# ( 1 )
# "Design of Immune Algorithm Based Tow- Dimensional Recurive Digital Filters using Multi- level ortho gonel Arrays"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmed F. AL-Ajlouni

## Abstract:

Taguchi Immune Algorithm (TIA) is based on both features of the biological immune system and the Taguchi method which increases the ability of the Immune Algorithm (IA) to find the global optimal solution in a nonlinear space. In the TIA, the clonal proliferation within hypermutation for several antibody diversifications and the recombination by using the Taguchi method for the local search are integrated to improve the capabilities of exploration and exploitation. Two major tools are used in the Taguchi method; namely the Orthogonal Arrays (OAs) and the Signal to Noise Ratio (SNR). The effect of selecting the number of levels adopted in the construction of OAs on TIA is not studied before. So, this paper addresses the problem increasing the convergence speed of immune algorithm based two-dimensional recursive digital filters design process by adopting two, three and four levels OAs. For seek of comparison, the same computational experiments adopted in [1] are considered. Numerical results show that increasing the number of OA levels yields to faster convergence and better antibody genes selection in order to achieve the potential recombination, and consequently enhance the design process.

## Keywords:

Taguchi methods, array signal processing, recursive filters, two-dimensional digital filters

## Published In:

# ( 2 )

# "Design of Two-Dimensional Recursive Digital Filters with Specified Magnitude and Group Delay Characteristics using Taguchi-based Immune Algorithm"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmed F. AL-Ajlouni

## Abstract:

This paper presents one modern heuristic optimisation algorithm, named Taguchi-Based Immune Algorithm (TBIA), to solve the problem of designing 2D recursive digital filters with specified magnitude and group-delay characteristics. The algorithm is detailed for the design of three recursive filters categories, namely filters with predefined magnitude, delay and magnitude and delay. On the basis of minimising the magnitude and group-delay errors, multi-criterion design combination is employed to obtain optimal recursive filters that satisfy the required specifications. Computational experiments show the ability of the proposed algorithm to obtain more robust stable complex filters compared with previously reported design methods.

## Keywords:

two-dimensional digital filters; IA; immune algorithm; Taguchi method; group delay.

## Published In:

# ( 3 )
# "The Convergence Speed of Single-And Multi-Objective Immune Algorithm Based Optimization Problems"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmed F. AL-Ajlouni

## Abstract:

Despite the considerable amount of research related to immune algorithms and it applications in numerical optimization, digital filters design, and data mining, there is still little work related to issues as important as sensitivity analysis, [1] [4]. Other aspects, such as convergence speed and parameters adaptation, have been practically disregarded in the current specialized literature [7] [8]. The convergence speed of the immune algorithm heavily depends on its main control parameters: population size, replication rate, mutation rate, clonal rate and hyper mutation rate. In this paper we investigate the effect of control parameters variation on the convergence speed for single and multi objective optimization problems. Three examples are devoted for this purpose; namely the design of 2 D recursive digital filter, minimization of simple function, and banana function. The effect of each parameter on the convergence speed of the IA is studied considering the other parameters with fixed values and taking the average of 100 times independent runs. Then, the concluded rules are applied on some examples introduced in [2] and [3]. Computational results show how to select the immune algorithm parameters to speedup the algorithm convergence and to obtain the optimal solution.

## Keywords:

Immune Algorithm, Convergence, Mutation, Hypermutation, Population Size, Clonal Selection

## Published In:

# ( 4 )
# "Digital Filters Design Educational Software Based on Immune, Genetic and Quasi-Newton Line Search Algorithms"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmed F. AL-Ajlouni

## Abstract:

This paper presents educational software developed for designing FIR and IIR digital filters using two evolutionary algorithms (EAs); namely immune algorithms (IAs) and genetic algorithms (GAs),together with quasi-Newton line search algorithm (QNLS). This software provides the user the ability to design one- and two-dimensional; low-pass, high-pass, band-pass and band-stop digital filters with arbitrary magnitude and group delay specifications. The software is evaluated by making the assessment quizzes for electrical engineering students and instructors. Students responses are very positive. A number of recommendations are made in this work based on instructor observation and students evaluations.

## Keywords:

digital filters; evolutionary algorithms; EAs; immune algorithm; IAs; genetic algorithm; GAs; quasi-Newton line search algorithm; QNLS; blending teaching and learning.

## Published In:

# ( 5 )
# A new algorithm for the compression of ECG signals based on mother wavelet parameterization and best-threshold levels selection

Mohammed Abo-Zahhad a, , Ahmad F. Al-Ajlouni b, Sabah M. Ahmed a, R.J. Schilling c

## Abstract:

This paper presents an ECG compression algorithm based on the optimal selection of wavelet filters and threshold levels in different subbands that achieve maximum data volume reduction while guaranteeing reconstruction quality. The proposed algorithm starts by segmenting the ECG signal into frames; where each frame is decomposed into m subbands through optimized wavelet filters. The resulting wavelet coefficients are thresholded and those having absolute values below specified threshold levels in all subbands are deleted and the remaining coefficients are appropriately encoded with a modified version of the run-length coding scheme. The threshold levels to use, before encoding, are adjusted in an optimum manner, until predefined compression ratio and signal quality are achieved. Extensive experimental tests were made by applying the algorithm to ECG records from the MIT-BIH Arrhythmia Database. The compression ratio (CR), the root-mean-square difference (PRD) and the zero-mean percent rootmean- square difference (PRD1) measures are used for measuring the algorithm performance (high CR with excellent reconstruction quality). From the obtained results, it can be deduced that the performance of the optimized signal dependent wavelet outperforms that of Daubechies and Coiflet standard wavelets. However, the computational complexity of the proposed technique is the price paid for the improvement in the compression performance measures.

## Keywords:

ECG signal compression Discrete wavelet transform Coding Thresholding Mother wavelet parameterization Best-threshold levels selection

## Published In:

# ( 6 )
# "A New Method for Fastening the Convergence of Immune Algorithms Using an Adaptive Mutation Approach"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmad F. Al-Ajlouni

## Abstract:

This paper presents a new adaptive mutation approach for fastening the convergence of immune algorithms (IAs). This method is adopted to realize the twin goals of maintaining diversity in the population and sustaining the convergence capacity of the IA. In this method, the mutation rate (pm) is adaptively varied depending on the fitness values of the so-lutions. Solutions of high fitness are protected, while solutions with sub-average fitness are totally disrupted. A solution to the problem of deciding the optimal value of pm is obtained. Experiments are carried out to compare the proposed approach to traditional one on a set of optimization problems. These are namely: 1) an exponential multi-variable func-tion; 2) a rapidly varying multimodal function and 3) design of a second order 2-D narrow band recursive LPF. Simula-tion results show that the proposed method efficiently improves IA□s performance and prevents it from getting stuck at a local optimum.

## Keywords:

Adaptive Mutation; Immune Algorithm; Convergence; Traditional Mutation

## Published In:

# ( 7 )
# Hybrid Uplink-Time Difference of Arrival and Assisted-GPS Positioning Technique

M. Abo-Zahhad, Sabah M. Ahmed, M. Mourad

## Abstract:

A hybrid positioning system is merely one in which multiple systems are used for positioning purposes. This virtually always, though not necessarily, includes Global Positioning System (GPS) as it is the only global positioning network currently. Combination of mobile network and GPS positioning techniques provide a higher accuracy of mobile loca-tion than positions based on a standalone GPS or mobile network based positions. High accuracy of mobile position is mainly essential for emergency, military and many other location based services such as productivity enhancement, entertainment, position-based advertising, navigation, asset management and geographic information access. Assisted GPS, also known as A-GPS or AGPS, enhances the performance of the standard GPS in devices connected to the cellu-lar network. This paper introduces a new hybrid technique for mobile location determination utilizing Universal Mobile Telecommunication System (UMTS) network, Mobile Station (MS) and GPS positioning characteristics. Different po-sitioning techniques are chosen according to positioning parameters. The minimum required number of UMTS base stations, location measurement units and GPS satellites are calculated in this paper. The required number of GPS satel-lites is reduced from four satellites to three ones while using three dimension positioning and from three satellites to two ones at two dimension positioning. Moreover, MS receiver main functions including both network and GPS received paths to achieve output assisted data are discussed. In this paper many drawbacks such as indoor positioning, receiver high power consumption, delay in first time to fix position, low position accuracy as well as large number of required satellites and base stations are improved.

## Keywords:

A-GPS; Hybrid Positioning System; Mobile Positioning

## Published In:

# ( 8 )
# A New ECG Compression Algorithm Based On Wavelet Foveation And Huffman Coding Techniques

Mohammed Abo-Zahhad, Sabah M. Ahmed and Ahmed Zakaria

## Abstract:

This paper introduces a new ECG signal compression algorithm based on modulating the ECG signal DWT coefficients with a proper mask constructed using the foveation principle. The constructed mask is a selective mask that gives a high resolution at a certain point (fovea) and falls down away from this point. The wavelet foveation of the ECG signal leads to decreasing the amount of information contained in the signal. So, the value of the foveated ECG signal Entropy will be decreased which by turn will increase the Compression Ratio (CR).The ECG signal after wavelet foveation is coded using Huffman codes; namely optimal selective Huffman coding, adaptive Huffman coding and modified adaptive Huffman coding. The performance of each coding technique is measured based on the CR, time cost and computational complexity.

## Keywords:

Wavelet Foveation; Optimal selective Huffman Coding; Adaptive Huffman Coding; Modified Adaptive Huffman Coding and Lossless compression.

## Published In:

# ( 9 )
# "Wavelet Threshold-Based ECG Data Compression Technique Using Immune Optimization Algorithm"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Ahmed F. AL-Ajlouni

## Abstract:

In this paper, a new ECG compression method called Wavelet Threshold Based Immune Algorithm (WTBIA) is proposed. This method based on finding the best threshold level for each wavelet subband using Immune Algorithm (IA). The WTBIA algorithm consists of three main steps: 1) Applying 1-D Discrete Wavelet Transform (DWT) on ECG signal; 2) Thresholding of wavelet coefficients in each subband; and 3) Minimization of the Percent Root mean square Difference (PRD) and maximization of the Compression Ratio (CR) using IA. The main advantage of this method is finding the best threshold level for each subband based on the required CR and PRD. The compression algorithm was implemented and tested upon records selected from the MIT-BIH arrhythmia database [6] using different wavelets such as Haar, Daubechies, Coiflet, Symlet and Biorthogonal. Simulation results show that the proposed algorithm leads to high CR associated with low distortion level relative to previously reported compression algorithms.

## Keywords:

Electrocardiogram, Data Compression, Wavelet Transform, Immune Algorithm

## Published In:

# ( 10 )

# "A New Energy-Efficient Adaptive Clustering Protocol Based on Genetic Algorithm for Improving the Lifetime and the Stable Period of Wireless Sensor Networks"

Mohammed Abo-Zahhad, Sabah M Ahmed, Nabil Sabor and Shigenobu Sasaki

## Abstract:

This paper presents a new Genetic Algorithm-based Energy-Efficient adaptive clustering hierarchy Protocol (GAEEP) to efficiently maximize the lifetime and to improve the stable period of Wireless Sensor Networks (WSNs). The new protocol is aimed at prolonging the lifetime of WSNs by finding the optimum number of cluster heads (CHs) and their locations based on minimizing the energy consumption of the sensor nodes using genetic algorithm. The operation of the GAEEP is broken up into rounds, where each round begins with a set-up phase, when the base station finds the optimum number of CHs and assigns members nodes of each CH, followed by a steady-state phase, when the sensed data are transferred to CHs and collected in frames; then these frames are transferred to the base station. The performance of the GAEEP is compared with previous protocols using Matlab simulation. Simulation results show that GAEEP protocol improves the network lifetime and stability period over previous protocols in both homogeneous and heterogeneous cases. Moreover, GAEEP protocol increases the reliability of clustering process because it expands the stability period and compresses the instability period.

## Keywords:

Wireless Sensor Networks, Genetic Algorithm, Clustering Protocols, Network Lifetime, Homogeneous and Heterogeneous Networks

## Published In:

# ( 11 )
# "Coverage maximization in mobile Wireless Sensor Networks utilizing immune node deployment algorithm"

Mohammed Abo-Zahhad, Sabah M Ahmed, Nabil Sabor and Shigenobu Sasaki

## Abstract:

A Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors with sensing, computation and wireless communication capabilities. Each sensor generally has the task to monitor, measure ambient conditions, and disseminate the collected data towards a base station. One of the key points in the design stage of a WSN that is related to the sensing attribute is the coverage of the sensing field. The coverage issue in WSNs depends on many factors, such as the network topology, sensor sensing model, and the most important one is the deployment strategy. The sensor nodes can be deployed either deterministically or randomly. Random deployment of the sensor nodes can cause coverage holes formulation; therefore, in most cases, random deployment is not guaranteed to be efficient for achieving the required coverage. In this case, the mobility feature of the nodes can be utilized in order to maximize the coverage. This is Non-deterministic Polynomial-time hard (NP-hard) problem. So in this paper, the Immune Algorithm (IA) is used to relocate the mobile sensor nodes after the initial configuration to maximize the coverage area with the moving dissipated energy minimized. The performance of the proposed algorithm is compared with the previous algorithms using Matlab simulation. Simulation results show that the proposed algorithm improves the network coverage and the redundant covered area with minimum moving consumption energy.

## Keywords:

Wireless Sensor Network, Immune Algorithm, moving consumption energy, Coverage

## Published In:

( 12 )
# A New EEG Acquisition Protocol for Biometric Identification Using Eye Blinking Signals

M. Abo-Zahhad, Sabah M. Ahmed, Sherif N. Abbas

## Abstract:

In this paper, a new acquisition protocol is adopted for identifying individuals from electroencephalogram signals based on eye blinking waveforms. For this purpose, a database of 10 subjects is collected using Neurosky Mindwave headset. Then, the eye blinking signal is extracted from brain wave recordings and used for the identification task. The feature extraction stage includes fitting the extracted eye blinks to auto-regressive model. Two algorithms are implemented for auto-regressive modeling namely; Levinson-Durbin and Burg algorithms. Then, discriminant analysis is adopted for classification scheme. Linear and quadratic discriminant functions are tested and compared in this paper. Using Burg algorithm with linear discriminant analysis, the proposed system can identify subjects with best accuracy of 99.8%. The obtained results in this paper confirm that eye blinking waveform carries discriminant information and is therefore appropriate as a basis for person identification methods.

## Published In:

# ( 13 )
# State-of-the-art methods and future perspectives for personal recognition based on electroencephalogram signals

Mohammed Abo-Zahhad, Sabah Mohammed Ahmed, Sherif Nagib Abbas

## Abstract:

In the past decade, biomedical instrumentations have witnessed major developments and now it is very easy to measure human biomedical electrical signals. One of these signals is the brain waves, known as electroencephalogram (EEG) signals, which became very easy to be measured using portable devices and dry electrodes. This opens the way for the use of brain waves in different applications rather than the biomedical diagnosis. One of the most recent non-medical applications for brain waves is the biometric authentication. Brain waves have some advantages which are not present in the commonly used identifiers, such as face and fingerprints, making them robust to spoof attacks. However, brain waves still face many challenges with reference to permanence and uniqueness. In this study, the authors discuss the employment of brain signals for human recognition tasks and focus on the challenges facing these signals towards the deployment of a practical biometric system. This study, also, provides a comprehensive review of the proposed approaches developed in EEG-based biometric authentication systems.

## Keywords:

NULL

## Published In:

# ( 14 )
# "Mobile Sink-Based Adaptive Immune Energy-Efficient Clustering Protocol for Improving the Lifetime and Stability Period of Wireless Sensor Networks"

Mohammed AboZahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki

## Abstract:

Energy hole problem is a critical issue for data gathering in wireless sensor networks. Sensors near the static sink act as relays for far sensors and thus will deplete their energy very quickly, resulting energy holes in the sensor field. Exploiting the mobility of a sink has been widely accepted as an efficient way to alleviate this problem. However, determining an optimal moving trajectory for a mobile sink is a non-deterministic polynomial-time hard problem. Thus, this paper proposed a mobile sink-based adaptive immune energy-efficient clustering protocol (MSIEEP) to alleviate the energy holes. A MSIEEP uses the adaptive immune algorithm (AIA) to guide the mobile sink-based on minimizing the total dissipated energy in communication and overhead control packets. Moreover, AIA is used to find the optimum number of cluster heads (CHs) to improve the lifetime and stability period of the network. The performance of MSIEEP is compared with the previously published protocols; namely, low-energy adaptive clustering hierarchy (LEACH), genetic algorithm-based LEACH, amend LEACH, rendezvous, and mobile sink improved energy-efficient PEGASIS-based routing protocol using MATLAB. Simulation results show that MSIEEP is more reliable and energy efficient as compared with other protocols. Furthermore, it improves the lifetime, the stability, and the instability periods over the previous protocols, because it always selects CHs from high-energy nodes. Moreover, the mobile sink increases the ability of the proposed protocol to deliver packets to the destination.

## Keywords:

Wireless sensor networks, immune algorithm, clustering protocols, mobile sink, energy hole problem

## Published In:

# ( 15 )

# "Rearrangement of mobile wireless sensor nodes for coverage maximization based on immune node deployment algorithm"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki

## Abstract:

One of the primary objectives of Wireless Sensor Network (WSN) is to provide full coverage of a sensing field as long as possible. The deployment strategy of sensor nodes in the sensor field is the most critical factor related to the network coverage. However, the traditional deployment methods can cause coverage holes in the sensing field. Therefore, this paper proposes a new deployment method based on Multi-objective Immune Algorithm (MIA) and binary sensing model to alleviate these coverage holes. MIA is adopted here to maximize the coverage area of WSN by rearranging the mobile sensors based on limiting their mobility within their communication range to preserve the connectivity among them. The performance of the proposed algorithm is compared with the previous algorithms using Matlab simulation for different network environments with and without obstacles. Simulation results show that the proposed algorithm improves the coverage area and the mobility cost of WSN.

## Keywords:

Wireless mobile sensor network, Coverage holes, Multi-objective immune algorithm, Deployment strategies, Connectivity, Mobility cost

## Published In:

# ( 16 )
# "Immune Node Deployment Algorithm for Mobile Wireless Sensor Networks with Limited Mobility based on Probabilistic Sensing Model"

Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki

## Abstract:

Coverage has direct effect on the network performance, thus it considered as the measure of quality of service in WSNs. The deployment strategy of sensor nodes in the sensor field is the most critical factor related to the network coverage. So, in this paper a centralized deployment algorithm based on immune optimization algorithm is proposed to improve the coverage of mobile sensor networks. The proposed algorithm redeploys the random deployed sensor nodes to maximize the coverage area based on a probabilistic sensing model. Moreover, the proposed algorithm limits the moving distance of mobile sensor nodes to reduce the dissipated energy in mobility and to ensure the connectivity among the sensor nodes. The performance of the proposed algorithm is compared with the CSAPO algorithm using MATLAB simulation. Simulation results show that the proposed algorithm outperforms the CSAPO algorithm in terms of the network coverage, mobility cost and convergence speed.

## Keywords:

Wireless Sensor Network; Immune Optimization Algorithm; Coverage Problem; Nodes Deployment; Coverage Holes Problem.

## Published In:

# ( 17 )
# A Novel Biometric Approach for Human Identification and Verification Using Eye Blinking Signal

M. Abo-Zahhad, Sabah M. Ahmed, Sherif N. Abbas

## Abstract:

In this letter, a novel technique is adopted for human recognition based on eye blinking waveform extracted from electro-oculogram signals. For this purpose, a database of 25 subjects is collected using Neurosky Mindwave headset. Then, the eye blinking signal is extracted and applied for identification and verification tasks. The pre-processing stage includes empirical mode decomposition to isolate electro-oculogram signal from brainwaves. Then, time delineation of the eye blinking waveform is utilized for feature extraction. Finally, linear discriminant analysis is adopted for classification. Based on the achieved results, the proposed system can identify subjects with best accuracy of 97.3% and verify them with an equal error rate of 3.7%. The obtained results in this letter confirm that eye blinking waveform carries discriminant information and is therefore appropriate as a basis for human recognition task.

## Keywords:

Biometric authentication discriminant analysis electro-oculogram empirical mode decomposition eye blinking time delineation

## Published In:

( 18 )
# Biometric authentication based on PCG and ECG signals: present status and future directions

M. Abo-Zahhad, Sabah M. Ahmed, Sherif N. Abbas

## Abstract:

Due to the great advances in biomedical digital signal processing, new biometric traits have showed noticeable improvements in authentication systems. Recently, the ElectroCardioGram (ECG) and the PhonoCardioGraph (PCG) have been proposed as novel biometrics. This paper aims to review the previous studies related to the usage of the ECG and PCG signals in human recognition. In addition, we discuss briefly the most important techniques and methodologies used by researchers in the preprocessing, feature extraction and classification of the ECG and PCG signals. At the end, we introduce some future considerations that can be applied in this topic such as: the fusion between different techniques previously used, use both ECG and PCG signals in a multimodal biometric authentication system and building a prototype system for real-time authentication.

## Keywords:

Review Biometric authentication Electrocardiography signals Phonocardiography signals

## Published In:

# ( 19 )
# PCG biometric identification system based on feature level fusion using canonical correlation analysis

M. Abo-Zahhad, Sabah M. Ahmed, Sherif N. Abbas

## Abstract:

In this paper, a new technique for human identification task based on heart sound signals has been proposed. It utilizes a feature level fusion technique based on canonical correlation analysis. For this purpose a robust pre-processing scheme based on the wavelet analysis of the heart sounds is introduced. Then, three feature vectors are extracted depending on the cepstral coefficients of different frequency scale representation of the heart sound namely; the mel, bark, and linear scales. Among the investigated feature extraction methods, experimental results show that the mel-scale is the best with 94.4% correct identification rate. Using a hybrid technique combining MFCC and DWT, a new feature vector is extracted improving the system's performance up to 95.12%. Finally, canonical correlation analysis is applied for feature fusion. This improves the performance of the proposed system up to 99.5%. The experimental results show significant improvements in the performance of the proposed system over methods adopting single feature extraction.

## Keywords:

Bark-frequency cepstral, Canonical correlation, Feature level fusion, Heart sounds, Linear frequency cepstral, Mel-frequency cepstral, PCG biometric authentication

## Published In:

Electrical and Computer Engineering (CCECE), 2014 IEEE 27th Canadian Conference on , NULL , NULL

( 20 )
# A New Biometric Modality for Human Authentication Using Eye Blinking

Mohammed Abo-Zahhad, Sabah M. Ahmed, and Sherif N. Abbas

## Abstract:

This paper proposes a new biometric identifier for humans based on eye blinking waveform extracted from brain waves. Brain waves were recorded using Neurosky Mindwave headset from 25 volunteers. Two approaches are adopted for the pre-processing stage; the first approach uses empirical mode decomposition to isolate electro-oculogram signal from brain waves, then, extracts eye blinking signal. The second approach extracts eye blinking signal directly from brain waves. Features are extracted based on time delineation of the eye blinking waveform and classified using linear discriminant analysis. The best correct identification and equal error rates achieved are 98.51% and 2.5% for identification and verification modes respectively. The obtained results in this paper confirm that eye blinking waveform carries discriminant information and is therefore appropriate as a basis for human recognition task.

## Keywords:

Biometric authentication Brain waves Discriminant analysis Electro-oculogram Empirical mode decomposition Eye blinking Time delineation

## Published In:

Biomedical Engineering Conference (CIBEC), 2014 Cairo International , NULL , NULL

# ( 21 )
# A comparative approach between cepstral features for human authentication using heart sounds

M. Abo-Zahhad, Mohammed Farrag, Sherif N. Abbas, and Sabah M. Ahmed

## Abstract:

The main objective of this paper is to provide a comparative study between different cepstral features for the application of human recognition using heart sounds. In the past 10 years, heart sound, which is known as phonocardiogram, has been adopted for human biometric authentication tasks. Most of the previously proposed systems have adopted mel-frequency and linear frequency cepstral coefficients as features for heart sounds. In this paper, two more cepstral features are proposed. The first one is based on wavelet packet decomposition where a new filter bank structure is designed to select the appropriate bases for extracting discriminant features from heart sounds. The other is based on nonlinear modification for mel-scaled cepstral features. The four cepstral features are tested and compared on two databases: One consists of 21 subjects, and the other consists of 206 subjects. Based on the achieved results over the two databases, the two proposed cepstral features achieved higher correct recognition rates and lower error rates in identification and verification modes, respectively.

## Keywords:

Heart sounds; PCG biometric authentication; Wavelet denoising; Cepstral features; Wavelet packet decomposition; Linear discriminant analysis.

## Published In:

Signal, Image and Video Processing , NULL , NULL

# ( 22 )
# A new multi-level approach to EEG based human authentication using eye blinking

M. Abo-Zahhad, Sabah M. Ahmed, and Sherif N. Abbas

## Abstract:

This letter proposes a new multi-level approach for human biometric authentication using Electro-Encephalo-Gram (EEG) signals (brain waves) and eye blinking Electro-Oculo-Gram (EOG) signals. The main objective of this letter is to improve the performance of the EEG based biometric authentication using eye blinking EOG signals which are considered as source of artifacts for EEG. Feature and score level fusion approaches are tested for the proposed multi-level system. Density based and canonical correlation analysis strategies are applied for the score and feature level fusions, respectively. Autoregressive modeling of EEG signals (during relaxation or visual stimulation) and time delineation of the eye blinking waveform are adopted for the feature extraction stage. Finally, the classification stage is performed using linear discriminant analysis. For evaluation, a database of 31 subjects performing three different tasks of relaxation, visual stimulation, and eye blinking was collected using Neursky Mindwave headset. Using eye blinking features, a significant improvement is achieved, in terms of correct recognition and equal error rates, for the proposed multi-level EEG biometric system over single level system using EEG only.

## Keywords:

Multi-level biometric authentication; Electro-encephalogram; Electro-oculogram; Eye blinking; Feature level fusion; Score level fusion.

## Published In:

# ( 23 )
# Design and Implementation of Building Energy Monitoring and Management System based on Wireless Sensor Networks

Mohammed Abo-Zahhad, Sabah M Ahmed, Mohammed Farrag, Mohammed F A Ahmed, Abdelhay Ali

## Abstract:

Wireless sensor networks (WSNs) play a key role in extending the smart grid implementation towards residential premises and energy management applications. Efficient supply and demand balance, and consequently reducing the electricity expenses and carbon emissions, is an immediate benefit of implementing smart grids. In this paper, design and implementation of an energy management system (EMS) for efficient load management are proposed. The EMS reduces the consumption of the consumers at the peak load hours and thus reduces the carbon emissions of the household. The proposed system consists of two main parts. The first part is an Energy Management Unit (EMU) which has a graphical user interface for runtime monitoring and control. The second part is sensor nodes which measure the power consumption of the different loads and transfer it to the EMU via multi-hop network. The EMU is implemented using NI LABVIEW software and XBee-PRO ZigBee module to communicate with sensor nodes. Hardware model is implemented using Arduino Uno microcontroller, XBee-PRO ZigBee module and the ACS712 current sensor. The EMS is applied to building of Electrical Engineering Department at Assiut University as a case study

## Keywords:

NULL

## Published In:

10th IEEE International Conference on Computer Engineering and Systems (ICCES 2015) , NULL , NULL

# ( 24 )
# A new biometric authentication system using heart sounds based on wavelet packet features

M. Abo-Zahhad ، Sabah M. Ahmed ، Sherif N. Abbas

## Abstract:

In this paper, a new approach for human recognition using heart sounds is proposed. The new approach is based mainly on extracting features from heart sounds using wavelet packet decomposition. Different linear and non-linear filter banks at different decomposition levels are designed using wavelet packet decomposition to select the appropriate bases for extracting discriminant features. Automatic wavelet de-noising and linear discriminant analysis are adopted for pre-processing and classification stages, respectively. The proposed system is tested using an open database for heart sounds known as HSCT-11 which contains data collected from 206 subjects. Based on the achieved results, the proposed system can identify subjects with best accuracy of 91.05% and verify them with an equal error rate of 3.2%. The obtained results in this paper show that wavelet packet based features are appropriate for human recognition task using heart sounds.

## Keywords:

Biometric authentication Cepstral analysis Heart sounds Wavelet packet decomposition

## Published In:

( 25 )

# A centralized immune-Voronoi deployment algorithm for coverage maximization and energy conservation in mobile wireless sensor networks

Mohammed Abo-Zahhad, Nabil Sabor, Shigenobu Sasaki, Sabah M. Ahmed

## Abstract:

Saving energy is a most important challenge in Mobile Wireless Sensor Networks (MWSNs) to extend the lifetime, and optimal coverage is the key to it. Therefore, this paper proposes a Centralized Immune-Voronoi deployment Algorithm (CIVA) to maximize the coverage based on both binary and probabilistic models. CIVA utilizes the multi-objective immune algorithm that uses the Voronoi diagram properties to provide a better trade-off between the coverage and the energy consumption. The CIVA algorithm consists from two phases to improve the lifetime and the coverage of MWSN. In the first phase, CIVA controls the positions and the sensing ranges of Mobile Sensor Nodes (MSNs) based on maximizing the coverage and minimizing the dissipated energy in mobility and sensing. While the second phase of CIVA adjusts the radio (sleep/active) of MSNs to minimize the number of active sensors based on minimizing the consumption energy in sensing and redundant coverage and preserving the coverage at high level. The performance of the CIVA is compared with the previous algorithms using Matlab simulation for different network configurations with and without obstacles. Simulation results show that the CIVA algorithm outperforms the previous algorithms in terms of the coverage and the dissipated energy for different networks configurations.

## Keywords:

Mobile wireless sensor networks; Immune algorithm; Voronoi Diagram; Coverage area; Node deployment

## Published In:

# ( 26 )
# An Unequal Multi-hop Balanced Immune Clustering protocol for wireless sensor networks

Nabil Sabor  Mohammed Abo-Zahhad  Shigenobu Sasaki  Sabah M. Ahmed

## Abstract:

In multi-hop routing, cluster heads near the base station act as relays for far cluster heads and thus will deplete their energy very quickly. Thus, hot spots in the sensor field result. This paper introduces a new clustering algorithm named an Unequal Multi-hop Balanced Immune Clustering protocol (UMBIC) to solve the hot spot problem and improve the lifetime of small and large scale/homogeneous and heterogeneous wireless sensor networks with different densities. UMBIC protocol utilizes the Unequal Clustering Mechanism (UCM) and the Multi-Objective Immune Algorithm (MOIA) to adjust the intra-cluster and inter-cluster energy consumption. The UCM is used to partition the network into clusters of unequal size based on distance with reference to base station and residual energy. While the MOIA constructs an optimum clusters and a routing tree among them based on covering the entire sensor field, ensuring the connectivity among nodes and minimizing the communication cost of all nodes. The UMBIC protocol rotates the role of cluster heads among the nodes only if the residual energy of one of the current cluster heads less than the energy threshold, as a result the time computational and overheads are saved. Simulation results show that, compared with other protocols, the UMBIC protocol can effectively improve the network lifetime, solve the hot spot problem and balance the energy consumption among all nodes in the network. Moreover, it has less overheads and computational complexity.

## Keywords:

## Published In:

( 27 )
# A Comprehensive Survey on Hierarchical-based Routing Protocols for Mobile Wireless Sensor Networks: Review, Taxonomy and Future Directions

Nabil Sabor , Shigenobu Sasaki , Mohammed. Abo-Zahhad , Sabah. M. Ahmed

## Abstract:

Introducing mobility to Wireless Sensor Networks (WSNs) puts new challenges particularly in designing of routing protocols. Mobility can be applied to the sensor nodes and/or the sink node in the network. Many routing protocols have been developed to support the mobility of WSNs. These protocols are divided depending on the routing structure into hierarchical-based, flat-based, and location-based routing protocols. However, the hierarchical-based routing protocols outperform the other routing types in saving energy, scalability, and extending lifetime of Mobile WSNs (MWSNs). Selecting an appropriate hierarchical routing protocol for specific applications is an important and difficult task. Therefore, this paper focuses on reviewing some of the recently hierarchical-based routing protocols that are developed in the last five years for MWSNs. This survey divides the hierarchical-based routing protocols into two broad groups, namely, classical-based and optimized-based routing protocols. Also, we present a detailed classification of the reviewed protocols according to the routing approach, control manner, mobile element, mobility pattern, network architecture, clustering attributes, protocol operation, path establishment, communication paradigm, energy model, protocol objectives, and applications. Moreover, a comparison between the reviewed protocols is investigated in this survey depending on delay, network size, energy-efficiency, and scalability while mentioning the advantages and drawbacks of each protocol. Finally, we summarize and conclude the paper with future directions.

## Keywords:

Mobile Wireless Sensor Networks, Mobile Sink, Hierarchical-based Routing, Classical-based Routing, Optimized-based Routing.

## Published In:

# ( 28 )
# A Graphical-based educational simulation tool for Wireless Sensor Networks Authors

Nabil Sabor ,Shigenobu Sasaki,Mohammed Abo-Zahhad,Sabah M Ahmed

## Abstract:

Many routing protocols have been developed to improve the lifetime, bandwidth reusability and scalability of the Wireless Sensor Networks (WSNs). The operation of routing protocols is difficult to understand and some problems may occur while developing these protocols. Simulation is a relatively fast way of estimating these protocols and understating what is happening in the network. Thus, this paper presents an open source Graphical-based educational simulation tool called Gbest-WSN for simulating routing protocols of the static and mobile, homogeneous and heterogeneous WSNs. Gbest-WSN tool has a user-friendly interface that helps the user to select the routing protocol and define the network configuration. It is provided with four routing protocols; namely LEACH, LEACH-Mobile, immune algorithm-based and genetic algorithm-based routing protocols. Also, it allows the user to update the existing routing protocols and add a new routing protocol. Gbest-WSN is provided with radio, coverage and mobility models for modeling the hardware of the sensor node. It shows a detailed 2D and 3D graphical perception for what is happing during the routing process. Also, it has the ability to compare the simulation results of different simulation methods or different network configurations. In addition, it allows the user to save and load simulation scenarios and also exports the graphical results on PDF files and the statistical results on excel or mat files. Moreover, Gbest-WSN is provided with html help documents to help the user how to use it. The illustrative simulation examples clarified that the Gbest-WSN is a helpful tool for the students, teachers and researchers who work in the field of WSNs.

## Keywords:

Wireless Sensor Networks; Routing protocols; Genetic algorithm; Immune algorithm; Open source software; Command-line; Graphic; Educational software

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# ( 29 )
# An Immune-Based Energy-Efficient Hierarchical Routing Protocol for Wireless Sensor Networks

Nabil Sabor Shigenobu Sasaki1 Mohammed Abo-Zahhad Sabah M. Ahmed

## Abstract:

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## Keywords:

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## Published In:

# ( 30 )

# Utilization of Multi-Objective Immune Deployment Algorithm for Coverage Area Maximization with Limit Mobility in Wireless Sensors Networks

M. Abo-Zahhad S. M. Ahmed N. Sabor S. Sasaki

## Abstract:

Coverage is one of the most important performance metrics for wireless sensor network (WSN) since it reflects how well a sensor field is monitored. The coverage issue in WSNs depends on many factors, such as the network topology, sensor sensing model and the most important one is the deployment strategy. Random deployment of the sensor nodes can cause coverage holes formulation. This problem is non-deterministic polynomial-time hard problem. So in this study, a new centralised deployment algorithm based on the immune optimisation algorithm is proposed to relocate the mobile nodes after the initial configuration to maximise the coverage area. Moreover, the proposed algorithm limits the moving distance of the mobile nodes to reduce the dissipation energy in mobility and to ensure the connectivity among the sensor nodes. The performance of the proposed algorithm is compared with the previous algorithms using Matlab simulation. Simulation results clear that the proposed algorithm based on binary and probabilistic sensing models improves the network coverage and the redundant covered area with minimum moving consumption energy. Furthermore, the simulation results show that the proposed algorithm also works when obstacles appear in the sensing field.

## Keywords:

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## Published In:

# ( 31 )
# ARBIC: An Adjustable Range Based Immune hierarchy Clustering protocol supporting mobility of Wireless Sensor Networks

Nabil Sabor, Sabah M Ahmed, Mohammed Abo-Zahhad, Shigenobu Sasaki

## Abstract:

Introducing the mobility to Wireless Sensor Networks (WSNs) puts new challenges in designing an energy-efficient routing. Improving the network lifetime and the packet delivered rate are the most important issues in designing of the Mobile Wireless Sensor Networks (MWSNs). MWSN is more difficult to deal with than its stationary counterpart because it does not have a fixed topology. This increases the complexity of routing due to the frequent link breaks between clusters and their members. Various clustering protocols are developed to support mobility of the nodes in the WSNs. However, these protocols suffer from some limitations in connectivity, energy-efficient, fault tolerance, load balancing and mobility adaption because they organize the network into fixed size clusters and select the heads of these clusters randomly. Thus, this paper proposes an Adjustable Range-Based Immune hierarchy Clustering protocol (ARBIC) with mobility supporting to deliver the sensory data of the MWSN to the base station in an efficient way for a long-time. The operation of ARBIC protocol depends on organizing the network into optimum clusters and adjusting the size of these clusters based on the speed of the mobile sensor nodes to preserve the cluster connectivity. ARBIC protocol utilizes the immune optimization algorithm to determine the best positions of the clusters heads that optimize the trade-off among the mobility factor, energy consumption, connectivity, residual energy and link connection time. In order to save the overhead packets and the computational time, the ARBIC protocol runs the clustering process if and only if the residual energy of any cluster head is less than a predefined energy threshold. Moreover, it performs a fault tolerance mechanism after sending each frame to reduce the packets drop rate by maintaining the stability of links between the clusters heads and their member nodes. Mathematical analyses are established to analyze the computational and overhead complexities of the ARBIC protocol. Simulation results show that, compared with other protocols, the ARBIC protocol can effectively improve the packet delivery ratio while simultaneously offering lower energy consumption and delay by using sensor nodes with adjustable transmission ranges.

## Keywords:

## Published In:

# ( 32 )
# A wireless emergency telemedicine system for patients monitoring and diagnosis

M Abo-Zahhad, SM Ahmed, O Elnahas

## Abstract:

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## Keywords:

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## Published In:

# ( 33 )
# Detection of primary user signal in wideband cognitive radio networks exploiting DCT as sensing matrix

Abo-Zahhad, M.; Ahmed, Sabah M.; Farrag, Mohammed; Baali, Khaled Ali

## Abstract:

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## Keywords:

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## Published In:

# ( 34 )
# An Unequal Multi-hop Balanced Immune Clustering protocol for wireless sensor networks

Sabor, Nabil; Abo-Zahhad, Mohammed; Sasaki, Shigenobu; Ahmed, Sabah M.

## Abstract:

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## Keywords:

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## Published In:

# ( 35 )

# A comprehensive survey on hierarchical-based routing protocols for mobile wireless sensor networks: Review, taxonomy, and future directions

Sabor, Nabil; Sasaki, Shigenobu; Abo-Zahhad, Mohammed; Ahmed, Sabah M.

## Abstract:

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## Keywords:

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# ( 36 )
# A Graphical-based educational simulation tool for Wireless Sensor Networks

Sabor, Nabil; Sasaki, Shigenobu; Abo-Zahhad, Mohammed; Ahmed, Sabah M.

## Abstract:

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## Keywords:

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## Published In:

# ( 37 )
# A centralized immune-Voronoi deployment algorithm for coverage maximization and energy conservation in mobile wireless sensor networks

Abo-Zahhad, Mohammed; Sabor, Nabil; Sasaki, Shigenobu; Ahmed, Sabah M.

## Abstract:

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## Keywords:

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## Published In:

Information Fusion , NULL , NULL

# ( 38 )
# C19. Immune node deployment algorithm for mobile wireless sensor networks with limited mobility based on probabilistic sensing model

Abo-Zahhad, Mohammed; Ahmed, Sabah M.; Sabor, Nabil; Sasaki, Shigenobu

## Abstract:

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## Keywords:

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## Published In:

# ( 39 )

# Heart-ID: Human identity recognition using heart sounds based on modifying mel-frequency cepstral features

Abbas, Sherif N.; Abo-Zahhad, Mohammed; Ahmed, Sabah M.; Farrag, Mohammed

## Abstract:

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## Keywords:

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## Published In:

# ( 40 )
# Biometrics from heart sounds: Evaluation of a new approach based on wavelet packet cepstral features using HSCT-11 database

Abo-Zahhad, M.; Ahmed, Sabah M.; Abbas, Sherif N.

## Abstract:

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## Keywords:

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