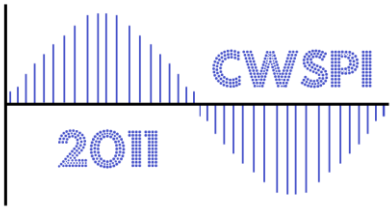
4th Cyprus Workshop on Signal Processing and Informatics

University of Cyprus, *Nicosia, Cyprus*
New Campus, THEE001 ROOM 148

July 14, 2011



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FINAL PROGRAM AND BOOK OF ABSTRACTS

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Preface:

Following the successful one-day workshop we had in the last three years, we would like to cordially invite you to participate in the upcoming 4th Cyprus Workshop on Signal Processing and Informatics (CWSPI 2011).

The overall objective of CWSPI 20011 is to disseminate new research results in several areas and help establish industry, university, and multi-university collaborations. The workshop is mainly targeted to our graduate students to present their most recent findings.

This one-day workshop hosts presentations by faculty, students, and industry researchers in the areas of signal processing image processing and analysis and informatics. A total of 19 abstracts are presented into 3 different sessions. These sessions are the following: *Biomedical Signal, Image and Video Processing, Computer Vision, and Sensor Networks and Intelligent Signal Processing.*. Moreover, we would like to express our sincere thanks to IEEE Cyprus Section, the IEEE EMBS Cyprus Chapter and the Cyprus Local Network for the sponsorship. The purpose of the workshop is to disseminate new research results in several areas and help establish industry, university, government and multi-university collaborations.

Last but not least we would like to express our sincere thanks to the two keynote lecturers: Prof. Marios M. Polycarpou, Director of the KIOS Research Center for Intelligent Systems and Networks, Department of Electrical and Computer Engineering, University of Cyprus, Cyprus, *Intelligent Monitoring, Control and Security of Complex Safety-Critical Systems*, and Prof. Nikos Papanikolopoulos, Department of Computer Science and Engineering, University of Minnesota, USA, *State-of-the-Art Computer Vision Algorithms for Real-World Applications*.

Wishing you a fruitful and joyful event.

E. Kyriakou, C. Loizou, A. Spanias, M.S. Pattichis, C.S. Pattichis
July 2011

Topics:

- Digital signal and image processing
- Sensor networks and signal analysis
- Biomedical signal, image, and video analysis
- Wireless communications and signal processing
- Multimedia systems
- Speech, and audio, processing
- Cognitive systems
- FPGAS in signal, image and video processing.

Workshop Organizing Committee:

Chair:	*E. Kyriakou,* Frederick University, Cyprus
Co-Chair:	*C. Loizou*, Intercollege, Cyprus
Program Chair:	*A. Spanias,* Arizona State University, USA
Program Co-Chair:	*M.S. Pattichis*, University of New Mexico, USA
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Technical Program

TIME	SESSIONS
12:30	**Introductions and Refreshments**
12:50	**Welcome** ***Andreas Spanias,* Arizona State University, USA**
	SESSION 1: Keynote Lecture 1 **Chair: *Andreas Spanias,* ECEE School, SenSIP center, Arizona State University, USA**
13:00	**Intelligent Monitoring, Control and Security of Complex Safety-Critical Systems** *Marios M. Polycarpou* Director of the KIOS Research Center for Intelligent Systems and Networks, Department of Electrical and Computer Engineering, University of Cyprus, Cyprus
	SESSION 2: Biomedical Signal, Image and Video Processing **Chair: *Efthyvoulos Kyriakou,* Frederick University, Cyprus**
13:30	**A comparative study on filtering protein secondary structure prediction** *Petros Kountouris[1], Michalis Agathocleous[1], Vasilis Promponas[2], Georgia Christodoulou[1], Simos Hadjicostas[1], Vassilis Vassiliades[1] and Chris Christodoulou[1]* [1]Department of Computer Science, University of Cyprus, Nicosia, Cyprus [2]Department of Biological Sciences, University of Cyprus, Nicosia, Cyprus
13:45	**Discrimination of 'awake' and 'anaesthetised' state in propofol general anaesthesia** *Nicoletta Nicolaou[1], Saverios Houris[2], and Julius Georgiou[1]* [1]KIOS Research Centre, and Holistic Electronics Research Lab, Dept. of Electrical and Computer Engineering, University of Cyprus, Cyprus [2]Anaesthesiology Dept., Nicosia General Hospital, Cyprus
14:00	**Initial Design and Development Steps through a Portable monitoring device for Children with Suspected Cardiac Arrhythmias** *Constantinos Giannopoulos[1], Athos Antoniades[2], Efthyvoulos Kyriacou[1], and Constantinos Pattichis[2]* [1]Department of Computer Science and Engineering, Frederick University, Cyprus [2]Department of Computer Science, University of Cyprus, Cyprus
14:15	**Evaluation of Gray-Level Co-Occurrence Features for Abnormality Detection** *Gregoris Liasis[1] and Styliani Petroudi[2]* [1]Open University of Cyprus, Nicosia, Cyprus [2]University of Cyprus, Nicosia, Cyprus
14:30	**A Simplified 2D Navigation System For Post-Exam Hysteroscopy Imaging** *Elena Michael[1], Ioannis Constantinou[1], Ioanna Herakleous[1], Marios S. Neofytou[1], Constantinos S. Pattichis[1], Vasilios Tanos[2]* [1]Department of Computer Science, University of Cyprus, Cyprus [2]Aretaeio Hospital, Nicosia, Cyprus
14:45	**Comparison of Texture Feature Analysis Techniques in Hysteroscopy Imaging** *Ioannis Constantinou[1], Marios S. Pattichis[2], Constantinos S. Pattichis[1],* *Marios S. Neofytou[1], Vasilios Tanos[3]*

	[1]Department of Computer Science, University of Cyprus, Cyprus [2]Dept. of Elect. and Comp. Eng., University of New Mexico, Albuquerque, USA [3]Aretaeio Hospital, Nicosia, Cyprus
15:00	**Emerging Methods in Image Processing: Longitudinal Texture Image Processing and Survival Analysis** *Marios S. Pattichis* Dept. of Elect. and Comp. Eng., University of New Mexico, Albuquerque, USA
15:15 – 15:45	**Coffee Break**
	SESSION 3: Keynote Lecture 2 **Chair: *Takis Kasparis,* Cyprus University of Technology**
15:45	**State-of-the-Art Computer Vision Algorithms for Real-World Applications** *Ravishankar Sivalingam, Guruprasad Somasundaram, Vassilios Morellas, and Nikos Papanikolopoulos* Department of Computer Science and Engineering, University of Minnesota, USA
	SESSION 4: Computer Vision **Chair: *Christos Loizou,* Intercollege, Cyprus**
16:15	**A novel hybrid motion object detection and segmentation algorithm based on a statistical and adaptive threshold** *Lakis Christodoulou[1], Takis Kasparis[1], and Christos Loizou[2]* [1]Dep. of Electrical Engineering & Information Technology, (EE&IT), Cyprus University of Technology [2]Intercollege, Dep. of Computer Science, School of Sciences, Limassol, Cyprus
16:30	**Hardware Object Detection using Depth Information** *C. Kyrkou and T. Theocharides* KIOS Research Center for Intelligent Systems and Networks, Department of Electrical and Computer Engineering, University of Cyprus
16:45	**A Real-Time FPGA Computation of the Disparity Map using Edge Information** *C. Ttofis, S. Hadjitheophanous, A. S. Georghiades, and T. Theocharides* KIOS Research Center for Intelligent Systems and Networks, Department of Electrical and Computer Engineering, University of Cyprus
17:00	**Facial Age Estimation: Lessons Learned by Humans** *Thomas Photiadis[1], Andreas Lanitis[2], and Panayiotis Zaphiris[3]* [1]Dept of Multimedia and Graphic Arts, Cyprus University of Technology [2]Dept of Multimedia and Graphic Arts, Cyprus University of Technology [3]Dept of Multimedia and Graphic Arts, Cyprus University of Technology
17:15	**Icon Restoration Using a Byzantine Style Specific Model** *Andreas Lanitis[1], Georgios Stylianou[2], and Chrysanthos Voutounos[3]* [1]Dept of Multimedia and Graphic Arts, Cyprus University of Technology [2]Dept. of Computer Science and Engineering, European University Cyprus [3]Dept of Multimedia and Graphic Arts, Cyprus University of Technology
17:30 – 17:45	**Coffee Break**
	SESSION 5: Sensor Networks and Intelligent Signal Processing **Chair: *Costas Pitris,* University of Cyprus, Cyprus**

17:45	**Congestion Mitigation in Wireless Sensor Networks using Mobile Nodes** *Marios Koutroullos, Charalambos Sergiou, and Vasos Vassiliou* Networks Research Laboratory, Department of Computer Science, University of Cyprus, Nicosia, Cyprus
18:00	**A Basic Dynamic Traffic Model for Wireless Sensor Networks** *Charalambos Sergiou and Vasos Vassiliou* Networks Research Laboratory, Department of Computer Science, University of Cyprus, Nicosia, Cyprus
18:15	**Building Energy-aware Smart Homes using Web Technologies** *Andreas Kamilaris, and Andreas Pitsillides* University of Cyprus, Nicosia, Cyprus
18:30	**Gait-based Person And Gender Recognition Using Micro-Doppler Signatures** *Guillaume Garreau[1], Charalambos M. Andreou[1], Andreas G. Andreou[1], Salvador Dura-Bernal[2], Thomas Wennekers[2], Sue Denham[2], and Julius Georgiou[1]* [1]Holistic Electronics Research Lab, University of Cyprus, Nicosia, Cyprus [2]Centre for Robotics and Neural Systems, University of Plymouth, United Kingdom
18:45	**Isolated Word Endpoint Detection using Time-Frequency Kernels** *Alexandros Kyriakides[1], Costas Pitris[1], and Andreas Spanias[2]* [1]University of Cyprus, Nicosia, Cyprus [2]Arizona State University, USA
19:00	**CLOSING REMARKS**

Abstracts

Session 1: Keynote Lecture 1

Intelligent Monitoring, Control and Security of Complex Safety-Critical Systems

Marios M. Polycarpou

Director of the KIOS Research Center for Intelligent Systems and Networks,
Department of Electrical and Computer Engineering, University of Cyprus, Cyprus

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Abstract:
Electronic devices are starting to become widely available for monitoring and controlling large-scale distributed systems. These devices may include sensing capabilities for on-line measurement, actuators for controlling certain variables, microprocessors for processing information and making real-time decisions based on designed algorithms, and telecommunication units for exchanging information with other electronic devices or possibly with human operators. A collection of such devices may be referred to as a networked intelligent agent system. Such systems have the capability to generate a huge volume of spatial-temporal data that can be used for monitoring and control applications of large-scale distributed systems. One of the most important research challenges in the years ahead is the development of information processing methodologies that can be used to extract meaning and knowledge out of the ever-increasing electronic information that will become available. Even more important is the capability to utilize the information that is being produced to design software and devices that operate seamlessly, autonomously and reliably in some intelligent manner. The ultimate objective is to design networked intelligent agent systems that can make appropriate real-time decisions in the management of large-scale distributed systems, while also providing useful high-level information to human operators. The goal of this presentation is to motivate the need for health monitoring, control and security of complex safety-critical systems and to provide a fault diagnosis methodology for detecting, isolating and accommodating both abrupt and incipient faults in a class of complex nonlinear dynamic systems. Various adaptive approximation techniques and learning algorithms will be presented and illustrated, and directions for future research will be discussed.

Short bio:
Marios M. Polycarpou is a Professor of Electrical and Computer Engineering and the Director of the KIOS Research Center for Intelligent Systems and Networks at the University of Cyprus. He received the B.A. degree in Computer Science and the B.Sc. degree in Electrical Engineering both from Rice University, Houston, TX, USA in 1987, and the M.S. and Ph.D. degrees in Electrical Engineering from the University of Southern California, Los Angeles, CA, in 1989 and 1992 respectively. In 1992, he joined the University of Cincinnati, Ohio, USA, where he reached the rank of Professor of Electrical and Computer Engineering and Computer Science. In 2001, he was the first faculty to join the newly established Department of Electrical and Computer Engineering at the University of Cyprus, where he served as founding Department Chair from 2001 to 2008. His teaching and research interests are in intelligent systems and control, adaptive and cooperative control systems, computational intelligence, fault diagnosis and distributed agents. Dr. Polycarpou has published more than 200 articles in refereed journals, edited books and refereed conference proceedings, and co-authored the book Adaptive Approximation Based Control, published by Wiley in 2006. He is also the holder of 3 patents.

Prof. Polycarpou served as the Editor-in-Chief of the IEEE Transactions on Neural Networks between 2004-2010. He currently serves on the Advisory Board of two international journals and is past Associate Editor of the IEEE Transactions on Neural Networks (1998-2003) and of the IEEE Transactions on Automatic Control (1999-2002). He served as the Chair of the Technical Committee on Intelligent Control, IEEE Control Systems Society (2003-05), as Vice President, Conferences, of the IEEE Computational Intelligence Society (2002-03) and as Chair of Awards Committee for the IEEE Computational Intelligence Society (2010). Dr. Polycarpou was the recipient of the William H. Middendorf Research Excellence Award at the University of Cincinnati (1997) and was nominated by students for the Professor of the Year award (1996). He has been invited as Keynote Plenary Speaker at 16 international conferences during the last five years and is currently an IEEE Distinguished Lecturer in computational intelligence. He participated in more than 50 research projects/grants, funded by several agencies and industry in the United States, by the European Commission and by the Research Promotion Foundation of Cyprus. Dr. Polycarpou is a Fellow of the IEEE and the President-Elect of the IEEE Computational Intelligence Society.

SESSION 2: Biomedical Signal, Image and Video Processing

A comparative study on filtering protein secondary structure prediction

Petros Kountouris[1], Michalis Agathocleous[1], Vasilis Promponas[2] , Georgia Christodoulou[1], Simos Hadjicostas[1], Vassilis Vassiliades[1] and Chris Christodoulou[1]

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[2]Department of Biological Sciences, University of Cyprus, Nicosia, Cyprus

Abstract:

Over the past 20 years, machine learning techniques and evolutionary information have significantly boosted the quality of protein secondary structure prediction methods. Moreover, filtering of the final predictions have been shown to improve and smooth the predictions, providing more realistic results. Both machine learning techniques and empirical rules have been used to filter the sequence-to-structure secondary structure prediction. Despite being employed widely, to the best of our knowledge, no study has been carried out to find the most suitable filtering technique. In this work, we perform a comparative study on the challenging problem of filtering, utilising both widely used empirical smoothing rules and machine learning techniques. In particular, we predicted the secondary structure using an ensemble of Bidirectional Recurrent Neural Networks and employed the WEKA software package to evaluate filtering with the following algorithms: Naive Bayes, Classification And Regression Tree, Logistic function, Radial Basis Function (RBF) Neural Network, k-Nearest Neighbour, Multilayer Perceptron, J48 decision trees, Random Forest and combinations of the above using several voting schemes. In addition, we filtered the predictions using Support Vector Machines (SVM) by utilising the LibSVM software package. For this task, we also implemented a Hidden Markov Model and an RBF Network, which is initialised by a Self-Organising Map. Different local window sizes were tested to select the optimal one for each approach. Notably, the Logistic function and the SVM have been found to be superior to the tested methods in terms of both predictive accuracy (Q3) and the Segment Overlap score, while combinations of machine learning techniques and empirical rules improved the quality of the predictions even further.

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Discrimination of 'awake' and 'anaesthetised' state in propofol general anaesthesia

Nicoletta Nicolaou[1], Saverios Houris[2], MD, and Julius Georgiou[1]

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[2]Anaesthesiology Dept., Nicosia General Hospital, Cyprus

Abstract:

General anaesthesia (GA) is a reversible state of unconsciousness and depression of reflexes to afferent stimuli, induced by the administration of chemical agents [1]. Awareness during GA, even though considered a rare event, has severe psychological consequences for those who experience it. Devices that utilise the electrical brain activity (EEG) for monitoring the depth of anaesthesia provide valuable means of identifying awareness during surgery.

We investigate the use of three measures for discrimination of 'awake' and 'anaesthetised' state from the EEG of 18 male patients during surgery under propofol general anaesthesia. The data were collected at the Nicosia General Hospital. Segments corresponding to recovery of consciousness (ROC) were extracted from the continuous EEG records. ROC was defined as the point at which the patient responded to verbal or tactile stimuli at the end of surgery. For each subject, 5 brain areas were defined as the average EEG activity from 19 available electrodes: left and right frontal, left and right posterior, and midline areas. The three measures are Granger causality (GC) [2], Approximate Entropy (ApEn) [3], and Permutation Entropy (PE) [4]. Classification is performed with a Support Vector Machine (linear and nonlinear kernels).

Performance was evaluated over B=100 bootstrap repetitions as the: $Specificity = SP = \frac{T_{ruP}}{T_{otP}}$, $Sensitivity = SE = \frac{T_{ruN}}{T_{otN}}$ and $Accuracy = Acc = \frac{1}{2}\left(\frac{1}{B}\sum_{b=1}^{B}\frac{T_{ruP}}{T_{otP}} + \frac{1}{B}\sum_{b=1}^{B}\frac{T_{ruN}}{T_{otN}}\right)$. T_{ruP} (T_{ruN}) are the true positives ('awake') and true negatives ('anaesthetised') respectively. T_{otP} (T_{otN}) is the total number of positive (negative) examples. The results are shown in table 1. It can be seen that all measures provide high performance and are appropriate for discriminating 'awake' and 'anaesthetised' states. However, GC has the advantage that it captures the underlying changes in effective connectivity, while ApEn and PE capture frequency-related changes in the EEG. ApEn and PE track the decrease in frequency of the EEG that is observed under anaesthesia. However, this is not unique to anaesthesia and is also observed for other physiological processes, such as sleep.

Table 1. Average performance for GC, ApEn and PE for ROC.

Features	Specificity		Sensitivity		Accuracy	
	Linear	NonLinear	Linear	NonLinear	Linear	NonLinear
GC	0.899	0.909	0.844	0.911	0.871	0.910
ApEn	0.940	0.951	0.935	0.951	0.938	0.951
PE	0.962	0.966	0.948	0.961	0.955	0.963

References

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[3] S. M. Pincus, I. M. Gladstone, and R. A. Ehrenkranz, "A regularity statistic for medical data analysis," *J Clin Monit,* vol. 7, pp. 335-345, 1991
[4] C. Bandt, and B. Pompe, "Permutation Entropy - a natural complexity measure for time series," *Phys Rev Lett,* vol. 88, p. 174102, 2002.

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Initial Design and Development Steps through a Portable monitoring device for Children with Suspected Cardiac Arrhythmias

Constantinos Giannopoulos[1], Athos Antoniades[2], Efthyvoulos Kyriacou[1], Constantinos Pattichis[2]

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Abstract:

Children with suspected cardiac arrhythmias constitute one of the most complicated problems in cardiology both in terms of diagnosis and management. Continuous monitoring of such subjects can significantly improve the identification of cardiac arrhythmias. In order to achieve this goal we need devices that can continuously monitor ECG signals for the longest possible periods of time. Nowadays this is achieved by using holter devices which can monitor a subject for a limited period of time. Advances in modern computing and communication technologies enable the creation of smaller devices which can work for longer periods of time.

Through this work we present the initial steps for the development of a portable medical device that can be used for continuous monitoring of a) ECG vital signals 3-12 leads. b) Exact GPS position of the carrier. All information will be continuously forwarded to a web based system which will be used by the expert doctors in order to monitor the patients. The overall system functionality is actually divided in two cases. a) The indoor case where the patient is located in his/ her house and the communication with the hospital's server is established via an ad hoc ZigBee network. b) Outdoor Environment case, where the patient is outside the house and the communication with the doctors' server is established via GPRS/3G networks. At the same time all acquired data will be locally stored on a memory card on the portable device.

The device is based on a modular architecture in order to enable future expansions. The central control is based on an Arduino microcontroller platform (8 Bit Atmega 2560 with 16MHz speed is used). The microcontroller coordinates all device operations and controls all data streams. In detail the device has a) a XBEE 2.5 PRO ZNet RF module in order to support the ad hoc network, operating at 2.4GHz with an indoor range of up to 100m and RF data rate of up to 250,000bps. This module will be used during the indoor case. b) An ADH8066 GSM/GPRS module with built in TCP/IP/FTP support in order to support transmission during the outdoor case. c) An EM-406A GPS module in order to get the exact location of the patient with NMEA 0183 data protocol support, a 20 channel receiver and up to 5 meters accuracy. d) A Texas Instruments- ADS1298R ECG recording module able to record 3-12 leads of ECG, with electrode-off detection, integrated Respiration Impedance measurement, digital PACE detection capability and built in Oscillator and reference, and e) A SD Memory card module where data received from the several modules are recorded

Initial design and development steps have been completed. This A-prototype is able to get GPS data and successfully transmit them over the ad hoc network. The future steps will be to integrate all modules and complete the device so as to get it through a small pilot testing on healthy volunteers.

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Evaluation of Gray-Level Co-Occurrence Features for Abnormality Detection

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Abstract:

Breast cancer is one of the most common causes of death amongst women. X-ray mammography is currently the modality used for population screening. This paper investigates the use of different texture features evaluated from gray-level co-occurrence matrix for detecting and classifying abnormalities. Gray-level co-occurrence matrices (GLCMs) show the relative frequency with which different combinations of different pixel intensity values as certain distances occur in an image. The matrices are used for the evaluation of different texture features such as autocorrelation, contrast, cluster prominence, energy, entropy, homogeneity. These features are computed for the different GLCMs for different pixel distances. For characterization of the abnormalities the different features are initially evaluated on ground truth segmentation provided by expert radiologists. The ability of the corresponding features to distinctly characterize different abnormalities is then evaluated by comparing the range of values the features achieve for normal and abnormal regions of mammograms and through the use of Principal Component Analysis. The different features are evaluated not only on the entire training set, but also on subsets that hold mammograms corresponding to different breast density classes. This work will present how the values of these features range not only for normal and abnormal tissue but also for different tissue density. Following different features are evaluated on mammograms with low density classification. For the feature selection the importance of each and every feature and its effect on the classification accuracy is investigated. The features which provided the best discrimination are selected for abnormality characterization. For this, the breast region is first segmented using contrast enhancement and level sets. Following the segmented region is block processed and the features are evaluated for each block. The resulting values are used to classify the different block regions as possible abnormalities and for assessment of the algorithm for possible mass detection and classification. Three textural features contrast, energy and entropy were selected for the assessment of the algorithm. Contrast measures the amount of local variations present in an image, entropy is a measure of nonuniformity or the complexity of the texture and energy is a measure of the uniformity. Since abnormal and normal cases were shown to have significant differences in terms of their texture uniformity, normal images contained smooth texture while abnormal images were heterogeneous, the utilization of entropy and energy along with contrast used for abnormality detection.

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A Simplified 2D Navigation System For Hysteroscopy Imaging

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Abstract:

Within the female population, gynecological cancer accounts for the second highest mortality rate. Cancer of the endometrium is the most common cancer of the female reproductive organs, in the United States. Early diagnosis and treatment of gynecological cancer are essential for better quality and longer life. The hysteroscopy examination is considered to be the gold-standard technique for the diagnosis of intrauterine pathology and for the assessment of endometrial cancer.

In previous studies by our group, we have shown that the use of a standardised protocol for capturing and analyzing endoscopic video facilitates the wide spread use of quantitative analysis as well as the use of CAD systems in gynaecological endoscopy. The objective of this paper is to introduce a simplified 2D navigation system for post-exam hysteroscopy imaging. This will help the physician in gaining a better understanding of the tissue-ROI under investigation, especially in the case of suspicious regions that need to be biopsied. To the best of our knowledge, no such system exists for hysteroscopy imaging.

The the 2D real time navigation system for hysteroscopy imaging is based on a position sensor. The position sensor is attached at the upper part of the hysteroscope. It records the x, y, and z coordinates, and the three angles, azimuth, elevation and roll. The analog video output of the hysteroscopy camera is digitized using a frame grabber. Both the position sensor data and the corresponding video frames are inputted to the k KD-tree algorithm. The KD-tree is built, supporting also the post-exam navigation and searching.

The proposed system was evaluated in virtual endometrium models with very satisfactory results, both with respect to and the position sensor measurement errors, as well as with respect to the output of the k KD-tree algorithm. This system performance was very acceptable by the physician.

The 2D navigation system, combined with the ROI quantitative image analysis system will help the physician in gaining a better understanding of the tissue pathophysiology of the ROI under investigation, especially in the case of suspicious regions that need to be biopsied. More work is needed to investigate thoroughly the aforementioned two systems in the clinical context.

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Comparison of Texture Feature Analysis Techniques in Hysteroscopy Imaging

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Abstract:

Within the female population, gynecological cancer accounts for the second highest mortality rate. Early detection and treatment are essential factors for better quality and longer life. The objective of this paper is to present a comparison of texture feature analysis techniques for the assessment of endometrial imaging tissue in terms of classification score.

Three texture feature analysis techniques were implemented: (a) Classical texture feature analysis techniques based on (i) Statistical Features (SF), (ii) Spatial Gray Level Dependence Matrices (SGLDM), and (iii) Gray Level Difference Statistics (GLDS), (b) a novel spectrum analysis technique based on circular masking spectrum statistical feature extraction, and (c) a new Amplitude Modulation-Frequency Modulation (AM-FM) technique based on adaptive filtering.

The results of the above texture feature analysis techniques were evaluated in terms of the classification accuracy of normal Vs abnormal ROIs of 64 by 64 pixels on a total sample of 140 ROIs (70 normal and 70 abnormal, collected from 40 subjets). SVM models were developed based on 20 bootstrapping sets (trained on 50% of the ROIs, and evaluated on the rest 50% of the ROIs).. The results for evaluation for the texture feature analysis methods showed that: (a) the classical texture feature techniques achieved a correct classifications score (CC) of 67%, (b) the novel spectrum analysis technique based on circular masking statistical feature achieved a CC score of 75%, and (c) the new AM-FM technique based on adaptive filtering achieved a CC score of 95%.

The results show that the new AM-FM technique based on adaptive filtering produced the most robust and powerful texture features. More work is needed in order to improve the AM-FM computational complexity of the proposed new method, as well as to be evaluated on more subjects.

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Emerging Methods in Image Processing: Longitudinal Texture Image Processing and Survival Analysis

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Abstract:

In this talk, I will discuss the integration of methods from statistical survival analysis into longitudinal texture image analysis. The primary goal of the talk is to argue for the strong promise of pursuing such methods in disease risk assessment to help physicians make clinical decisions with statistical confidence.

SESSION 3: Keynote Lecture 2

State-of-the-Art Computer Vision Algorithms for Real-World Applications

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Abstract:

Computer vision entails mining information from images and video to extract meaningful information. We encounter state-of-the-art computer vision techniques every day - surveillance camera systems, face detection in our digital cameras, sports analysis, and the recent very popular Kinect system by Microsoft, to name a few. In all of these situations, computer algorithms process images and video to get useful information, so that a human user need not look through, say, hours and hours of surveillance footage. Computer vision research has come a long way over the decades, and today you can take a picture of an object on your cell phone camera and search for it, without typing a word. We will talk about some of the cutting-edge computer vision algorithms we are developing at the Distributed Robotics Laboratory at the University of Minnesota. We will see techniques that try to understand the underlying notion of saliency in image information, which is used not only for improved object recognition and classification, but also for identifying peculiar objects. Think of spotting the one car among thousands, which does not have a rear passenger door. Robust algorithms are being developed for everyday applications of identification of human actions such as walking, running, and waving, tracking and identification of persons across large surveillance networks, face detection and recognition, and even cancer recognition from images of tissue samples. These are some of the real-world problems that state-of-the-art computer vision algorithms tackle today.

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Short bio:

Nikolaos P. Papanikolopoulos (IEEE Fellow) received the Diploma degree in electrical and computer engineering from the National Technical University of Athens, Athens, Greece, in 1987, the M.S.E.E. in electrical engineering from Carnegie Mellon University (CMU), Pittsburgh, PA, in 1988, and the Ph.D. in electrical and computer engineering from Carnegie Mellon University, Pittsburgh, PA, in 1992. Currently, he is a Distinguished McKnight University Professor in the Department of Computer Science at the University of Minnesota and Director of the Center for Distributed Robotics and SECTTRA. His research interests include computer vision, sensors for transportation applications, robotics, and control. He has authored or coauthored more than 260 journal and conference papers in the above areas (sixty six refereed journal papers). He was finalist for the Anton Philips Award for Best Student Paper in the 1991 IEEE Int. Conf. on Robotics and Automation and recipient of the best Video Award in the 2000 IEEE Int. Conf. on Robotics and Automation. Furthermore, he was recipient of the Kritski fellowship in 1986 and 1987. He was a McKnight Land-Grant Professor at the University of Minnesota for the period 1995-1997 and has received the NSF Research Initiation and Early Career Development Awards. He was also awarded the Faculty Creativity Award from the University of Minnesota. One of his papers (co-authored by O. Masoud) was awarded the IEEE VTS 2001 Best Land Transportation Paper Award. Finally, he has received grants from DARPA, DHS, U.S. Army, U.S. Air Force, Sandia National Laboratories, NSF, Lockheed Martin, Microsoft, INEEL, USDOT, MN/DOT, Honeywell, and 3M (more than $20M).

SESSION 4: Computer Vision

A novel hybrid motion object detection and segmentation algorithm based on a statistical and adaptive threshold

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Abstract:

The current research project proposes a novel hybrid motion object detection and segmentation algorithm based on a statistical and adaptive threshold. Moving object detection and segmentation is very important in intelligent video surveillance.
The main motivation of this research work is to overcome current technical difficulties of existing motion and segmentation techniques, and realize efficient and fast detection and segmentation algorithm. The actual driven-motivation is to use the proposed hybrid motion object detection and segmentation algorithm for an introduced 3D Stereo/Multi-view image sensor system introducing multi-data fusion and modeling for smart video surveillance and motion object monitoring. The introduced new hybrid object detection and segmentation would be deployed and used in a prototype 3D Stereo vision system for automatic and intelligent surveillance and monitoring that will provide object recognition and tracking. In the case of stereo or multi-view video capturing, recording, processing, and analyzing it is very important to develop and build efficient, robust, and fast detection and segmentation algorithms. The research project will focus on developing intelligent, biologically inspired image and video analysis algorithms that are capable of performing relevant human or other object motion surveillance tasks based on visual information acquired from one and more cameras.

We are introducing a smart and efficient algorithm based on motion detection, foreground and background segmentation, using DSP and adaptive threshold techniques that are superior of existing conventional motion object detection and segmentation algorithms. The proposed algorithm is based on a hybrid motion technique that relies on the three frame differencing and on statistical quantities, such as the mean and the variance. Also, the algorithm shows a foreground-background segmentation methodology that is combined with a moving detection algorithm. The hybrid motion algorithm has been tested and verified for gate entrance and access control for human object surveillance system. Experimental results show the improved hybrid motion algorithm overcomes the technical difficulties of the three frame-differencing method. The hybrid motion algorithm has a low computational complexity, a high detection segmentation accuracy rate, a fast and computational processing speed. This methodology is also providing a low-cost web-camera solution for visual surveillance and automated monitoring applications, efficient and robust for video analytics. The main benefit is the development of a novel hybrid motion detection and segmentation video object algorithm based on adaptive and statistical DSP algorithms.

Future work involves additional adaptive motion detection and probability techniques, multi-object detection-segmentation-recognition, and incorporating 3D Stereo/Multi-view video processing based on 3D computer vision, 3D Depth maps, and 3D object reconstruction.

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Hardware Object Detection using Depth Information

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Abstract:

Object detection is a vital task in several emerging applications, requiring real-time detection frame-rate and low energy consumption for use in embedded and mobile devices. This paper proposes a hardware-based, depth-directed search method for reducing the search space involved in object detection, resulting in significant speed-ups and energy savings. The proposed architecture utilizes the disparity values computed from a stereoscopic camera setup, in an attempt to direct the detection classifier to regions that contain objects of interest. By eliminating large amounts of search data, the proposed system achieves both performance gains and reduced energy consumption. FPGA simulation results indicate performance speedups up to 4.7 times and high energy savings ranging from 41-48%, when compared to the traditional sliding window approach.

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A Real-Time FPGA Computation of the Disparity Map using Edge Information

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Abstract:

Disparity map computation is a vital step in extracting depth information from stereo images, and thus, has been used in a wide range of emerging computer vision applications, such as geographic information systems, satellite-based earth and space exploration, autonomous robots and vehicles, pedestrian detection and security systems. Existing software-based implementations cannot satisfy the performance requirements for such constrained systems; hence an embedded hardware mechanism might be more suitable. In this work, we present an architecture of a disparity map computation system, which we implement on Virtex-2 Pro FPGA. The architecture uses a Sobel edge detector to achieve real-time performance (75 fps for a stereo image pair of 320x240 pixels), and is configurable in terms of various application parameters, making it suitable for a number of application environments. This work also presents a design exploration on algorithmic parameters such as disparity range, correlation window size, and input image size, illustrating the impact on the performance for each parameter.

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Facial Age Estimation: Lessons Learned by Humans

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Abstract:

Facial age estimation is the process where either the exact age of a subject or the age group of a subject is determined based on facial information. Facial estimation could figure in numerous real life applications such as age-adaptive human computer interaction, age-based access control to physical sites and/or internet sites and age-based surveillance systems. Recently the topic of automatic age estimation received increased attention and as a result numerous age estimation algorithms where reported in the literature. Although in some cases the results reported are impressive, more effort is required in developing accurate age estimation algorithms capable of handling unconstrained face images where the lighting, facial orientation and image quality may vary considerably. With our work we aim perform a thorough investigation in the process of facial age estimation as performed by human observers. By analyzing the ways in which humans perceive the age of a person we aim to devise improved algorithms that perform more accurately the process of age estimation. As part of our preliminary work, 25 face images were presented to 36 volunteers who were asked to provide an estimate of the age of the person in the corresponding images. During the process the areas of the images that attracted the attention of the volunteers were recorded using an eye tracker. Eye-fixation data is analyzed by generating statistical models describing the main trends of attention focus adopted by different users. The results of a preliminary analysis in relation to personal characteristics of the volunteers and in relation to characteristics of the faces in the images used, reveals important conclusions related to the process of facial age estimation. It is expected that the conclusions derived from this experiment will be crucial in developing more accurate facial estimation algorithms. The overall approach adopted in this work can also be used in other application domains where the analysis of the behavior of humans can provide essential information that can facilitate the development of automated applications.

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Icon Restoration Using a Byzantine Style Specific Model

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Abstract:

Byzantine art describes the development of the unique artistic style of the artefacts created in Byzantine Empire. In contrast to the naturalistic painting, a Byzantine image does not attempt to imitate accurately human physiognomies but instead follows a unique design style governed by geometric and chromatic rules that define system of “en face” analogies. That system describes the use of axes and partitions for human face representation which is based on harmonic analogies between face characteristics like the forehead, hair, eye brows, eyes, the nose, cheek bones, ears, lips and the chin.

Unfortunately Byzantine art saved to our days is often damaged either due to natural causes or deliberate human actions. With our work we propose a method that can be used for virtual restoration of faces appearing in Byzantine icons using dedicated image processing methods that enable the restoration of the facial shape and texture. Given a 2D face image showing a face appearing in an icon we first locate on a face a number of landmarks on the visible parts of the face using a semi-automatic specially developed tool. Based on the landmarks located on the face (corresponding to the non-damaged facial regions) a 3D reconstruction method is employed in order to estimate the 3D structure of the face. A key aspect of our work is the use of a customized 3D deformable face model suitable for representing the geometry of Byzantine faces, the so called Byzantine Style Specific Model (BSSM). A BSSM is generated by enforcing rule-based constraints on a deformable model trained using 3D scans of human faces. The use of a BSSM ensures that the Byzantine style is preserved during the process of 3D reconstruction and the process of shape restoration. Once the shape of a damaged face is restored a texture restoration algorithm is applied on the 3D representations so that the texture of the damaged regions is predicted based on the texture of non-damaged regions.

The work reported in this abstract builds on our previous work in the area. However, a key recent development is the use of the customized geometric Byzantine-style model (BSSM) during the shape-restoration process. Experimental results prove the superiority of using the customized BSSM as opposed to the use of a model representing the geometry of human faces.

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SESSION 5: Sensor Networks and Intelligent Signal Processing

Congestion Mitigation in Wireless Sensor Networks using Mobile Nodes

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Abstract:

Network Congestion is a common issue in Wireless Sensor Networks. In some cases the event duration may be extensive and as a result node buffers may overflow and a huge amount of information may be lost. Our approach introduces the notion of using mobile nodes into such networks, to mitigate congestion and consequently improve the performance of the network. This idea is effective in situations where congestion happens repeatedly, or is of high duration, or even permanent. The purpose is not to replace existing congestion control or routing algorithms but instead, to mitigate congestion, running in parallel with them.

Our solution comprises four mechanisms: the Congestion Detection Mechanism, the Congested Node Selection Mechanism, the Congestion Notification Mechanism, and the Reaction Mechanism.

In the Congestion Detection Mechanism the nodes monitor their available buffer and when this drops below a threshold they start rate monitoring for all of their senders. At the end of this period, if the sum of rates including the rate that the node generates data is higher than some threshold they trigger the next mechanism. On the other hand if the sum is lower they continue rate monitoring. Rate monitoring is disabled if the available buffer rises above a safety threshold. In the Congestion Selection Mechanism, the node decides which nodes to select to keep on serving and which ones to request support for. The criteria for this selection include the age of the link and the link quality. In addition, the congested node aims to minimize the number of handoffs so it tries to minimize the number of nodes that it will request support for. The list of nodes that need support is created and included into a Congestion Notification Message which is sent to the sink. The Congestion Notification Mechanism aims to deliver this message to the sink with the highest priority. The last mechanism involved is the Reaction Mechanism. In this mechanism the sink decides how many paths to build, how many mobile nodes to use, and where to place them in the areas areas between the congested nodes and the sink. These newly created paths provide alternate paths to the sink for the nodes that were loading the congested node.

Simulations results prove that newly created paths improved the network performance both in packet drop reduction and throughput increase. Our future work is to complete the implementation of Mobile-CC mechanisms and experiment with other ideas, like the use of a distributed decision algorithm and the use of the sender nodes' location for deciding which nodes to continue serving.

A Basic Dynamic Traffic Model for Wireless Sensor Networks

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Abstract:

In numerous models arising in engineering applications and the applied sciences, the one-dimensional flow of a quantity can be described by a *conservation law*, that is, a partial differential equation of the type

$\partial_t \mathbf{u} + \partial_x \mathbf{f}(x, \mathbf{u}) = 0$ (1)

where **u** is a vector of state variables (for example, density, linear momentum and energy of a single fluid; or concentrations of individual species in a multi-species flow model), and we seek **u** as a function of position *x* and time *t* .
In this work we firstly discuss the existence of a *conservation law* concerning packet flows, in specific instances of Wireless Sensor Networks, and using this law we define a basic traffic flow model for WSNs.

Initially we introduce three basic variables. These are traffic density ***ρ(x, t)***, hops passing rate ***r*(*x, t*)** and flow ***f*(*x, t*)**. Traffic density is the number of packets that exist in position x at time t, hops traffic rate is the number of hops that a packet is passing in a specific time unit and flow is the product of ***ρ(x, t***) *x* ***r*(*x, t*)** which is the number of packets per time unit that pass point x at time t

f(x,t)= ρ(x, t) *x* ***r*(*x, t*)** (2)

We suggest that the relation between them can be described by the fundamental diagram and Eq. (1), having the form of a nonlinear hyperbolic conservation law, which is referred to in this context as the Lighthill-Whitham- Richards (LWR) model of vehicular traffic.

Finally, we check how this model applies in the two basic methods for congestion control in WSNs. These are ‘’resource control’’ and ‘’traffic control’’. In the ”traffic control” method, congestion is controlled by reducing the number of transmitted data packets to node(s) that experience buffer congestion or to the area that due to simultaneous transmission faces packets collisions in the medium. On the other hand in the ”resource control” method the data rate remains the same and data packets employ the resources of the extra nodes which are not in the initial path from a source to the sink (multiple or alternative path creation).

Building Energy-aware Smart Homes using Web Technologies

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Abstract:

Household appliances are being equipped with embedded micro-controllers and wireless transceivers, offering smart behavior. These augmented appliances form wireless networks and transform residential areas into smart homes. Residential smart meters extend smart homes into energy-aware environments.

Advancements such as the effective penetration of the Internet in embedded computing and the promising practice of the Web of Things, allow the realization of Web-oriented smart homes.

We have developed a Web-based application framework for smart homes, supporting concurrent interaction from multiple family members. Our system includes a 6LoWPAN-based wireless sensor network inside the home environment, as well as a wireless smart metering network. We address issues such as device discovery and service description, in a Web-based way.

Web techniques such as HTTP caching and push messaging, facilitate the efficient operation of a fully Web-based smart home. Through a technical evaluation, we show the benefits of Web-enabling embedded sensors in terms of performance and energy conservation. The development of a Web-based graphical application abstracts home automation procedure for typical residents.

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Gait-based Person And Gender Recognition Using Micro-Doppler Signatures

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Abstract:

The ability to identify an individual quickly and accurately is a critical parameter in surveillance. Conventional contactless systems are often complex and expensive to implement since video-based processing requires high computational resources. The most common applications are: detecting presence, counting, tracking and identifying individuals. In this work, we investigate the recognition of individuals as well as the gender classification using micro-doppler gait signatures. Ten subjects (7 males and 3 females) participated in the study. The subjects were facing the ultrasound (US) module presented in [1] and performed a variety of activities. The corresponding micro-doppler (mD) signatures were visualized using a short-time Fourier transform. The resulting spectrograms were segmented and a set of features or events was estimated from each micro-sonar file. Prototypes representing each category (activity and/or gender) are extracted for categorization purposes. The categorization stage is implemented using k-means clustering [4] to learn a set of prototypes from the data, followed by a nearest neighbour approach to determine the closest prototype (Euclidean distance) for each test event. This is repeated 30 times and the average success rate is estimated. Table 1 shows the average performance achieved, as well as performance reported in the literature. We obtained performance as high as 88% for individuals recognition and 94% for gender classification. This outperforms the methods reported in [2] and [3]. Such identification can be achieved with a low-cost, low-power compact system.

Table 1. Average performance in individual identification and gender classification.

Source	Kalgaonkar et al., 2007 [2]	Zhang et al., 2008 [3]	Garreau et al.
Subjects (%)	72	90	88
Gender (%)	69	No data	94

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Isolated Word Endpoint Detection using Time-Frequency Kernels

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Abstract:

The accuracy and robustness of a speech recognition system can be greatly increased by first separating the regions of the input sound signal into speech and non-speech regions. In the case of isolated word recognition, it is assumed that the input sound signal consists of a single word. Only a certain region of this signal is the actual spoken word. Before the start of the word, and after the end of the word, there are non-speech regions which consist of silence and background noise. Endpoint detection is the process of finding the start point and end point of a word in a signal, and thus separating the speech region from the non-speech regions.

Assuming that endpoint detection is performed accurately, this segmentation can be important for two reasons. The first reason is that the speech recognition algorithm will not need to process non-speech regions. This makes the recognition process faster and more accurate. The second reason is that the words can be normalized in terms of time duration. When a word is spoken, the time duration of the word is not always the same, even for the same exact word. Normalizing a word in terms of time duration can improve the accuracy of certain speech recognition systems.

In this work, we present an endpoint detection system based on a two-dimensional time-frequency representation of sound. This two-dimensional image is processed using variance kernels in order to find the endpoints of spoken words. The accuracy of our system compares favorably to other endpoint detection systems. The main advantage of our system is its robustness to added background noise.

A KIOS-SenSIP Collaborative Project.

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