CWSPI'23

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15th Cyprus Workshop on Signal Processing and Informatics

FINAL PROGRAM
AND BOOK OF ABSTRACTS

Venue: University of Cyprus, Library "Stelios Ioannou"

Room: LRC 014, Ground floor

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14:15-18:45, July 5th, 2023

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Preface:

Following the successful one-day workshop hosted over the past 14 years, we would like to cordially invite you to participate in the upcoming 15th Cyprus Workshop on Signal Processing and Informatics (CWSPI 2023).

The overall objective of CWSPI 2023 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. The workshop is strongly supported by the CYENS and KIOS Centres of Excellence, constituting 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 in hybrid mode, given the current situation with the pandemic.

Wishing you a fruitful and joyful event.

Christos Loizou, Andreas Panayides,
Constantinos S. Pattichis, Andreas Spanias,

July 2023

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.

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University of Cyprus (New Campus) Library "Stelios Ioannou" LRC 014, Ground floor P.O.Box. 20537, CY-1678 Nicosia, CYPRUS
More info
Tel.: + 357-22892700, Fax: + 357-22-892701, e-mail: cs@ucy.ac.cy

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Technical Program

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	AVARIS: Prehospital Emergency Care Ecosystem

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Abstracts

SESSION 1: PLENARY TALKS

Video Analysis Methods for Recognizing Multiple Human Activities

Marios S. Pattichis, *University of New Mexico, USA*

Abstract
In this talk, I will introduce fast and reliable methods for recognizing human activities. The talk will discuss all aspects of the problem, starting from the development of custom datasets to the developing of efficient models for processing large video datasets with limited ground truth.

ShortBio
Marios S. Pattichis received the B.Sc. degree with high honours and special honours in Computer Sciences, the Bachelor of Arts with high honours in Mathematics, and a minor in Electrical Engineering from the University of Texas at Austin in 1991. He received the M.S. in Electrical Engineering and the Ph.D. in Computer Engineering from the University of Texas at Austin in 1993 and 1998 respectively. He is currently a Professor and director of the image and video processing and communications lab (ivPCL) at the Department of Electrical and Computer Engineering, at the University of New Mexico. He is currently working on the developing large-scale video analysis systems for processing educational videos and biomedical datasets. For educational videos, his goal isto develop computer assisted methods for recognizing student activities in collaborative learning videos. For biomedical video analysis, his research is focused on supporting the development of computer aided diagnosis systems for echocardiography video analysis and atherosclerotic plaque ultrasound video analysis. He has served as a Senior Associate Editor for the IEEE Transactions on Image Processing, a Senior Associate Editor for IEEE Signal Processing Letters, Associate Editor for IEEE Transactions on Image Processing, IEEE Transactions on Industrial Informatics. He has served as a Guest Associate Editor for special issues published by the Teachers College Record, the IEEE Journal of Biomedical and Health Industry, the IEEE Transactions on Information Technology in Biomedicine, and Biomedical Signal Processing and Control. Recently, he has served as the guest editor for the special issue titled “Large-Scale Medical Image and Video Analytics for Clinical Decision Support,” published by the IEEE Journal of Biomedical and Health Informatics in 2023. He was elected Fellow of the European Alliance of Medical and Biological Engineering and Science (EAMBES) for his contributions to biomedical image analysis.

SESSION2: NSF IRES ASU SenSIP-UCy KIOS Research

Quantum Positive Unlabelled Learning for PV Fault Detection

Brent Brightwell[1], Andreas Spanias[1], Glen Uehara[1], LenosHadjidemetriou[2], Christos Laoudias[2]

[1]School of ECEE at Arizona State University, [2]KIOS Research and Innovation Centre of Excellence at University of Cyprus

Abstract

The semi-supervised machine learning process of Positive Unlabelled Learning has shown good potential in managing large datasets that would otherwise be expensive to work with using traditional classification techniques. Through this process, known positive values are selected from a larger, otherwise unknown dataset and used to classify the set in its entirety. By making use of the current research and development in the field of quantum computing, this presentation will cover the implementation of positive unlabelled learning in a quantum computing environment. Specifically, this real-world application will be explored using solar fault detection data. Quantum constraints, such as quantum noise, lengthy training times, and computing resources will also be considered in analysis of the results. The presentation will also briefly cover the engagement at the University of Cyprus KIOS Center. This collaborative ASU SenSIP - UCy KIOS IRES project is sponsored by the NSF award 1854273.

Classical vs Quantum Neural Networks for Fault Detection in Solar Cell Arrays

Emma Skaggs[1], Glen Uehara[1], Andreas Spanias[1], Lenos Hadjidemetriou[2]

[1]SenSIP, School of ECEE at Arizona State University, Arizona, USA**,** [2]KIOS Center at University of Cyprus, Nicosia, Cyprus

Abstract

As non-renewable energy resources continue to decline; photovoltaic (PV) cells have emerged as a popular alternative with their ability to provide renewable energy worldwide. However, under certain conditions solar panels can be inefficient, converting only around 6-20% of light into usable energy. The efficiency of these PV arrays can drop even further with shading, degradation, soiling, and short circuit conditions. To reduce stress on the power grid, the goal is to keep these arrays operating at peak efficiency by detecting faults in real-time. Therefore, this IRES study aims to compare the accuracy of classical and quantum machine learning algorithms, with an emphasis on neural networks (NN), in detecting and classifying faults in solar panel arrays. The initial testing of the classical neural network yielded around 90% accuracy. However, as experimentation expands to include quantum neural networks, we are limited by quantum noise, long runtimes, and computational bandwidth. The final presentation will address these issues and briefly cover the engagement at the University of Cyprus KIOS Center. This collaborative ASU SenSIP -UCy KIOS IRES project is sponsored by the NSF award 1854273.

Quantum SVM Based Positive Unlabelled Learning for PV Fault Detection

Salil Naik[1], Glen Uehara[2], Lenos Hadjidemetriou[3], Andreas Spanias[2]

[1]SCAI at Arizona State University, Arizona, USA**,** [2]SenSIP, School of ECEE at Arizona State University**,** [3]Kios Lab at University of Cyprus, Nicosia, Cyprus

Abstract

Positive unlabeled (PU) learning is a semi supervised machine learning (ML) approach to a binary classification problem where a small subset of the data has positive labels, and the rest are unlabelled. These PU learning algorithms can be very effective at reducing the total cost of training ML classifiers because the labeling of data to support supervised machine learning algorithms is extremely expensive in both time and manpower. This IRES study adapts PU learning methods into the quantum computing do main and explores the feasibility of various quantum positive unlabeled (QPU) methods of machine learning and their applications in photovoltaic fault detection. Quantum circuits for QML have been designed for this IRES study. The primary problems with quantum machine learning QML) implementations include quantum

measurement noise and qubit precision, long training sessions with QML, and availability of computing resources that typically require GPU's and large amounts of memory. In preliminary testing of a quantum-classical hybrid neural network within the QPU learning framework, we achieved an accuracy of 77.4%. Further work must be done to improve this accuracy and test other quantum machine learning algorithms such as QSVM's. The presentation will also briefly cover the engagement at the University of Cyprus KIOS Center. This collaborative ASU SenSIP-UCy KIOS IRES project is sponsored by the NSF award 1854273.

A Comparative Study of Classical and Quantum Machine Learning for Solar Energy Fault Detection

Fiorella Yasmin Estrada[1], Glen S. Uehara[1], Andreas Spanias[1], Lenos Hadjidemetriou[2]

[1]SenSIP REU, School of ECEE, Arizona State University, [2]University of Cyprus

Abstract

Solar Energy is nowadays widely deployed in utility scale and rooftop type renewable sources of energy. An array of photovoltaic (PV) or solar panels are typically used to produce energy through the internal solid-state cells that convert light (irradiance) into energy. A dominating issue present with PV panels are the numerous faults that can occur which result in loss of efficiency and expensive repairs. The intent of this investigation is to implement and compare classical and quantum machine learning (ML) algorithms for PVfault detection and classification. The method to be explored relies on the use of feed forward neural networks that learn from training PV datasets to detect and classify faults. In addition, a quantum neural network (QNN) will be implemented and results from the QNN will be compared against a classical NN to determine whether there is quantum advantage in determining PV faults. The hurtles presented in quantum machine learning are the longevity of the training sessions, large memory capacity with a GPU in the device and qubit precision with quantum noise. The presentation will also briefly cover the engagement at the University of Cyprus KIOS Center. This collaborative ASU SenSIP-UCy KIOS IRES project is sponsored by the NSF award 1 854273.

A Machine Learning Approach for Simultaneous Human and Remotely Operated Vehicle Monitoring for Anomalous Command Detection

[1]Rafaella Elia, [2]Theocharis Theocharides

[1]KIOS Research and Innovation Center of Excellence, [2]Department of Electrical & Computer Engineering, University of Cyprus, Nicosia, Cyprus

Abstract

Constant technological advancements in the area of remotely operated vehicles (ROVs) facilitate their widespread use in a variety of safety-critical applications. Stress and fatigue can be challenging factors during such missions, and they can compromise the outcome and safety of the mission. Therefore, the operator is prone to issue some involuntary movements to the controller. Nevertheless, real-time monitoring of the operator and the ROV can prevent possible accidents. In this work, we present a feature-based Machine Learning (ML) approach for the classification of abnormal commands, using fused data from both the human operator and the ROV, during a mission. We perform feature extraction and selection, and then the selected features were incorporated into six well-known classification algorithms in order to identify the best performance. Each classification algorithm was tested on an embedded platform; the Jetson Xavier NX, and the processing time, energy consumption, and classification accuracy were extracted, as performance metrics. The evaluation results conclude the best trade-off across all the performance metrics, reaching 82% accuracy with minimal processing time and energy consumption.

Introduction: Remotely Operated Vehicles (ROVs) are widely used across many safety-critical application domains spanning across realtime monitoring, search, and rescue missions. However, the human operator is needed to control the ROV in harsh environments such as natural or man-made disasters, and emergency response scenarios. These situations can induce stress to the operator and also increases his/her fatigue levels [1]. As a result, the operator is prone to involuntary movements during the mission or being unable to control the vehicle. Real-time monitoring will enable us to detect normal and abnormal conditions. Therefore, we aim to capture the contextual awareness of the human operator and the ROV in order to safeguard missions. This can be achieved by monitoring simultaneously the human and the ROV. Hence, we aim to optimize the data recorded both from the human operator and the ROV during a mission, by reducing the dimensionality, but at the same time, maintaining high performance and low computational overheads. We performed feature extraction, feature selection, and classifier optimization and analysis toward anomaly

detection. A real-life environment dataset was constructed for the evaluation of the proposed approach since a large percentage of the existing studies are simulation-based. Our main goal in this work is a resource-constrained and real-time classification of the state of the human and the ROV during a mission.
Dataset and Methodology: We constructed a dataset that consists of data from a human operator and an ROV, in our case an Unmanned Aerial Vehicle (UAV) [2], [3]. Data from 19 subjects were collected and analysed. Each participant was instructed to follow a predefined path of movements including an additional task with an increased level of difficulty. Moreover, a stress induction technique was employed in the second stage of the experiment. The physiological signals monitored from the human operator are the surface Electromyography (sEMG) signal from both hands, Heart Rate (HR), Blood Volume Pulse (BVP), Skin Temperature (SKT) and Electrodermal Activity (EDA) from the dominant hand. From the Inertial Measurement Unit (IMU) of the UAV the following values were employed in this analysis: accelerometer (x, y, z), gyroscope (x, y, z), magnetometer (x, y, z), altitude and relative height. After data acquisition, we performed feature extraction and selection, using a window of 10 sequential time-frames. Features were selected using the feature importance score. Afterward, the selected features were fed into 6 classification algorithms (Decision Trees (DT), Randorm Forest (RF), Support Vector Machines (SVM), AadaBoost (ADA), k-Nearest Neighbor (KNN) and Artificial Neural Network (ANN)) evaluated on the embedded platform. We extracted the classification accuracy, processing time, and energy consumption, as performance metrics.
Experimental Evaluation: In general, with the proposed optimizations on the data and the classification algorithms, we can achieve accuracy between 72% and 82%. All the classification algorithms required similar amount of time, except the KNN and SVM which showed to be slower. The DT and RF classifier showed the lowest energy demands, but the DT is the classifier with the lowest performance in terms of classification accuracy. The KNN and SVM are the most energy-demanding and the most timeconsuming in the trade-off between energy consumption and processing time.

Semantic Segmentation of 3D Point Clouds with Point Convolutions: Preliminary Results and Future Directions

Antonis Savva[1], Christos Kyrkou[1], Panayiotis Kolios[1], Theocharis Theocharides[1,2]

[1]KIOS Research and Innovation Center of Excellence, [2]Department of Electrical and Computer Engineering, University of Cyprus

Abstract
The recent advances in 3D acquisition technology have made widely available 3D sensors of various types, such as airborne and terrestrial Light Detection and Ranging (LiDAR) and RGB-D cameras, for acquiring high-quality outdoor large-scale and indoor scenes. Additionally, the rapid development of deep learning methods for various computer vision applications, such as classification, detection and segmentation, initiated increased scientific interest in applying these approaches for the respective tasks when dealing with 3D point clouds. Initially, the employed methods consisted of projecting the 3D points to 2D planes to capitalize on well-established 2D deep learning networks, while other approaches used regular representations to fully utilize the 3D information and simultaneously address the varying point density issue. Recently, novel point convolution approaches have been proposed, which directly operate on the 3D points without any intermediate representation; thus, addressing shortcomings of previous methods, also achieving high-performance. In this presentation, special focus will be given on semantic segmentation of large-scale 3D scenes acquired with airborne LiDAR sensors, using point convolution methods. Specifically, a brief introduction to the problem will be given along with the approaches that have been used in the literature. Subsequently, a more detailed description of point convolutions will be provided, illustrating how they deal with point cloud irregularities, as well as their equivalency to 2D convolutions. Preliminary results will be presented, discussing on trade-offs between building blocks of the network and computational complexity, as well as current challenges and future directions of research in this domain.
Keywords—Point-based convolution, scene understanding, deep learning, 3D semantic segmentation.

SESSION 3: EMERGING MEDICAL APPLICATIONS

A Comparative Performance Assessment of Different Video Codecs

Ioanna Valiandi[1], Efthyvoulos Kyriacou[2], Constantinos S. Pattichis[1], Marios S. Pattichis[3], Andreas S. Panayides[1]

[1]CYENS Centre of Excellence, Nicosia, Cyprus, Department of Computer Science, University of Cyprus, [2]CYENS CoE, Nicosia, Cyprus, [3]Electrical and Computer Engineering, University of New Mexico, New Mexico, U.S.A.

Abstract

The present study provides a comprehensive comparative evaluation analysis of six popular video codecs across multiple video datasets of different video characteristics and content, including general-purpose and clinical videos.

Introduction: Over the past decade, video streaming applications have witnessed widespread adoption, becoming the main source of internet traffic. To support future expansion, there is a critical need to develop effective compression and video delivery algorithms. In the video codecs development landscape, new video coding tools are emerging that support ultra-high definition (4K and beyond) video, with a focus on real-time, mobile video streaming, as well as catering for the growing demand for 360° video applications. As a result, new video compression standards complement their established and widely used predecessors. The latter triggers a non-so trivial question with respect to the best video codec to use per underlying application. For example, despite notable compression efficiency advances, the associated complexity is often disregarded, leading to computationally expensive tools. Optimized (open source) software implementations that are standards compliant help combat this issue before hardware enabled implementations comes into play. On the other hand, lower video resolutions rendered on earlier devices might not need (or not support) more computationally expensive tools while the selection of earlier video compression standards might be a greener option. The objective of this study is to provide a fair comparison of six different video codecs, namely the Versatile Video Coding (VVC) (both its reference implementation and UVG-266) and the AV1 codecs, along with both its predecessors, namely x265 implementation and VP9 respectively, as well and the recently released Essential Video Coding (EVC) and its open-source implementation, the eXtra-fast Essential Video Encoder (XEVE).

Methodology: Experimental evaluation was based on three general-purpose video datasets and one ultrasound video dataset of the common carotid artery (CCA). More specifically, the first one comes from the SJTU 4K Video Sequence Dataset and consists of five 4K (3840 x 2160) UHD videos at 30 fps. The second one is abstracted from the Netflix Dataset comprising of 10 videos (768 x 432) of which seven have a frame rate of 25 fps while the remaining three have a frame rate of 50 fps. Finally, the CCA dataset consists of ten ultrasound videos (560 x 448) with a framerate of 40 fps. All selected videos are 10 seconds long and are in yuv420p raw format. To facilitate a fair comparison, the experimental setup was created in accordance with the relevant literature. Selected quantization parameters for constant quality encoding comprised of 27, 35, 46, 55 for AV1 and VP9 codecs, while matching QPs of 22, 27, 32, 37 for VVC, UVG-266, XEVE, and x265 codecs. The aim here was to support a variety of representative bandwidths, as recommended by the literature. Objective video quality assessment was based on PSNR611 scores. Additionally, BD-Rate results were further given to demonstrate the bitrate demands reductions for equivalent objective video quality (i.e. PSNR611) of the more efficient video compression standards compared to their earlier or less-performing counterparts.

Results: Following a thorough comparative review that looked at current and established video codecs across multiple video datasets of different video content and characteristics, this study confirmed the ascendancy of the VVC encoding standard in terms of compression efficiency. Both SVT-AV1 and UVG-266 outperformed all the remaining codecs while achieving similar compression efficiency between them. Likewise, the x265 and XEVE codecs are closely ranked, with the former receiving slightly favourable performance rankings in all scenarios. The rate-distortion graph below demonstrates that at the lowest performing end, we can find the earlier VP9 codec. SVT-AV1's dominance was undeniable in terms of encoding time, and it was the only implementation that could meet the requirements for real-time performance. On the other hand, VVC's reference software implementation is the most suited for evaluating the effectiveness of the various encoding tools at the expense of being much slower than rival video codecs.

Computer Vision for Autonomous Navigation in Indoor Healthcare Workspaces

Eleftherios G. Vourkos[1,2], Evropi Toulkeridou[2], Antreas Kourris[1,2], Stefanos Christophorou[3], Raquel Julia Ros[4], Eftychios G. Christoforou[1,2], Nacim Ramdani5, Andreas S. Panayides[2]

[1]Dept. of Mechanical and Manufacturing Engineering, University of Cyprus, Nicosia, Cyprus, [2]Videomics FRG, CYENS Center of Excellence, Nicosia, Cyprus, [3]3AE HEALTH LTD, Nicosia, Cyprus,[4]Robotnik Automation Paterna, Valencia, Spain, [5]Univ. Orleans, INSA CVL, PRISME EA 4229, F45072 Orleans, France

Abstract

Healthcare workspaces would greatly benefit from the employment of robotic assistants in both clinical and non-clinical tasks. However, despite their advantages, a major shortcoming for the deployment of robots limiting their widespread acceptance by the market is the fact that existing robotic solutions were originally designed for large industrial and warehouse spaces. Herein, we examine state-of-the-art computer vision methods that enable robots to detect the presence and identify the type of dynamic obstacles inside their visual field and adapt their navigation accordingly.

Introduction: HUMAN-Robot Interaction (HRI) is the field of study that explores the use of robotic systems by humans; moreover, it investigates, understands, and evaluates the communication between robots and humans. As new robotic applications emerge, interest in HRI research is growing too, driven by its ever-increasing social impact. In such complex workspaces the robots should interact with other robots while overcoming challenges related to untrained healthcare personnel or patients and visitors. The goal is to train the robots to recognize humans and other robots, predict their motions in real time, and adjust their movement. In this study, we opted for the open-source algorithm YOLO (You Only Look Once). Its general architecture uses Convolutional Neural Networks (CNNs).

Methodology: To select the appropriate model and version for our dataset, we compared different versions of YOLOv5, YOLOv7 and YOLOv8 models. After fine-tuning YOLOv5, an appropriate value for the batch size was found to be 16. The network was trained for 60 epochs as both training and validation precision plateaued for more epochs, as shown in Fig 1. The same behavior was observed in the case of YOLOv7 and YOLOv8. The proposed study targets autonomous mobile robot navigation in less structured environments. Simultaneous localization and mapping (SLAM) need to take place so that a map of the operating environment is created. The mobile robots are controlled using the open-source Robot Operating System (ROS). We trained our system using contemporary deep learning methods (namely YOLO architecture and its variations) and obtained promising results in both human and robot detection. For that purpose, a newly constructed dataset consisting of robot images was used, complementing the well-known COCO dataset.

Results: To make the results of the three models for our dataset readily comparable, we use the same hyperparameters for training. Although all models reached more than 90% precision during training, Yolov8 outperformed the other two models.

Conclusion: The present study contributes towards the key objective of safe robot navigation in healthcare spaces and underpins the wider application of studies on Human-Robot Interaction in less structured environments. The resulting network was further tested for real-time detection in human and robot populated environments to achieve a detection accuracy of up to 0.9.

A Review on Machine Learning Methods on BioVid Heat Pain Database

Melpo Pittara[1], Nicolai Petkov[1], Constantinos S. Pattichis[2]

[1]Bernoulli Institute for Mathematics Computer Science and Artificial Intelligent, University of Groningen, Groningen, Netherlands, [2]Department of Computer Science, University of Cyprus, Nicosia, Cyprus

Abstract

For millions of people worldwide, pain is an unpleasant physical and mental experience that lowers their quality of life. To provide patients appropriate medical care, studies focused on intelligent pain assessment and management systems development based on physiological signals, and facial expressions analysis through Machine Learning (ML) technology. In this review, we explore different ML method uses and their accuracy on BioVid Heat Pain Database for pain intensity estimation, and classification.

Introduction: Pain is a distressing experience comprising sensory, emotional, cognitive, and social characteristics that is linked to real or potential tissue damage. Despite that most of the physicians and researchers most frequently utilize self-rating pain assessment tools like the numerical rating scale (NRS) or the visual analogue scale (VAS) to quantify pain severity, these measures only function when the individual is sufficiently conscious, and cooperative. Accordingly, automatic pain identification and valuation are of particular importance to patient groups with verbal and/or cognitive impairments as well as in scenarios where the level of pain cannot be communicated. In this review, we provided 12 studies using different ML techniques on the same database (BioVid Heat Pain Database) for pain intensity estimation and classification.

Materials and Methods: A systematic review of the current literature was conducted using the Google Scholar library. Twelve papers related to BioVid Heat Pain Database and ML were included. BioVid Heat Pain database containing both video and biomedical signals (ECG, EMG, and SC) from 85 subjects were participated in experiment with 4 pain levels of heat changes.

Results: Table I. revealed the most significant features and ML methods for pain intensity identification. Accuracy level is higher in SC signal than the other signals in almost all the studies that used it. Only 3 studies in our review used facial videos for pain intensity estimation with low accuracy.

Discussion: Our review emphasizes the necessity for continued use of ML in pain research in order to create new algorithms that can successfully forecast and help medical professionals diagnose and manage patients' pain effectively.

Automated segmentation and classification of the atherosclerotic carotid plaque in ultrasound videos

Georgia D. Liapi[1], Michalis Gemenaris[1], Christos P. Loizou[1], Kyriacos P. Constantinou[2], Constantinos S. Pattichis[2], Andrew Nicolaides[3], Efthyvoulos Kyriacou[1]

[1]Dept. of Electrical Engin., Computer Engin. And Informatics, Cyprus University of Technology, Limassol, Cyprus, [2]Dept. of Computer Science, University of Cyprus, Nicosia, Cyprus, [3]Vascular Screening and Diagnostic Centre, Nicosia, Cyprus

Abstract

The automated delineation of carotid plaques in ultrasound (CUS) videos is highly significant for the management of the disease. To facilitate stroke risk assessment, in this study, we propose and evaluate an integrated software system for automated segmentation and classification of the atherosclerotic carotid plaques in longitudinal CUS videos. The proposed methodology involves video frame (VF) resolution and intensity normalization, speckle reduction filtering, Motion-mode state-based cardiac cycle (CC) identification, deep learning (DL)-based plaque segmentation, extraction and selection of plaque region of interest (ROI)-specific textural features, and statistical analysis to identify features with high discriminatory power for Asymptomatic (AS) and Symptomatic (SY) cases. A priorly trained DL model was evaluated in plaque segmentation, for each VF, and the segmented ROI was projected onto its primary resolution-normalized VF counterpart, from which textural and amplitude modulation frequency modulation (AM-FM) plaque ROI features were extracted. Statistical analysis on the total AS and SY VFs was used for feature selection. We identified 2 plaque-originating AM-FM features, which exhibited statistically significant differences between the AS and SY standardized VFs ($p<0.05$), followed by 3 textural features ($p<0.05$).

Introduction: A recent study [1] estimated that in 2020 approximately 21% of the global population would have developed atherosclerotic plaques in the carotids. To focus on the examination of carotid plaques in CUS videos, clinical experts need to annotate ROIs. To automate this process, multiple studies have proposed DLbased systems to segment plaques in CUS images and videos. In the majority of the studies, comparisons between samples are drawn in the absence of image pre-processing, VF standardization and uniform cardiac cycle (CC) selection. Here, we propose and evaluate the first steps of our integrated system for automated segmentation of atherosclerotic plaques in CUS videos, and image-based feature extraction for plaque classification.

Methodology: In this study, 10 internal carotid artery longitudinal CUS videos (5 AS and 5 SY) were used. An experienced vascular surgeon manually annotated the carotid plaques, for the first VF per video. We applied standardization as proposed in [2] and used the 'DSFhmedian' filter (2 iterations) as in [3]. Then, we isolated a 'diastole-systole-diastole' CC-compliant VF range, as in [2] and the VF number was further reduced, to leave out redundant VFs. We finally had 88 CC-refined VFs (44 AS and 44 SY). Next, we deployed a CFPNet-M [4] we had previously trained, from scratch, with CUS pre-processed VFs. CFPNet-M(634,336 parameters) was trained for 120 epochs, with the images cropped and resized (256x128) to the plaque area. From the CFPNet-M-predicted ROIs, we extracted different textural and AM-FM [5] features and applied statistical analysis to detect the most discriminatory for the AS and SY cases.

Results: CFPNet-M reached a mean 79.7±6.9% Jaccard coefficient. A segmented set of VFs is shown in Fig. 1. Our findings on image textural and AM-FM feature AS/SY comparisons are in accordance with those in previous studies of our group. The Instantaneous Phase (Medium) and Instantaneous Frequency (Medium) showed a superior power, when differentiating between AS and SY cases ($p<0.05$ for both features).

Conclusions: The AM-FM features will possibly replace previous plaque textural features, in our future plaque classification tasks.

Semi-Automated Patch-based Segmentation of Different Size Groups of Brain Metastases in MRI Images

Vangelis Tzardis, Efthyvoulos Kyriacou, Christos P. Loizou

Cyprus University of Technology Limassol, Cyprus

Abstract

A semi-automated method for the segmentation of brain metastases (BM) was proposed as the basis for a computer-assisted decision support tool to be used by medical experts. Because of the size variability of BM, the method was trained and tested separately on small ([2.65, 13.26) mm^2), medium ([13.26, 37.11) mm2) and large ([37.11, 1152.21) mm^2) BM and all combinations (7 developed models in total). 2D image patches (N=875) containing at least one BM were extracted and 5-fold cross validation was performed using a UNet3+ network. The segmentation results yielded Dice Similarity Coefficient (DSC) per patch with median (interquartile range) = 0.66 (0.17), 0.76 (0.12), 0.87 (0.11), 0.71 (0.18), 0.79 (0.22), 0.82 (0.15), and 0.77 (0.21) for small (S), medium (M), large (L), S/M, S/L, M/L, S/M/L BM respectively.

Introduction: BM is the most common intracranial malignant cancer in adults, being developed from ~20% of cancer patients. It appears with a debilitating symptomatology and a poor survival prognosis. There is still great need in clinical practice for reliable automated tools to aid medical experts on the BM delineation task, which will be used for treatment planning. The proposed method would require the medical expert to pan a square box around the region of probable appearance of BM, in order for the method to automatically segment BM in new images.

Methodology: T1-weighted gradient-echo post-contrast images were used from the public BM dataset "BrainMetShare" with 105 patients in total. The images were originally resampled to 256 × 256 pixels in the transverse plane, with a resolution of 0.94 mm, and were skull-stripped. The resolution in between planes was 1.0 mm. From each image, its mean was subtracted, and the result was divided by its standard deviation. BM lesions were grouped in small (S, [2.65, 13.26) mm^2), medium (M, [13.26, 37.11) mm^2) and large (L, [37.11, 1152.21) mm^2), with each group having approximately the same BM number. Patches of 64x64 in size containing one or more BM were randomly cropped. Patches with all BM in one size group were assigned to S, M or L groups accordingly. Patches with BM in multiple size groups were assigned to S/M, S/L, M/L or S/M/L groups, accordingly, ensuring the constituting single size groups to be balanced as for their BM number. For each group, five-fold cross validation was performed, thus resulting in seven different trained models. The segmentation network was a 2D U-Net3+, consisting of 4 levels, (two convolution blocks of filter size 3×3 each), using Rectified Linear Units, maxpooling (encoder) and bilinear upsampling (decoder). The encoder filters were doubled in each level starting from 64. In each level of the decoder, all outputs from the encoder levels were passed through 64 filters. Then, the resulted feature maps were concatenated and passed through another series of 320 filters. For the training, the focal Tversky loss, with the Adam optimizer and learning rate 10–3 with decay 0.995 were used. The batch size was set to 25, after experimenting with various sizes from 5 to 40. For each BM size group, the best number of epochs was found independently. For S, M, L, S/M, S/L, M/L, and S/M/L, the models trained for 300, 230, 260, 290, 300, 220, and 290 were selected based on the average minimum validation loss among the 5-fold cross validation splits. Furthermore, the probability threshold to discern between BM and non-BM pixels was experimentally determined, by evaluating the model on the training data with different threshold values, and aiming to balance a large Dice similarity coefficient (DSC) metric with a small number of falsely detected BM. The average of the best thresholds of all patches, was selected for each BM size group and split and varied in range 0.90-0.97.

Results: The segmentation results yielded Dice Similarity Coefficient (DSC) per patch with median (interquartile range) = 0.66 (0.17), 0.76 (0.12), 0.87 (0.11), 0.71 (0.18), 0.79 (0.22), 0.82 (0.15), and 0.77 (0.21) for S, M, L, S/M, S/L, M/L, and S/M/L groups respectively. Also, true positive rate (TPR), normalized Matthews Correlation Coefficient (nMCC) and Average Symmetric Surface Distance (ASSD) were calculated.

An Explainable Artificial Intelligence Model in the Assessment of Brain MRI Lesions in Multiple Sclerosis Using Amplitude Modulation - Frequency Modulation Multi-scale Feature Sets

Antria Nicoloaou[1], Constantinos S. Pattichis[1], Chistos. P. Loizou[2]

[1]Department of Computer Science, University of Cyprus, Nicosia, Cyprus, [2]Departement of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus

Abstract

The objective of this study was to implement an explainable artificial intelligence (AI) model with embedded rules to assess Multiple Sclerosis (MS) disease evolution based on brain Magnetic Resonance Imaging (MRI) multi-scale lesion evaluation. Amplitude Modulation-Frequency Modulation (AM-FM) features were extracted from manually segmented brain MS lesions obtained using MRI and were labelled with the Expanded Disability Status Scale (EDSS). Machine learning models were used to classify the MS subjects with a benign course of the disease and subjects with advanced accumulating disability. Rules were extracted from the selected model with high accuracy and then were modified to perform argumentation-based reasoning. It is demonstrated that the proposed explainable AI modelling can distinguish MS subjects and give meaningful information to track the progression of the disease. Future research will examine more subjects and add new feature sets and models.

Explainability in Clinical Cognitive Systems based on Clinical Practice Guidelines

Chara Skouteli

Department of Computer Science University of Cyprus

Abstract

The main scope of a Medical Cognitive System based on clinical practice guidelines is to provide guidance to the physicians based on their experience level. Such a system should not only be able to handle multiple categories of recommendations but also organize them and guidance the physician by providing evidence and explanations in order to be trusted. Each suggested action of such a system arises from the processing of clinical practice guidelines initially produced by domain experts and eventually knowledge retrieved from the knowledge base in a formal way. However, one of the main challenges these systems have to address is the ambiguity and uncertainly initiated by either the practice guidelines or the noisy and incomplete records. Thus, extending the recommendation with explanations and evidence is the key in order to minimize the risk of false actions and maximize the trust between the physician and the system. To this end, such a system should provide transparency both on the execution of practical guidelines but also in the results of any prediction or value, which is generated by machine learning or artificial intelligent algorithms. Thus, the key to success of such a system is the proper formalization of the recommendation linked with the maximum explanation provision in each level. This research will exploit the use of explainable AI (XAI) towards generating a medical cognitive system based on clinical practice guidelines that interacts in a natural way with its users (physicians) through explanations and informed dialogues.

AI-enabled solutions for predicting sepsis in ICUs: a systematic review

Christina-Athanasia Alexandropoulou[1], Ilias Panagiotopoulos[1], Charithea Stylianides, Styliani Kleanthous, George Dimitrakopoulos[1], Ioannis Constantinou, Stavri Vassiliou, Eleni Politi, Dimitrios Ntalaperas, Xanthi Papageorgiou, Nikos Ioannides, Lakis Palazis, Constantinos S. Pattichis, Andreas S. Panayides

[1]Department of Informatics and Telematics, Harokopio University of Athens, Greece, [2]CYENS CoE, Cyprus, [3]3EHealth, Nicosia, Cyprus.

Abstract

Artificial Intelligence (AI) advances in healthcare require better data management so that prompt and informed decisions towards patients' care are taken. Life-threatening conditions like sepsis can benefit from this, as they demand immediate and appropriate clinical intervention. While studies involving the use of AI for sepsis prediction exist, systematic reviews on the topic are limited. In this study, AI-enabled solutions for septic shock prognosis are studied, while explainability techniques appear crucial and promising towards ethical data use and clinicians' trust and interventions.

Introduction: Sepsis is a complex disease with high mortality rates, affecting millions every year. The timely availability and analysis of heterogeneous healthcare data are key prerequisites for its early efficient diagnosis, prognosis, or treatment. AI-enabled predictive systems can address this, while pointing to the need for better explainability techniques to tackle ethical issues and the opaque nature of AI.

Methodology: The literature search considered eligible articles published within the last five years. A final count of 19 papers related to ICU sepsis prediction models are presented.

AI Systems for the Early Prediction and Diagnosis of Sepsis: Researchers are showing an increasing interest in the topic as every hour of delay in antimicrobial treatment increases mortality. Tree-based algorithms like Gradient Boosting Trees, as well as deep learning ones, like Convolutional Neural Networks are used. Clinical outcomes include sepsis diagnosis, septic shock prognosis and prediction of sepsis death or survival in ICU. The most used database is the Medical Information Mart for Intensive Care (MIMIC), along with features of demographics, vital signs, laboratory results and organ failure scores.

Ethical Concerns of Using an AI in Sepsis: Healthcare research involves vulnerable people and potential biases, pointing to the need for Clinical Decision Support System (CDSS) protocols. However, data transparency challenges, like the need for consent, non-representative data due to medical needs and symptoms progression variability, and opaqueness of AI approaches, arise. Guidelines to deidentify and process data, updated datasets that reflect populations including demographic data, and trust of system predictions by healthcare providers are required, respectively.

Explainable AI and Sepsis: Explainability and accountability in the context of ICU predictions are crucial towards professionals' interventions. Explainable Artificial Intelligence (XAI) can contribute to clinical acceptance of CDSS and translational potential of predictions with confidence, trustworthiness, causality and efficiency, if suitable explanation types and levels for ICU sepsis prognosis are explored.

Conclusions: The study provides a systematic literature review of ICU sepsis prediction models and highlights the need for guidelines for sensitive data use, demographic data for accurate population representation and suitable explanations of predictions for transparency, and clinician's trust.

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Mobile Application for Telemonitoring Cancer Patients - eCAN Joint Action

Michalis Gemenaris[1], Paraskevas Lagakis[2], Efthyvoulos Kyriacou[1]

[1]Dept. of Electrical Engin., Computer Engin. And Informatics, Cyprus University of Technology, Limassol, Cyprus, [2]Laboratory of Medical Physics and Digital Innovation, School of Medicine, Aristotle University of Thessaloniki, Greece

Abstract

The advent of eHealth interventions has created unique opportunities to enhance cancer prevention and care. Notably, telehealth technology, as a patient-centered approach, offers vast benefits, particularly in non-emergency and routine cancer care. It reduces the burden on healthcare facilities, improves accessibility, minimizes infectious transmission, and provides wide-reaching access to caregivers. This technology's transformative potential emphasizes its effectiveness, affordability, and adaptability to various care settings. Furthermore, the integration of teleconsultation and telemonitoring could potentially improve patient outcomes and empower both patients and healthcare providers.

Introduction: With the recent availability of eHealth interventions, we are witnessing a revolution in cancer prevention and care. These interventions not only enhance reach but also allow for information tailoring to meet individual patients' needs. Telehealth technology has emerged as a potent tool in this realm, providing a patient-centered approach that protects the well-being of patients, caregivers, and health professionals. In this context, we introduce the eCAN project.The eCAN project, focusing on telemedicine and telemonitoring solutions in the field of cancer care, will conduct two clinical trials across 10 European countries. These trials aim to examine the effectiveness and perceived usefulness of tele-rehabilitation and tele-psychological support for cancer patients. The project's objective is to evaluate the clinical benefits, adoption challenges, and patient satisfaction associated with these interventions. The research question at the heart of this project is: "To what extent do teleconsultation and telemonitoring programs for rehabilitation and psychological support influence Patient Reported Outcome Measures (PROMs) and Patient Reported Experiences Measures (PREMs) in cancer patients?". The pilot trials will adopt a multi-centric, prospective, randomized, open-label design, focusing on patients affected by breast cancer (Pilot 1a), head and neck cancer (Pilot 1b), and advanced cancer (Pilot 2). This research aspires to provide valuable insights into the efficacy and usability of remote psycho-oncology support among patients with advanced cancers. Moreover, the study will explore Patient Reported Experiences on teleconsultations and telemonitoring in this clinical context using a usability questionnaire, aligning with the development of the utility study within the eCAN project.

AVARIS: Prehospital Emergency Care Ecosystem

Stelios M. Mapouras, Prokopis Frangos

Department of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus

Abstract

Scope: AVARIS is an integrated software system that aims to assist the State Health Services Organization of Cyprus during the procedures of handling emergency cases and Ambulance dispatch.

Methodology: The integrated system is built on a client-server software architecture, which is comprised of a central server acting as the backbone of the system and three integrated applications acting as clients. The backbone of the system is responsible for managing the functionality related to the database of the ecosystem. This includes the provision of the necessary software interfaces and APIs for each client in order to operate smoothly and efficiently. The first subsystem that constitutes a client is a web application that is used in the organization's call center, so as to record all the emergency calls and forward them to the supplementary integrated subsystems. Such subsystem includes an Android application that operates through tablets that reside in the Ambulance vehicles, that is responsible for notifying the appropriate personnel, and also recording the procedures and outcomes of each emergency case. The last integrated client subsystem includes a reporting system that is responsible for providing insights to the management personnel related to the handling of emergency cases.

Results: The ecosystem is able to handle thousands of emergency cases per month while providing the organization with real-time data related to each case. These data can be used as proof of evidence for each case handling and also can be used to improve and optimize the emergency handling procedures.

Conclusion & Future Trends: The future of this ecosystem includes further research and development of the system to provide more functionality as per the organization's needs. In addition, using advanced ICT techniques such as machine learning, AI, and business process mining we are aiming to optimize the operating procedures & Ambulance routes, provide decision support, and make predictions regarding emergency case handling & outcomes.