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Hani Hagras The Computational Intelligence Centre School of Computer Science and Electronic Engineering, University of Essex, UK

Francisco Herrera Head of Research Group SCI2S (Soft Computing and Intelligent Information Systems), Department of Computer Science and Artificial Intelligence, University of Granada, Spain

Tom Heskes Head of Machine Learning Group, Intelligent Systems Institute for Computing and Information Sciences (iCIS) Faculty of Science Radboud University Nijmegen, The Netherlands

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New Applications of Brain–Computer Interfaces

Francisco Pelayo University of Granada
M.A. López Gordo University of Granada
Ricardo Ron University of Malaga
Optimization Algorithms in Graphic Processing Units
Antonio Mora University of Granada
Maribel García-Arenas University of Granada
Pedro Castillo University of Granada

Computing Languages with Bio-inspired Devices
M. D. Jimenez-Lopez University of Rovira i Virgili
A. Ortega De La Puente Autonomous University of Madrid

Computational Intelligence in Multimedia
Adriana Dapena University of A Coruña
Julio Bregáins University of A Coruña
Nicolás Guil University of Malaga

Biologically Plausible Spiking Neural Processing
Eduardo Ros University of Granada
Richard R. Carrillo University of Almeria

Video and Image Processing
Enrique Domínguez University of Malaga
José García University of Alicante

Hybrid Artificial Neural Networks: Models, Algorithms and Data
Cesar Hervás University of Cordoba
Pedro Antonio Gutiérrez University of Cordoba

Advances in Machine Learning for Bioinformatics and Computational Biomedicine
Paulo J.L. Lisboa Liverpool John Moores University
Alfredo Vellido Polytechnic University of Catalonia
Leonardo Franco University of Malaga

Biometric Systems for Human–Machine Interaction
Alexandra Psarrou University of Westminster
Anastassia Angelopoulou University of Westminster
C.M. Travieso-Gonzlez University of Las Palmas de Gran Canaria
Jordi Solé-Casals University of Vic
Data Mining in Biomedicine
Julián Dorado University of A Coruña
Juan R. Rabuñal University of A Coruña
Alejandro Pazos University of A Coruña

Bio-inspired Combinatorial Optimization
Carlos Cotta Porras University of Malaga
Antonio J. Fernández Leiva University of Malaga

Applying Evolutionary Computation and Nature-Inspired Algorithms to Formal Methods
Ismael Rodríguez Complutense University of Madrid

Recent Advances on Fuzzy Logic and Soft Computing Applications
Inma P. Cabrera University of Malaga
Pablo Cordero University of Malaga
Manuel Ojeda-Aciego University of Malaga

New Advances in Theory and Applications of ICA-Based Algorithms
Addison Salazar Polytechnic University of Valencia
Luis Vergara Polytechnic University of Valencia

Biological and Bio-inspired Dynamical Systems
Vladimir Rasvan University of Craiova
Daniela Danciu University of Craiova

Interactive and Cognitive Environments
Andreu Catalá Polytechnic University of Catalonia
Cecilio Angulo Polytechnic University of Catalonia
Preface

We are proud to present the set of final accepted papers for the eleventh edition of the IWANN conference “International Work-Conference on Artificial Neural Networks” held in Torremolinos (Spain) during June 8–10, 2011.

IWANN is a biennial conference that seeks to provide a discussion forum for scientists, engineers, educators and students about the latest ideas and realizations in the foundations, theory, models and applications of hybrid systems inspired by nature (neural networks, fuzzy logic and evolutionary systems) as well as in emerging areas related to the above items. As in previous editions of IWANN, this year’s event also aimed to create a friendly environment that could lead to the establishment of scientific collaborations and exchanges among attendees. Since the first edition in Granada (LNCS 540, 1991), the conference has evolved and matured. The list of topics in the successive Call for Papers has also evolved, resulting in the following list for the present edition:

1. **Mathematical and theoretical methods in computational intelligence**: Mathematics for neural networks; RBF structures; Self-organizing networks and methods; Support vector machines and kernel methods; Fuzzy logic; Evolutionary and genetic algorithms
2. **Neurocomputational formulations**: Single-neuron modelling; Perceptual modelling; System-level neural modelling; Spiking neurons; Models of biological learning
3. **Learning and adaptation**: Adaptive systems; Imitation learning; Reconfigurable systems; Supervised, non-supervised, reinforcement and statistical algorithms
4. **Emulation of cognitive functions**: Decision making; Multi-agent systems; Sensor mesh; Natural language; Pattern recognition; Perceptual and motor functions (visual, auditory, tactile, virtual reality, etc.); Robotics; Planning motor control
5. **Bio-inspired systems and neuro-engineering**: Embedded intelligent systems; Evolvable computing; Evolving hardware; Microelectronics for neural, fuzzy and bioinspired systems; Neural prostheses; Retinomorphic systems; Brain–computer interfaces (BCI) nanosystems; Nanocognitive systems
6. **Hybrid intelligent systems**: Soft computing; Neuro-fuzzy systems; Neuro-evolutionary systems; Neuro-swarm; Hybridization with novel computing paradigms: Quantum computing, DNA computing, membrane computing; Neural dynamic logic and other methods; etc.
7. **Applications**: Image and signal processing; Ambient intelligence; Biomimetic applications; System identification, process control, and manufacturing; Computational biology and bioinformatics; Internet modeling, communication and networking; Intelligent systems in education; Human–robot interaction. Multi-agent systems; Time series analysis and prediction; Data mining and knowledge discovery
At the end of the submission process, we had 202 papers on the above topics. After a careful peer-review and evaluation process (each submission was reviewed by at least 2, and on average 2.4, Program Committee members or additional reviewer), 154 papers were accepted for oral or poster presentation, according to the recommendations of reviewers and the authors’ preferences.

It is important to note that for the sake of consistency and readability of the book, the presented papers are not organized as they were presented in the IWANN 2011 sessions, but classified under 21 chapters and with one chapter on the associated satellite workshop. The organization of the papers is in two volumes and arranged following the topics list included in the call for papers. The first volume (LNCS 6691), entitled *Advances in Computational Intelligence*. *Part I* is divided into ten main parts and includes the contributions on:

1. Mathematical and theoretical methods in computational intelligence
2. Learning and adaptation
3. Bio-inspired systems and neuro-engineering
4. Hybrid intelligent systems
5. Applications of computational intelligence
6. New applications of brain–computer interfaces
7. Optimization algorithms in graphic processing units
8. Computing languages with bio-inspired devices and multi-agent systems
9. Computational intelligence in multimedia processing
10. Biologically plausible spiking neural processing

In the second volume (LNCS 6692), with the same title as the previous volume, we have included the contributions dealing with topics of IWANN and also the contributions to the associated satellite workshop (ISCIF 2011). These contributions are grouped into 11 chapters with one chapter on the satellite workshop:

1. Video and image processing
2. Hybrid artificial neural networks: models, algorithms and data
3. Advances in machine learning for bioinformatics and computational biomedicine
4. Biometric systems for human–machine interaction
5. Data mining in biomedicine
6. Bio-inspired combinatorial optimization
7. Applying evolutionary computation and nature-inspired algorithms to formal methods
8. Recent advances on fuzzy logic and soft computing applications
9. New advances in theory and applications of ICA-based algorithms
10. Biological and bio-inspired dynamical systems
11. Interactive and cognitive environments
12. International Workshop of Intelligent Systems for Context-Based Information Fusion (ISCIF 2011)
During the present edition, the following associated satellite workshops were organized:

1. **4th International Conference on Computational Intelligence in Security for Information Systems (CISIS 2011)**. CISIS aims to offer a meeting opportunity for academic and industry-related researchers belonging to the various vast communities of computational intelligence, information security, and data mining. The corresponding selected papers are published in an independent volume (LNCS 6694).

2. **International Workshop of Intelligent Systems for Context-Based Information Fusion (ISCIF 2011)**. This workshop provides an international forum to present and discuss the latest scientific developments and their effective applications, to assess the impact of the approach, and to facilitate technology transfer. The selected papers are published as a separate chapter in the second volume (LNCS 6692).

3. **Third International Workshop on Ambient-Assisted Living (IWAAL)**. IWAAL promotes the collaboration among researchers in this area, concentrating efforts on the quality of life, safety and health problems of elderly people at home. IWAAL papers are published in LNCS volume 6693.

The 11th edition of IWANN was organized by the Universidad de Malaga, Universidad de Granada and Universitat Politecnica de Catalunya, together with the Spanish Chapter of the IEEE Computational Intelligence Society. We wish to thank to the Spanish Ministerio de Ciencia e Innovacion and the University of Malaga for their support and grants.

We would also like to express our gratitude to the members of the different committees for their support, collaboration and good work. We specially thank the organizers of the associated satellite workshops and special session organizers. Finally, we want to thank Springer, and especially Alfred Hofmann, Anna Kramer and Erika Siebert-Cole, for their continuous support and cooperation.

June 2011

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Abstract. This work deals with the transmission of images, previously coded using the Embedded Zerotree Wavelet (EZW) transform, over wireless systems in which Space-Time Coding (STC) is used. It is shown how the system performance, measured in terms of Peak Signal to Noise Ratio (PSNR), can be improved using bit allocation strategies that take into account the special structure of the EZW bitstream, where the bits firstly allocated are associated to the lowest frequency subbands, and therefore, an error–free transmission of such bits will be crucial to appropriately recover the transmitted image.

Keywords: Artificial neural networks, learning rules, EZW transform, Alamouti coding, PSNR metric, image processing, bit allocation, channel estimation.

1 Introduction

The Embedded Zerotree Wavelet (EZW) transform is a quite simple image compression algorithm based on a tree–ordering of the wavelet coefficients [1,2]. By taking into account that, for wavelet transforms, the highest energy coefficients reside in the lowest frequency subbands placed at the root node, and that a parent-child relationship is defined between wavelet coefficients from frequency subbands spatially related, so that the children correspond to higher frequencies than their respective parents, one or more subtrees will entirely have coefficients whose value is zero or almost zero with high probability. Those subtrees are called zerotrees. Therefore, the bitstream is organized according to the wavelet coefficients ordered from lowest to highest frequency subbands, which allows the decoder to stop the decoding process at any point of the bitstream and still recover the transmitted images but with lower quality. This property is termed as progressive or incremental decoding.

This paper focuses on the transmission of EZW-coded images over wireless systems making use of the popular Orthogonal Space-Time Block Code (OSTBC) scheme proposed by Alamouti [3], which has been incorporated to the
IEEE 802.11 and IEEE 802.16 standards, for example. Coherent detection using Alamouti–coded systems demands a unitary channel matrix, which is commonly acquired from transmitted training symbols (pilots) by means of supervised algorithms \[4,5\]. In order to increase the system throughput, there exists a great interest about the development of algorithms to directly estimate the channel from the observations without using pilots. This type of algorithms are termed as unsupervised or blind \[6\].

**Principal Component Analysis** (PCA) was developed in 1901 by Karl Pearson and it is one of the most important paradigms in *Artificial Neural Networks* (ANN) since it is connected with Hebbian-type learning rules \[7\]. Nowadays, PCA is mostly used as a tool for data analysis and for predictive modeling. Shahbazpanahi et al. in \[8\] have shown that the channel matrix of Alamouti coding systems can be estimated using PCA although it requires different energies for signal transmission. This unbalanced energy implies a degradation in terms of *Bit Error Rate* (BER) for the signal transmitted with lower energy. In fact, for EZW–coded images it will be shown how *Peak Signal to Noise Ratio* (PSNR) can be considerably improved when the bits associated to the lowest frequency subbands are sent using higher energy than that assigned for the bits corresponding to higher subbands. However, this bit allocation strategy penalizes the EZW property for incremental decoding and, for this reason, it is also proposed in this work a simple decision criterion to decide when that strategy must be used or not.

The work is structured as follows. The channel model is shown in Section 2 where the utilization of PCA for channel estimation is also described. Section 3 shows three different strategies to convert the EZW bitstream to the signals transmitted through the antennas, and Section 4 compares those strategies by performing several computer simulations. Finally, Section 5 presents the main work conclusions.

## 2 Alamouti Coding Systems

We define the sources \(s_1\) and \(s_2\) as independent equiprobable discrete random variables with values from a finite set of symbols belonging to a real or complex modulation (PAM, PSK, QAM...). In a \(2 \times 1\) *Multiple–Input/Single–Output* (MISO) case, the vector \(x = [x_1 \ x_2]^T\) of received signals (so–called observations) can be written as \(x = Hs + v\), where \(s = [s_1 \ s_2]^T\) is the source vector, \(v = [v_1 \ v_2]^T\) is the *Additive White Gaussian Noise* (AWGN) vector, and the \(2 \times 2\) channel matrix has the form

\[
H = \begin{bmatrix}
h_1 & h_2 \\
h_2^* & -h_1^*
\end{bmatrix}.
\]

(1)

Note that this matrix is orthogonal, i.e. \(H^H H = HH^H = I_2 \|h\|_2^2\), where \(\|h\|_2^2 = |h_1|^2 + |h_2|^2\) and thus, the sources can be recovered applying \(\hat{s} = H^H x\).

In recent years, several unsupervised methods to estimate the channel matrix (and to recover the sources) have been developed assuming that both sources
and channel matrices are completely unknown at the receiver side (see, for instance, \cite{9} and references therein). PCA constitutes an interesting unsupervised method to estimate the channel matrix since it implies to perform a reduced number of operations. By considering the covariance matrix $C_x$ obtained from the observations, i.e. $C_x = E[xx^H]$, PCA computes an orthogonal basis $U$, so that a new set of orthogonal signals, given by $z = U^H x$, can be obtained \cite{7}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{SER performance of general SOS algorithm for randomly generated symbols}
\end{figure}

For the scenario of Alamouti coding systems, since $H$ is unitary, the matrix $U$ is simply a normalized version of the channel matrix $H$. It has been proved in \cite{8} that the identification of the channel matrix is possible only when the sources have different energies, i.e. when the source $s_1$ is transmitted with an energy given by $E[|s_1(n)|^2] = 2/(1 + \gamma^2)$, while $s_2$ is sent with the energy $E[|s_2(n)|^2] = 2\gamma^2/(1 + \gamma^2)$, where $\gamma$ is the parameter of energy unbalance.

Many methods can be applied to compute the PCA decomposition. For instance, Via et al. in \cite{10} have proposed an adaptive learning procedure, while Pérez et al. in \cite{9} have presented a block algorithm for that purpose. In both cases, the matrix $C_x$ is estimated by sampling averaging of the $N_B$ symbols received per frame.

In order to illustrate the degradation associated to the source energy unbalance, we consider a scenario where blocks of $N_B = 1000$ symbols are generated from an equiprobable distribution. These symbols are modulated using 4-QAM and transmitted through block fading Rayleigh channels. We use the PCA implementation presented in \cite{9} referred to as general Sum-Of-Square (SOS) reconstruction, where the aforementioned unbalancing parameter, $\gamma$, is used and whose value is set up to $\gamma^2 = 0.64$, i.e. $\gamma = 0.8$. Figure 1 plots the Symbol Error Rate (SER) in terms of Signal Noise Ratio (SNR) for each source, $s_1$ and $s_2$, and the corresponding mean SER value. As a reference, it is also depicted SER under
Perfect Channel Side Information (Perfect CSI) assumptions. Note that Perfect CSI corresponds to the mean SER obtained for the two sources ($s_1$ and $s_2$) when CSI is perfectly known at the receiver side. By comparing the perfect CSI curve to those obtained using PCA, it can be seen from the figure that the source with highest energy ($s_1$) exhibits lower SER, while the source with smaller one ($s_2$) suffers from a loss in terms of SER with respect to perfect CSI scenario.

3 Bit Allocation Strategies

The results above reported show that the unbalanced energy is an important drawback for the use of PCA because it produces a SER degradation for one of the sources. In this section, we show that this degradation can be compensated with an adequate bit allocation taking into account the bit organization into the stream. The common strategy to convert a bitstream to a modulated signal (like, for example, an M-QAM signal), consists of sequentially processing that bitstream by taking groups of $b = \log_2(M)$ bits, which are mapped to their corresponding modulated symbol. The modulated symbols are subsequently divided into two sources (remember that a $2 \times 1$ Alamouti coded system is implemented): odd symbols, which are sent by the source $s_1$, and even symbols, which are sent by $s_2$. For EZW, such bit allocation implies that bits associated to any frequency subband are transmitted by both sources and, as a consequence, the degradation caused by unbalanced energy affects to all the subbands. This bit allocation is termed as Approach 1 in the following.

On the other hand, as a result of the structure observed for the EZW bitstream, we propose a novel bit allocation strategy (termed as Approach 2 in this work), where the bitstream is divided into two parts. The first part (corresponding to the lower subbands) is transmitted by $s_1$, while the second part (corresponding to higher subbands and to the so-called refinement bits) by $s_2$. This method permits that the energy degradation does not affect to the lower subbands but note, however, that it keeps from the incremental decoding of EZW. For this reason, it is desirable to use this approach only when the resulting quality of the recovered image is considerably better than that obtained applying Approach 1.

The immense majority of current wireless communication standards make use of feedback channels (usually limited in terms of throughput) between both sides of the link to periodically send channel state information from the receiver to the transmitter. For example, Worldwide Interoperability for Microwave Access (WiMAX) standard uses this channel to send an index for selecting the most adequate code according to channel conditions. In this work, we propose to use this feedback channel to indicate to the transmitter which bit allocation strategy must be used in order to obtain an adequate PSNR.

Since it is not possible to compute the PSNR at the receiver–end for a given image, it is also proposed to use a set of training images to get the estimated PSNR according to visual image quality as a function of SNR. Then, this information is stored at the receiver. Before the transmission of each new image, the
receiver estimates the SNR and decides the bit allocation approach with higher estimated PSNR for a given SNR. An alternative way of interpreting this rule consists of defining the SNR threshold, denoted by SNR_t, which marks out the working regions for each approach. In other words, this approach, termed as Hybrid Approach, can be described by the following decision rule

\[
\text{estimated SNR} \geq \text{SNR}_t \rightarrow \text{Use Approach 1} \\
\text{estimated SNR} < \text{SNR}_t \rightarrow \text{Use Approach 2},
\]

whose result is sent to the transmitter through the feedback channel. The open issue is how to find that SNR threshold, SNR_t, which defines the border between the two working regions. In the next section, we will show a method based on the visual quality of the recovered images.

4 Computer Simulations

In order to compare the proposed bit allocation strategies, we consider a computer scenario where the bitstream of EZW-coded images is modulated using 4-QAM. The symbols are transmitted in blocks of size N_B = 1000 using Alamouti coding. In order to guarantee that the channel matrix can be estimated using PCA, the transmitter unbalances the source energy by means of a parameter \( \gamma^2 = 0.64 \). Thus, PCA is used to acquire the channel matrix estimate per received frame. Note that the covariance matrix obtained from the observations is computed using all the frame symbols, i.e. N_B symbols.

For the training step, the four images plotted in Figure 2 have been coded using EZW.\(^1\) Figure 3 plots the PSNR in terms of SNR obtained by averaging

\(^1\) The original images are constituted by 256 × 256 pixels with 256 gray levels.
the results for 10 Rayleigh channels randomly generated. It can be seen from this figure that the Approach 2 provides the best PSNR for low and medium SNR values since bits associated to lower frequency subbands are sent by means of the source having highest energy. With the goal of establishing the threshold parameter SNR\textsubscript{t} for the decision rule described in Equation (2), the recovered images corresponding to different SNR values, specifically 14, 17, and 20 dB for 10 channel realizations, have been empirically observed. A test oriented to decide which approach provides the best quality percentage or ratio taking into account all the set of training images is applied. Thus, Figure 3 also shows the results obtained from this visual test, which allows us to conclude that

- Firstly, for an SNR value of 14 dB, the improvement achieved with Approach 2 compared to Approach 1 is substantial. Therefore, it is apparent that Approach 2 is the best choice in such a case leading to better quality reconstruction.

- Secondly, for an SNR value of 17 dB, the improvement achieved with Approach 2 compared to Approach 1 is not as significant. By considering the results obtained with Approach 1 and that both approaches exhibit exactly the same performance for about a ratio of 20 to 100 (this scenario is labeled in the figure as \textit{Same performance}), Approach 1 can be decided as a more adequate choice than Approach 2 if progressive decoding is desired.

- Finally, for an SNR value of 20 dB, Approach 1 is clearly the best choice, since it is only outperformed by Approach 2 less than 20\% of cases.

As a result, it can be established a threshold parameter of SNR equal to 17 dB.

Figure 4 shows a comparison in terms of PSNR versus SNR between the three bit allocation strategies studied in this work only considering one of the test images depicted in Figure 2 and 10 channel realizations. Figure 5 illustrates
5 Conclusions and Future Work

A lot of algorithms based on wavelets for image compressing, like EZW, produce bitstreams by ordering the subbands from lowest to highest, which allows to achieve different image qualities after the progressive decoder. This means that the first bits of the EZW sequence are “more important” than the following bits. In this work, we have used this property to improve the performance of the EZW images transmitted over wireless systems where Alamouti space-time block coding is used. We have focused on the utilization of PCA to acquire the channel
matrix estimate avoiding the use of pilot symbols. As a result, three proposed bit allocation strategies combined with a decision rule based on an empirical SNR threshold parameter allow us to improve the quality of the reconstructed images after their transmission affected by fluctuating wireless channel conditions.

Future work to be developed by the authors is focused on studying different bit allocation strategies like, for instance, the sending of the refinement bits corresponding to LL subband through the channel with largest energy. Since PSNR criterion above explained is empirically obtained, other assessment metrics must be analyzed, specially those based on Human Visual System, as for example the Visual Information Fidelity measure. Additionally, this work could be extended to the standard of image processing JPEG2000, thus avoiding some of the drawbacks inherent to EZW.

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References