UAVs architecture. UAVs are able to learn from, navigate in, and explore their environment using simple, easy to grasp algorithms that favor their behavioral predictability, as well as cognition-enhanced functionalities that facilitate adaptation.

*a) Inspired by Human Cognition:* Although UAVs still make use of custom, predefined, “intuitive” policies, they also *learn* from, and adapt to, their environment using timing-based perception and attention mechanisms coupled with working and long-term memory systems derived from Cognitive Psychology [3]. Cognition is further enhanced through AI techniques (e.g., decision trees to learn from UAV-operator interactions), and Swarm Intelligence techniques (e.g., biologically-inspired algorithms to learn across the swarm).

*b) Pathfinding and Exploration:* Planned pathfinding (for avoiding known obstacles) uses the  $A^*$  algorithm with post-smoothing. Unplanned pathfinding (for avoiding other UAVs and unknown obstacles) uses a “mental model” constructed from past perceptions (as opposed to immediate sensor data), and a “sum-of-forces” approach that integrates the Boids algorithm [4], various static repelling forces, a best-direction selection algorithm based on VFH [5], and a swarm intelligence algorithm utilizing other UAVs’ environmental knowledge to

improve path efficiency. Exploration of the environment is performed using a semi-stochastic search algorithm derived from a random walk, but guaranteeing a certain level of exploratory performance by favoring visits of previously-unseen areas.

*c) UAV-Operator Interactions:* An iteration of the ID3 algorithm [6] is repeatedly used by each UAV to update its decision tree following operator feedback, enabling informed decisions to be taken autonomously after some training.

## III. EVALUATION AND CONCLUSIONS

Evaluation through a custom-built simulator demonstrates that: UAVs advantageously utilize their cognitive functions to perform “smarter” pathfinding by learning to avoid prominent, previously-seen obstacles; on-board exploration algorithms result in good area coverage by the UAV swarm; UAVs quickly learn from their operator’s feedback, while also adapting to changing feedback over time (e.g., due to new field reports).

We expect that with the future integration of more advanced cognitive functions, our proposed cognitive swarm of UAVs architecture will be able to demonstrate further improvements.

## ACKNOWLEDGMENTS

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# Detecting Obstacles for Pedestrians’ Safety

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**Abstract**—Walking is directly related to the quality of life, both as a form of exercise, and by helping reduce car traffic, air pollution and traffic noise. City walking, however, is often dangerous—according to the World Health Organization, 26% of all road traffic deaths in 2016 involved pedestrians and cyclists [1]. A major cause of such accidents is the many forms of obstructions blocking pedestrian paths, forcing pedestrians to use less safe walking routes. Keeping pedestrian routes clear of any obstacles should therefore be a top priority for the authorities; this however is often a difficult task, since new obstacles often go unreported for considerable amounts of time.

Citizen-science, which directly involves citizens in scientific research related to real-world problems, has gained considerable attention in recent years. Exploiting the ubiquitous use of smartphones, citizen-science studies have focused on crowdsourcing data collection using smartphone applications, overcoming many limitations of conventional collection methods, while at the same time increasing citizen awareness for the problems they study. Here, taking advantage of the potential of citizen-science for crowdsourcing data, we develop a smartphone app aiming to enhance the safety of pedestrians, by allowing them to be directly involved in the obstacle reporting process.

The proposed Android app enables users to quickly report obstacles they encounter while walking, aiding the process through the use of Computer Vision. The reporting process is as streamlined and quick as possible, and involves the following steps: Upon opening the app (Fig. 1a), the user can capture an image of an obstacle (Fig. 1b), which is instantly analysed using an embedded Convolutional Neural Network (CNN), specifically trained for recognising various road obstructions [2]. Based on the CNN analysis, the user is presented with the 5 most probable obstacle types to choose from, speeding up the type selection step (Fig. 1c). The option to show more obstacle types exists, in case the actual obstacle type is not included in the recommended types (any disparities between the CNN predictions and user choice are recorded, and can be used to continuously improve the CNN). In parallel, using other available sensors on the user’s device, the app automatically collects other important details about the obstacle, such as location, altitude and orientation of the device.

Once the user is satisfied with the collected information, a report can be submitted (Fig. 1d). As soon as an appropriate network connection becomes available, the reports are automatically uploaded to the crowdsourcing platform *iNicosia*<sup>1</sup>. The centralised reporting of pedestrian obstacles can then be used to inform both the authorities and pedestrians, leading to an increase in pedestrian safety.

<sup>1</sup><https://inicosia.rise.org.cy> (under development); backup url: <https://7e3fa2d3.ngrok.io>

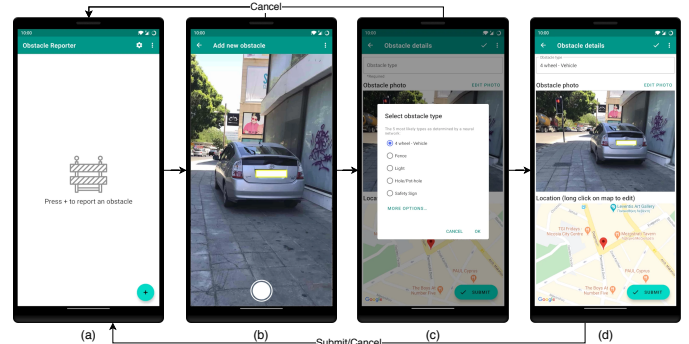


Fig. 1. App workflow.

A short evaluation of the app prototype regarding user experience (UX) was carried out, with the help of 18 volunteers, who tested the app in real conditions while walking in the city, and answered a shortened version of the User Experience Questionnaire (UEQ) [3]. UEQ evaluates the UX in 6 scales, as shown in Fig. 2. The prototype received a generally positive evaluation, scoring *Excellent* in 5 of the 6 scales, and *Above Average* in the Perspicuity scale. Perspicuity measures how easy it is for users to get familiar and learn how to use the app, suggesting that the prototype would benefit from improvements in those areas. The feedback collected from users in the preliminary evaluation will help us to improve the application, and will be taken into account for its finalisation.

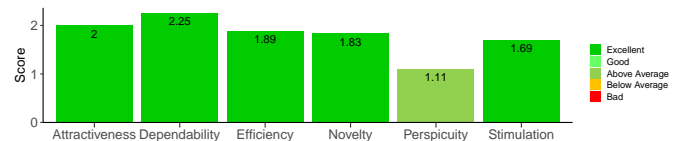


Fig. 2. App prototype UX evaluation results.

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# Detection of Breast Cancer with Mammography: Use of temporal subtraction of sequential mammograms

Kosmia Loizidou, Galatea Skouroumouni, Christos Nikolaou and Costas Pitris

**Abstract**—Breast cancer is one of the deadliest malignancies worldwide. In this retrospective study, a new technique for the detection and classification of breast Micro-Calcifications (MCs), using subtraction of temporal pairs of mammograms is proposed. Screening digital mammographic examinations from 100 women were included. These examinations had precisely markings at MC locations in order to be used as a reference. The classification performance was evaluated with and without the use of temporal subtraction. Various features were extracted, and eight classifiers were tested in a Leave-One-Patient-Out (LOPO) and k-Fold cross-validation. The best classification accuracy was 90.22% with temporal subtraction and 83.88% without temporal subtraction (p-value = 0.01).

## I. INTRODUCTION

Breast cancer is the most frequently diagnosed cancer and mammography is extensively used as a screening and diagnostic tool. Computer Aided Diagnosis (CAD) systems are being developed to assist radiologists for the assessment of breast cancer [1]. Although various algorithms have been proposed [2], few existing methods compare the recent with the older mammograms for more accurate identification of abnormalities. The objective of this study was to evaluate the effect of temporal subtraction of sequential mammograms, eliminate the overlapping Micro-Calcifications (MCs), detect and classify the MCs. For comparison, the methodology was evaluated only on the most recent images.

## II. MATERIALS AND METHODS

A new dataset was developed consisting of 50 patients with suspicious MCs and 50 healthy participants with (28 out of 50), or without (22 out of 50) benign MCs, along with precise annotation of each individual MC to be used as a reference (Fig. 1).

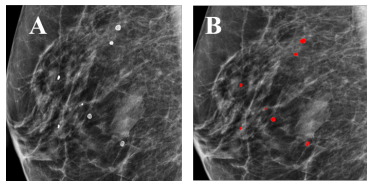


Fig. 1. Dataset example. (A) Zoomed region of a mammogram with MCs. (B) The same image with precise marking (red dots) at MC locations, as defined by two expert radiologists.

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The prior mammogram was registered to the most recent one, using Demons, and then subtraction took place. Machine learning, was then implemented, to reduce the large number of falsely detected regions and classify the true MCs as benign or suspicious. The complete dataset was used in a Leave-One-Patient-Out cross-validation and k-Fold cross-validation.

## III. RESULTS

The average Contrast Ratio (CR) of the subtracted images was 57 times higher, compared to the CR of the recent images (Fig. 2). The proposed method achieved 90.22% classification accuracy and 83.88% using only the most recent mammograms. Additionally, by using temporal subtraction the overlapping MCs were removed and only the new developed ones were imported to the classifier.

## IV. DISCUSSION

The accuracy was improved by 6% with the addition of temporal subtraction (p-value = 0.01). This study demonstrates that temporal subtraction shows superior performance for the diagnosis of MCs compared to using only the most recent mammograms, and has the potential to considerably contribute to the development of automated CAD systems, provide vital assistance to radiologists and impact patient prognosis.

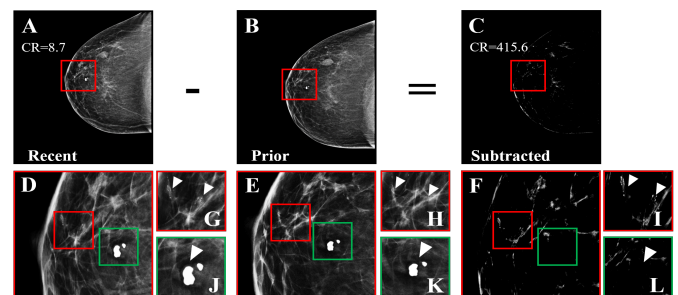


Fig. 2. Improvement of CR and subtraction of pre-existing MCs. (A) Most recent mammogram. (B) Prior mammogram. (C) The result of subtracting the registered version of B from A. (D)-(F) are the zoomed regions marked by the red squares in A-C. The CR has increased 47 times, after subtraction. The red squares in D-F correspond to the zoomed images (G)-(I) and show a new suspicious MC cluster, which was not subtracted. On the contrary, the green squares, which correspond to (J)-(L), show a pre-existing benign MC, which was completely subtracted.

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# Machine Learning Techniques Comparison for Classification of Barrett's and Dysplasia from *In Vivo* Esophagus Optical Coherence Tomography Images

Christos Photiou<sup>1</sup>, George Plastiras<sup>1</sup>, Guillermo Tearney<sup>2</sup>, Costas Pitris<sup>1</sup>

**Abstract**— Endoscopic Optical Coherence Tomography (EOCT) systems can perform *in vivo*, real-time, high-resolution imaging of the human esophagus and, thus, play an important role in the early diagnosis and improved prognosis of esophageal diseases such as Barrett's, dysplasia and adenocarcinoma. However, the massive data volumes produced make manual evaluation of the generated information extremely difficult. The algorithms, developed thus far, have not been able to provide effective computer-aided diagnosis. In this study, we evaluated different machine learning methods for the classification of esophageal tissue from *in vivo* EOCT images. An automated algorithm is presented, capable of discriminating normal tissue from Barrett's Esophagus (BE) and dysplasia. The classification was based on a wide range of features extracted from EOCT images, including intensity-based statistics, group velocity dispersion (GVD) and the average scatterer size (SS) of each A-Scan. The areas of the epithelium were annotated as normal, BE or dysplasia by an expert. The comparison and evaluation of various machine learning (ML) techniques has shown that a neural network based approach provided the best performance, separating BE from dysplasia, for individual A-Scans, with an accuracy of 89%.

## I. INTRODUCTION

Barrett's esophagus (BE) is a condition where the normal squamous epithelium of the esophagus transforms due to gastroesophageal reflux. BE progresses through different stages of dysplasia before developing into adenocarcinoma thus providing a window for an early detection that improves patient prognosis. EOCT systems can acquire cross-sectional images of the microscopic structure of the esophageal layers helpful for tissue characterization [1,2]. In this study, we classify different regions of esophageal OCT images, utilizing a fully automated algorithm for image segmentation and feature extraction. Several ML classifiers were evaluated for accuracy and capability to differentiate normal from abnormal tissues and BE vs. dysplasia from *in vivo* acquired data.

## II. METHODS

The OCT images were collected using a swept source EOCT system. EOCT esophageal images from ten patients were used, enrolled in a study at Massachusetts General Hospital, creating a dataset of 320 images. The annotated regions were 461, of which, 170 normal, 118 BE and 173 dysplastic providing a total of 154,066 annotated A-Scans. In order to extract features for the classification, an automated algorithm for tissue segmentation and feature extraction was created. Each image was segmented at three different depths (0.4, 0.55, 0.7mm), beginning from the top surface of the tissue to investigate the layers necessary for optimal classification results.

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## III. EXPERIMENTAL PROCEDURE

The classification of the tissue regions was performed using various features extracted from the segmented regions of the EOCT images annotated by an expert. Features included: Intensity based statistics dividing the regions in two and in three parts, average scatterer size (SS) of each A-Scan [3] and the group velocity dispersion (GVD) calculated for each A-Scan [4]. Paired t-test and Multivariate Analysis of Variance (MANOVA) utilized for feature selection and six classifiers evaluated: Linear Discriminant Analysis (LDA), Naïve-Bayes (NB), Decision Trees (DT), *k*-nearest neighbor (KNN), Ensemble of Decision Trees (EDT) and neural networks (NN). The performance of each classifier model verified using leave-one-patient-out cross-validation [5-7].

## IV. RESULTS

Tables I and II present the performance of all models for normal vs. abnormal classification and Barrett's vs. dysplasia. Mean, variance, median, sum, min and max of the upper and lower parts appeared to be the most significant features along with the GVD and SS. NN classifier had the best performance for both tasks with an accuracy of 85% and 89% respectively.

Table I. Best results for normal vs abnormal classification for every segmentation depth

Depth [mm]	Region Div.	Classifier	SEN [%]	SPE [%]	ACC [%]	AUC	G-mean
0.4	2	NN	72	92	84	0.78	0.80
0.55	2	LDA	76	83	81	0.80	0.79
<b>0.7</b>	<b>2</b>	<b>NN</b>	<b>67</b>	<b>95</b>	<b>85</b>	<b>0.82</b>	<b>0.80</b>

Table II. Best results for BE vs Dysplasia classification for every segmentation depth

Depth [mm]	Region Div.	Classifier	SEN [%]	SPE [%]	ACC [%]	AUC	G-mean
<b>0.4</b>	<b>2</b>	<b>NN</b>	<b>80</b>	<b>92</b>	<b>89</b>	<b>0.85</b>	<b>0.84</b>
0.55	2	NN	78	92	86	0.81	0.82
0.7	2	LDA	81	79	80	0.80	0.80

## ACKNOWLEDGMENT

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