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Attentional Mechanisms for Interactive Image Exploration

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A lot of work has been devoted to content-based image retrieval from large image databases. The traditional approaches are based on the analysis of the whole image content both in terms of low-level and semantic characteristics. We investigate in this paper an approach based on attentional mechanisms and active vision. We describe a visual architecture that combines bottom-up and top-down approaches for identifying regions of interest according to a given goal. We show that a coarse description of the searched target combined with a bottom-up saliency map provides an efficient way to find specified targets on images. The proposed system is a first step towards the development of software agents able to search for image content in image databases.

Keywords and phrases: exploratory vision, bottom-up exploration, top-down exploration, attention, situated vision.

1. INTRODUCTION

Image analysis is confronted with the development of large image databases and new techniques have to be designed for image and content retrieving in this context. The agent paradigm has proved its efficiency for searching in unstructured databases. An agent exhibits interaction abilities with its environment and an autonomous behavior driven by its perceptions of the environment and its expectancies. This viewpoint emphasizes the role of interaction in visual processing and is related to the active vision paradigm mainly used in robotics [1, 2]. We propose here to use a similar paradigm of active vision for implementing content retrieval mechanisms in fixed image or video sequences. To drive the active vision system, we need a mechanism for identifying salient regions in the visual scene. Most of the systems proposed for the computation of saliency maps are based on bottom-up approaches [3, 4]. We use here a bottom-up mechanism to identify a first set of salient regions and a top-down mechanism for target recognition. Salient regions can be defined as high-energy contrast regions. On the other hand, regions of interest are characterized by their high relevance according to a given goal. Preattentional mechanisms are based on saliencies while attentional top-down processes are goal-directed. We thus propose an approach that combines both mechanisms in the following way.

We distinguish two nested regions in an image: the whole visual field, a low-resolution area that can be shifted by attention from position to position, and a small central foveal region that can be analyzed at full resolution. A first set of points is computed at low resolution from the whole visual field and used to give the focus to each potentially interesting region one at a time. We study here how information on the target can bias this exploratory step and improve its efficiency. We also compare different approaches for identifying or rejecting the target when it is foveated.

2. MODEL

2.1. Definition of a saliency space

The first step in our work consisted in defining a projection space in which we can compute the saliencies present in

the visual field. Although saliencies can be computed from various methods (e.g., local image contrast), we assumed here that saliencies are mainly based on preferred orientations and spatial frequencies. Consequently, we used an approach based on Gabor wavelets. The image convolution by a bidimensional Gabor wavelet can be described by the equation

$$r(\mathbf{x}, \mathbf{\Omega}_{k,\theta}) = e^{(-1/2)\mathbf{x}^{\tau}\Sigma^{-1}\mathbf{x}} e^{-i\Omega_{k,\theta}\mathbf{x}} * I(\mathbf{x}), \tag{1}$$

where $I(\mathbf{x})$ is the initial image, $r(\mathbf{x}, \mathbf{\Omega}_{k,\theta})$ the filtered image, and $e^{(-1/2)\mathbf{x}^{\tau}\Sigma^{-1}\mathbf{x}} e^{-i\Omega_{k,\theta}\mathbf{x}}$ is the Gabor convolution kernel. $\mathbf{\Omega}_{k,\theta}$ is a row vector defining the preferred orientations of the filter such that $\mathbf{\Omega}_{k,\theta} = \mathbf{\Omega}_k \mathbf{R}_\theta$ where $\mathbf{R}_\theta$ is the rotation matrix defining the orientation of the filter and $\mathbf{\Omega}_k = (\omega_k \quad 0)$ the central frequency of the filter.

In the present work $\theta \in \{0, \pi/4, \pi/2, 3\pi/4\}$ and $k \in \{1/12, 1/6, 1/3 \text{ cyc/pixel}\}$.

Thus, starting from the hypothesis that only low frequencies are used to orient the exploratory bottom-up mechanism, we computed the saliency map as explained below.

From a statistically significant set of natural images analyzed through a Gabor wavelet bank, we extracted small image patches at random. Each patch had the same size as the foveal region. From each patch, we computed as many signature vectors $\mathbf{v}_k = \{\bar{r}_{k,\theta}\}_{\theta \in \{0,\pi/4,\pi/2,3\pi/4\}}$ as the number of desired frequency bands according to the following equation:

$$\bar{r}^2_{k,\theta} = \frac{1}{N} \sum_{\mathbf{x}} r(\mathbf{x}, \mathbf{\Omega}_{k,\theta}) \times r^*(\mathbf{x}, \mathbf{\Omega}_{k,\theta}), \tag{2}$$

where N is the number of pixels in the image patch and $r^*(\mathbf{x}, \mathbf{\Omega}_{k,\theta})$ and $r(\mathbf{x}, \mathbf{\Omega}_{k,\theta})$ are complex conjugates.

The multiresolution technique used to compute the $\mathbf{v}_k$ vector is similar to the one proposed by [5]. A principal component analysis (PCA) was then applied to each of these vectors for each spatial frequency channel according to $\mathbf{z} = \mathbf{U}^{\tau}\mathbf{v}$ where $\mathbf{U}$ is an orthogonal projection matrix such that $\langle \mathbf{z}\mathbf{z}^{\tau} \rangle$ is diagonal.

We thus obtained four projection axes in each frequency band, the components of which are linear combinations of the initial orientations. The obtained projection space is significant of the second-order statistical regularities observed in the used subset of natural images. However, experiments performed with various subsets did not show significant differences.

2.2. Preattentional and attentional controls

The saliencies of the scene at each position in the visual field can then be obtained as the projection of the $\mathbf{v}_k$ vectors on the corresponding axis of the PCA (Figure 1). We have shown elsewhere that the salient points computed by this method differ according to the considered axis [6]. Here only the first eigenvector at low resolution was used.

The obtained salient points are used to control the exploration of the scene. In the present study, two methods were used: the bottom-up control uses only information extracted from the visual scene in a Preattentional way, while the top-down control implements an attentional mechanism driven by a previously memorized information concerning the target.

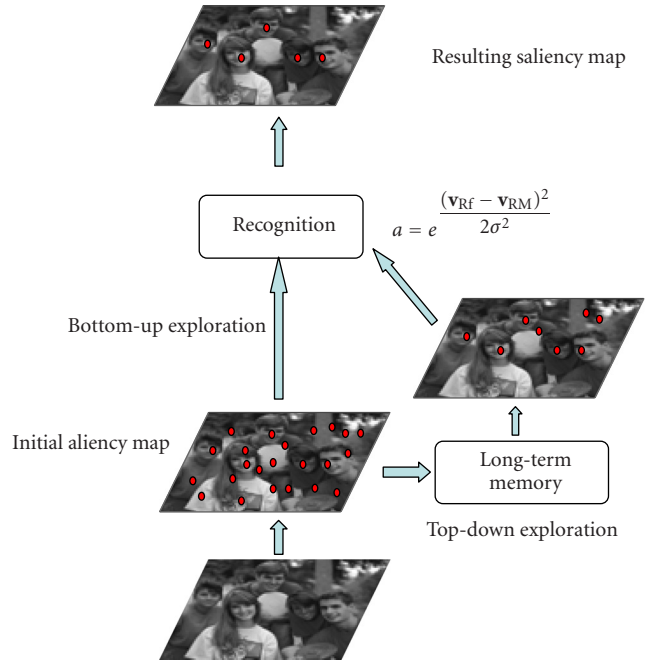


Figure 1: An overall presentation of the attentional model. A bottom-up saliency map is biased with the information on the desired target lying in long-term memory.

We tested this architecture on a task where the system's behavior is to find targets similar to the one pointed out by the user.

In bottom-up control mode, when the user points to a region, the system finds the nearest salient point in its present visual field, focuses on it, and then computes the low-resolution bottom-up salient points in its new visual field. It then focuses on the most salient of these points and computes a recognition score of the target. Two kinds of scores have been tested: (i) one from the average of the Gabor norms, (ii) the other being simply the concatenation of the Gabor norm image vectors covering the foveal area of the system. In this study, these vectors are of dimension 12 (3 spatial frequencies, 4 orientations).

In top-down control mode, the system performs a low-resolution comparison between the salient points in its whole visual field and a low-resolution signature of the target. It thus retains only salient points superior to a given threshold. This mechanism leads to a modulation of the natural saliency of the considered point according to the low-resolution characteristics of the searched target. Two kinds of score computations were tested: (i) a comparison of the energy vectors computed from the low-resolution part of the multiresolution analysis, respectively, from the salient point $\mathbf{x}_s$ and the target representation $\mathbf{x}_t$ (TDE) (ii) a direct comparison of the low-frequency images of the salient region and of the target

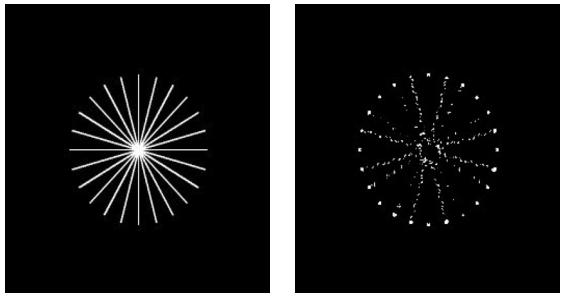


Figure 2: Bottom-up detection of interest points. The figure illustrates the end-stopping (termination detector) properties of the approach.

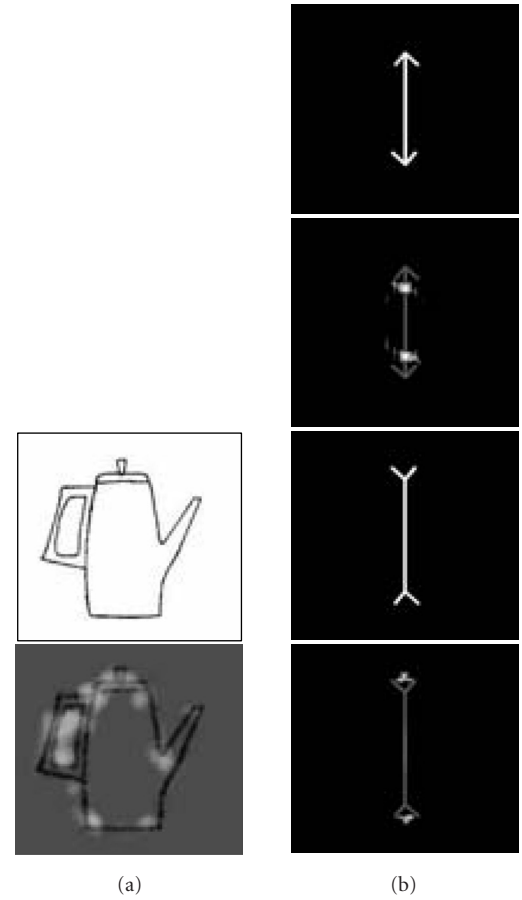
(TDV). The similarity score is thus computed using a radial basis function $a = e^{-\|\mathbf{x}_s - \mathbf{x}_t\|^2/2\sigma^2}$.

2.3. Discussion of the model properties

Some points concerning this approach deserve to be discussed before the description of the obtained results. Major results have been obtained during the last decade concerning the first steps of visual processing in natural systems [7, 8, 9]. These papers show that the first filtering steps consist in the elaboration of an optimal code based on the maximization of a statistical independence criterion. It leads to similar filters such as those obtained using independent component analysis (ICA) [10, 11, 12]. They have been shown to be very similar to Gabor filters [13]. This is why we use this approach in our model.

However, it is interesting to analyze the kind of salient features obtained from the computations described above. Experiments with several different images demonstrated that the features emphasized by such projections mainly consist in termination and curvature points. For instance, some of the features extracted from a test image according to the first PCA axis are rotation-invariant curvature points (Figure 2).

Due to their properties of end-stopping detectors, it is interesting to observe that the saliant positions computed from the image in Figure 3 can be invoked as an explanation for the Müller-Lyer illusion.



(a) (b)

Figure 3: Bottom-up detection of interest points. (a) Detection of interest points is made on the basis of curvature and termination characteristics. (b) The energy peak from these detectors is located inside the direct arrowheads and outside the reversed arrowheads, as expected in the Müller-Lyer illusion where the direct arrowheads appear shorter than the reverse arrowheads.

3. RESULTS

Although the system can be used in various object search tasks, we only present here the results obtained in a face retrieval task.

The user points a face in a scene and the task of the system is to find similar patterns across the image. On this task, we tested the three methods presented above (bottom-up, top-down energy (TDE), and top-down vector (TDV), see Figure 4).

In bottom-up mode, the system is driven by the natural saliencies computed from the scene. These saliencies are sorted according to their decreasing intensities in such a way that the system begins its exploration with the highest intensity saliency. The similarity score obtained in this case ranges from 0.1–1.0. Ten percent of the points have a similarity score in the range 0.9-1.0, while 17% are in the range 0.8-0.9. The majority of the points have a score in the range 0.6–0.9.

In the top-down mode, the system is guided through high-level information. In TDE mode, the similarity scores range from 0.3–1.0. Fourteen percent of the points lie between 0.9 and 1.0 while 22% range from 0.8-0.9. Most of the visited points have a similarity score between 0.7 and 1.0.

In TDV mode, there is a decrease in the variability of the similarity score. Sixty five percent of the points have a similarity score in the range 0.9–1.0 and 10% between 0.8 and 0.9. The most visited points lie between 0.9 and 1.0. The use of top-down information leads to a significant reduction in the number of visited points (234 for the bottom-up exploration, 107 for TDE, and 31 in TDV for the example in Figure 4).

When this experiment is repeated with various images (up to 20 images), faces always yield similarity scores greater than 0.8. We retained this value as a decision threshold separating faces and nonfaces locations. We were thus able to compute an error rate for the different experiments from a

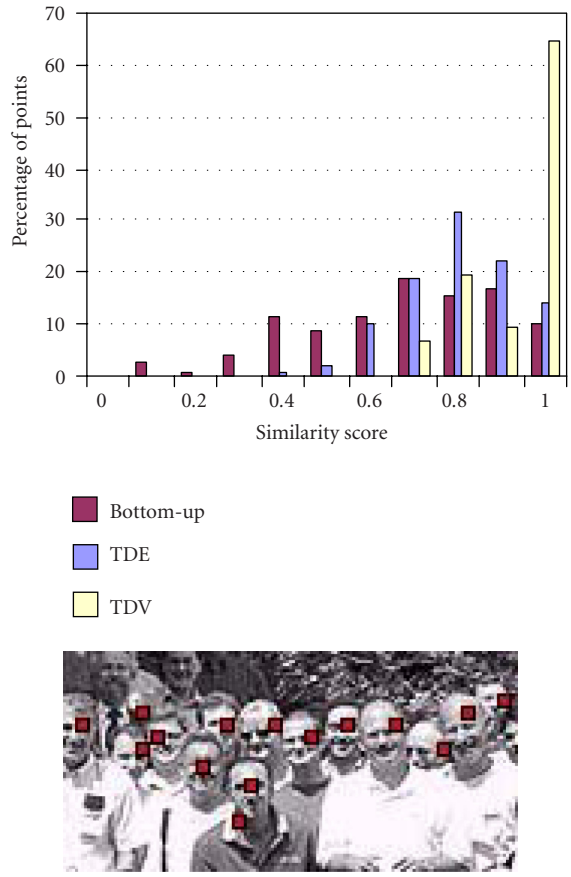


FIGURE 4: Percent of visited points according to the similarity score. The figure shows that a large portion of visited points have a low similarity score in bottom-up exploration, while in TDE and in TDV the visited points exhibit greater similarity scores. The image shows the result obtained with the face recognition task in TDV mode.

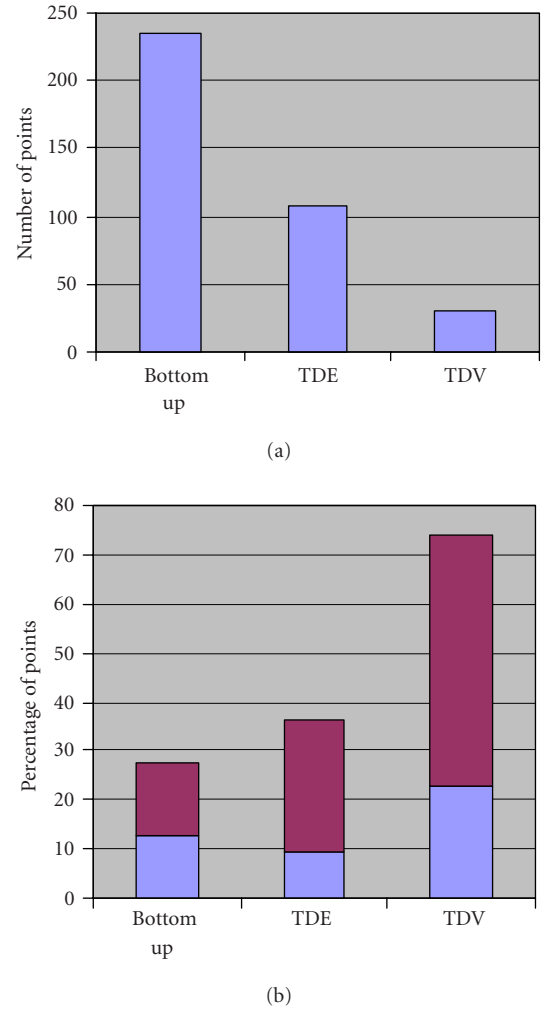


FIGURE 5: (a) Evolution of the number of points explored by the system in the three investigated modes. (b) Evolution of the ratio between faces and nonfaces in the visited points (upper values) and evolution of the recognition error rate (lower values).

comparison between the answer of the system (a similarity score greater than 0.8 being now considered as a positive answer) and the ground truth of the target.

It results from these investigations that in the bottom-up mode only 27% of the visited points are faces while this percentage increases to 36% in the TDE mode and reaches 74% in the TDV mode (Figure 5). On the other hand, in the bottom-up mode the error rate is 47%. It decreases to 26% and 30% in TDE and TDV, respectively. The TDV method gives rise to the best results.

One mandatory specification of this kind of system is its robustness according to the variations of illumination. We tested the behavior of the system in the case of the search for identical targets in a series of video images. This property is indeed especially important in the case where we want to follow the same object through a video sequence. We have used the TDV mode to search for a zone pointed out by the user in a midilluminated scene (image mean intensity 151.9 expressed in grey level) through a set of homologous images the illumination of which ranges from 69.24–185.69. Figure 6a shows the variation of the similarity score according to the illumination for homologous points (i.e., points corresponding to the same target, in order to detect false negatives).

Figure 6b shows the same result for heterologuous points (i.e., points corresponding to different targets, in order to detect false positives). The mean score remains approximately constant in function of illumination. Its variance increases with illumination but the discrimination ability of the system (measured by the threshold between the two curves) is preserved.

4. DISCUSSION AND CONCLUSION

The system presented in this paper is based on two principles: (i) the selection of salient points used to guide exploratory saccades, (ii) the combination of bottom-up and top-down information to bias the saliencies in favor of the searched target. This last modulation reduces the computational load of the system. The identification of the salient points is indeed

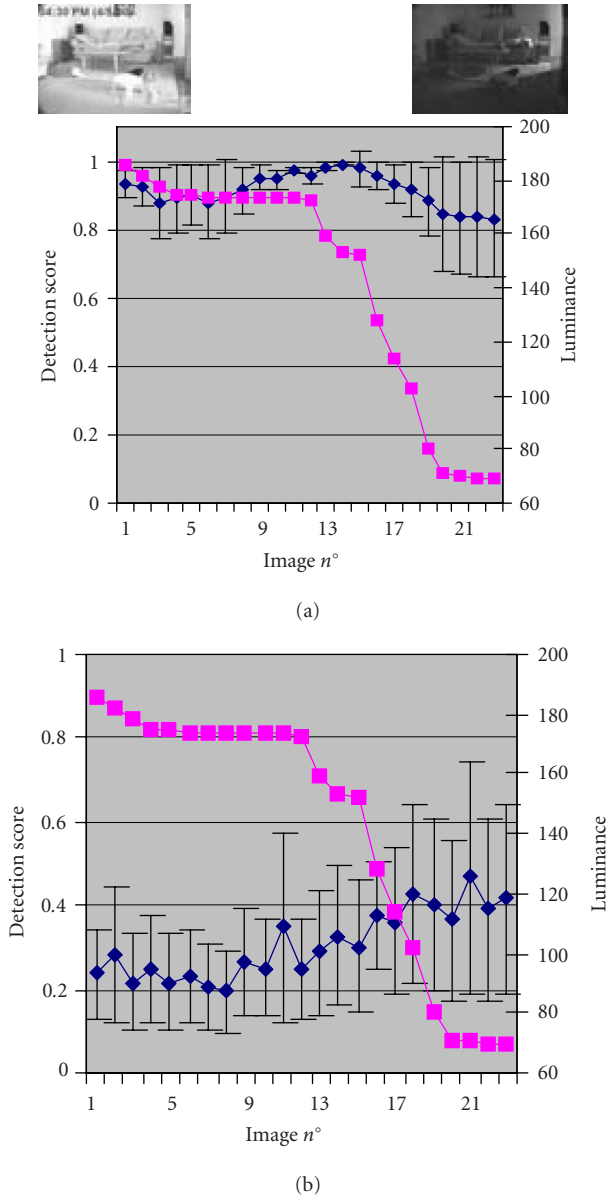


Figure 6: Robustness to the variations of illumination. A video sequence with a continuous variation in luminance has been used to follow the detection of homologous interest points from image to image. The figure shows the mean detection score for (a) targets and (b) nontargets superimposed with the luminance curve (expressed in grey levels).

not based on a saliency map computed on the whole scene [3, 14, 15] but limited to the visual field and computed at low resolution.

The list of the potentially interesting coordinate points can thus be viewed as a sparse representation of the scene consisting of a system of references to the external location where the complete information lies. Such a view was first introduced by O'Regan who proposes to see the world as an external memory [16]. It implements the first principles of the sensori-motor theory of perception proposed by this author [17]. This mechanism is also related to the notion of deictic pointers proposed by Ballard [18]. Note that only stable landmarks can be used for this purpose and that new questions could arise in the case of video applications.

The proposed architecture allows to perform any search and exploration task. It is indeed independent of the type and size of image and the searched target.

Our final goal is to build an exploratory vision architecture able to work in real-time. The reduction of the computational load is critical to achieve this goal. This constraint explains the limited number of preferred directions used in the computation of saliencies and the relative simplicity of the coding method.

The multiresolution technique used here, which performs the complex processing steps on previously selected regions, also provides a mechanism to overcome the real-time constraints. Though the retained information does not allow a complete reconstruction of the initial scene, it is sufficient to ensure a sufficiently fast exploration mechanism. The advantages of this approach, which distinguishes low-resolution and large-field processing from high-resolution focused computations, is twofold. It indeed reduces the need for complex computation during the exploration process and, perhaps more importantly, clearly separates the exploration and exploitation steps that constitute the behavior of the system. As suggested by psychophysics experiments [19], we make the hypothesis that the identification processes happening in peripheral and central vision are quite different. In peripheral vision, we do not need to cope with invariance, since the available representation is simplified, partial, and sparse. It is only made of a set of pointers useful for driving action. From these regions, it seems to be impossible to get a complex representation of objects [19]. On the contrary, the central part of the visual field provides the information for building complex objects representations. One of the major contributions of the proposed approach is that the system does not need a complete representation of the object to select locations to focus at. The recognition process can thus take place in two steps: (i) identification of potentially interesting locations according to the searched target, (ii) recognition of the target after foveation. When the search process is biased by low-resolution information related to the target, the number of potentially interesting points dramatically decreases which improves the efficiency of the search process. We can thus parallel this mechanism with the one at work in natural vision system in which the search for a given target could be driven by a simplified description of the target, the recognition process being made easier by the fact that it operates only on focused regions.

One can argue that the proposed method is neither rotation- nor scale-invariant. However, it is inherently invariant in translation; since the targets will eventually be centered, the translational invariance problem disappears.

Another interesting fallout of considering perception as a dynamical mechanism is that the system endowed with those perceptual abilities can be viewed as a kind of autonomous agent. The interactive process in which the agent is involved can thus be improved using learning techniques

popular within the agent's or robotics communities. Among these methods, the use of reinforcement learning is presently under investigation in our laboratory.

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on

Advanced Video Technologies and Applications for H.264/AVC and Beyond

Call for Papers

The recently developed video coding standard H.264/MPEG-4 AVC significantly outperforms previous standards in terms of coding efficiency at reasonable implementation complexity and costs in VLSI realization. Real-time H.264 coders will be available very soon. Many applications, such as surveillance systems with multiple video channel recording, multiple channel video services for mobile devices, will benefit from the H.264 coder due to its excellent coding efficiency. The new video coding technology introduces new opportunities for video services and applications. However, advanced video coding is only one aspect for successful video services and applications. To enable successful new applications, additional technologies to cope with time-varying channel behaviors and diverse usage characteristics are needed. For serving multiple videos, some extended designs such as joint rate-distortion optimization and scheduling of multiple parallel video sessions are also required to achieve fair and robust video storage and delivery. For video surveillance systems, intelligent video content analysis and scalabilities in video quality, resolution, and display area, coupled with wireless transmission, can offer new features for the application. Finally, computational complexity reduction and low-power design of video codecs as well as content protection of video streams are particularly important for mobile devices.

The goal of this special issue is to discuss state-of-the-art techniques to enable various video services and applications on H.264/AVC technologies and their new developments.

Topics of interest include (but are not limited to):

- Video over DVB-H
- Error resilience of video over mobile networks
- Video delivery in multiuser environments
- Rate-distortion optimization for multiple video sources
- Multipath delivery of video streams
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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on
Advances in Blind Source Separation

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Almost every multichannel measurement includes mixtures of signals from several underlying sources. While the structure of the mixing process may be known to some degree, other unknown parameters are necessary to demix the measured sensor data. The time courses of the source signals and/or their locations in the source space are often unknown a priori and can only be estimated by statistical means. In the analysis of such measurements, it is essential to separate the mixed signals before beginning postprocessing.

Blind source separation (BSS) techniques then allow separation of the source signals from the measured mixtures. Many BSS problems may be solved using independent component analysis (ICA) or alternative approaches such as sparse component analysis (SCA) or nonnegative matrix factorization (NMF), evolving from information theoretical assumptions that the underlying sources are mutually statistically independent, sparse, smooth, and/or nonnegative.

The aim of this special issue is to focus on recent developments in this expanding research area.

The special issue will focus on one hand on theoretical approaches for single- and multichannel BSS, evolving from information theory, and especially on nonlinear blind source separation methods, and on the other hand or their currently ever-widening range of applications such as brain imaging, image coding and processing, dereverberation in noisy environments, and so forth.

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Special Issue on
Tracking in Video Sequences of Crowded Scenes

Call for Papers

Object tracking in live video is an enabling technology that is in strong demand by large application sectors, such as video surveillance for security and behavior analysis, traffic monitoring, sports analysis for enhanced TV broadcasting and coaching, and human body tracking for human-computer interaction and movie special effects.

Many techniques and systems have been developed and demonstrated for tracking objects in video sequences. The specific goal of this special issue is to provide a status report regarding the state of the art in object tracking in crowded scenes based on the video stream(s) of one or more cameras. The objects can be people, animals, cars, and so forth. The cameras can be fixed or moving. Moving cameras may pan, tilt, and zoom in ways that may or may not be communicated to the tracking system.

All papers submitted must address at least the following two issues:

- Processing of live video feeds

For many applications in surveillance/security and TV sports broadcasting, the results of processing have value only if they can be provided to the end user within an application-defined delay. The submitted papers should present algorithms that are plausibly applicable to such incremental ("causal") processing of live video feeds, given suitable hardware.

- Handling of crowded scenes

Crowded-scene situations range from relatively simple (e.g., players on a planar field in a soccer match) to very difficult (e.g., crowds on stairs in an airport or a train station). The central difficulties in crowded scenes arise from the constantly changing occlusions of any number of objects by any number of other objects.

Occlusions can be resolved to some degree using a single video stream. However, many situations of occlusion are more readily resolved by the simultaneous use of several cameras separated by wide baselines. In addition to resolving ambiguities, multiple cameras also ease the exploitation of 3D structure, which can be important for trajectory estimation or event detection.

Topics of interest include principles and evaluation of relevant end-to-end systems or important components thereof, including (but not limited to):

- Handling of occlusions in the image plane in single-camera scenarios
- Handling of occlusions in a world coordinate system (3D, possibly degenerated to 2D) in single- or multi-camera scenarios
- Fusion of information from multiple cameras and construction of integrated spatiotemporal models of dynamic scenes
- 3D trajectory estimation
- Tracking of multiple rigid, articulated, or nonrigid objects
- Automatic recovery of camera pose from track data
- Detection and recognition of events involving multiple objects (e.g., offside in soccer)

Papers must present a thorough evaluation of the performance of the system or method(s) proposed in one or more application areas such as video surveillance, security, sports analysis, behavior analysis, or traffic monitoring.

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on

Advances in Subspace-Based Techniques for Signal Processing and Communications

Call for Papers

Subspace-based techniques have been studied extensively over the past two decades and have proven to be very powerful for estimation and detection tasks in many signal processing and communications applications. Such techniques were initially investigated in the context of super-resolution parametric spectral analysis and the related problem of direction finding. During the past decade or so, new potential applications have emerged, and subspace methods have been proposed in several diverse fields such as smart antennas, sensor arrays, system identification, time delay estimation, blind channel estimation, image segmentation, speech enhancement, learning systems, and so forth.

Subspace-based methods not only provide new insight into the problem under investigation but they also offer a good trade-off between achieved performance and computational complexity. In most cases they can be considered as low cost alternatives to computationally intensive maximum likelihood approaches.

The interest of the signal processing community in subspace-based schemes remains strong as is evident from the numerous articles and reports published in this area each year. Research efforts are currently focusing on the development of low-complexity adaptive implementations and their efficient use in applications, numerical stability, convergence analysis, and so forth.

The goal of this special issue is to present state-of-the-art subspace techniques for modern applications and to address theoretical and implementation issues concerning this useful methodology.

Topics of interest include (but are not limited to):

- Efficient and stable subspace estimation and tracking methods
- Subspace-based detection techniques
- Sensor array signal processing
- Smart antennas
- Space-time, multiuser, multicarrier communications
- System identification and blind channel estimation
- State-space model estimation and change detection
- Learning and classification
- Speech processing (enhancement, recognition)
- Biomedical signal processing
- Image processing (face recognition, compression, restoration)

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on Image Perception

Call for Papers

Perception is a complex process that involves brain activities at different levels. The availability of models for the representation and interpretation of the sensory information opens up new research avenues that cut across neuroscience, imaging, information engineering, and modern robotics.

The goal of the multidisciplinary field of perceptual signal processing is to identify the features of the stimuli that determine their "perception," namely "a single unified awareness derived from sensory processes while a stimulus is present," and to derive associated computational models that can be generalized.

In the case of vision, the stimuli go through a complex analysis chain along the so-called "visual pathway," starting with the encoding by the photoreceptors in the retina (low-level processing) and ending with cognitive mechanisms (high-level processes) that depend on the task being performed.

Accordingly, low-level models are concerned with image "representation" and aim at emulating the way the visual stimulus is encoded by the early stages of the visual system as well as capturing the varying sensitivity to the features of the input stimuli; high-level models are related to image "interpretation" and allow to predict the performance of a human observer in a given predefined task.

A global model, accounting for both such bottom-up and top-down approaches, would enable the automatic interpretation of the visual stimuli based on both their low-level features and their semantic content.

Among the main image processing fields that would take advantage of such models are feature extraction, content-based image description and retrieval, model-based coding, and the emergent domain of medical image perception.

The goal of this special issue is to provide original contributions in the field of image perception and modeling.

Topics of interest include (but are not limited to):

- Perceptually plausible mathematical bases for the representation of visual information (static and dynamic)
- Modeling nonlinear processes (masking, facilitation) and their exploitation in the imaging field (compression, enhancement, and restoration)
- Beyond early vision: investigating the pertinence and potential of cognitive models (feature extraction, image quality)
- Stochastic properties of complex natural scenes (static, dynamic, colored) and their relationships with perception
- Perception-based models for natural (static and dynamic) textures. Theoretical formulation and psychophysical validation
- Applications in the field of biomedical imaging (medical image perception)

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on
Music Information Retrieval Based on Signal Processing

Call for Papers

The main focus of this special issue is on the application of digital signal processing techniques for music information retrieval (MIR). MIR is an emerging and exciting area of research that seeks to solve a wide variety of problems dealing with preserving, analyzing, indexing, searching, and accessing large collections of digitized music. There are also strong interests in this field of research from music libraries and the recording industry as they move towards digital music distribution. The demands from the general public for easy access to these music libraries challenge researchers to create tools and algorithms that are robust, small, and fast.

Music is represented in either encoded audio waveforms (CD audio, MP3, etc.) or symbolic forms (musical score, MIDI, etc.). Audio representations, in particular, require robust signal processing techniques for many applications of MIR since meaningful descriptions need to be extracted from audio signals in which sounds from multiple instruments and vocals are often mixed together. Researchers in MIR are therefore developing a wide range of new methods based on statistical pattern recognition, classification, and machine learning techniques such as the Hidden Markov Model (HMM), maximum likelihood estimation, and Bayes estimation as well as digital signal processing techniques such as Fourier and Wavelet transforms, adaptive filtering, and source-filter models. New music interface and query systems leveraging such methods are also important for end users to benefit from MIR research.

Although research contributions on MIR have been published at various conferences in 1990s, the members of the MIR research community meet annually at the International Conference on Music Information Retrieval (ISMIR) since 2000.

Topics of interest include (but are not limited to):

- Automatic summarization (succinct representation of music)
- Automatic transcription (audio to symbolic format conversion)
- Music annotation (semantic analysis)
- Music fingerprinting (unique identification of music)
- Music interface
- Music similarity metrics (comparison)
- Music understanding
- Musical feature extraction
- Musical styles and genres
- Optical music score recognition (image to symbolic format conversion)
- Performer/artist identification
- Query systems
- Timbre/instrument recognition

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on Visual Sensor Networks

Call for Papers

Research into the design, development, and deployment of networked sensing devices for high-level inference and surveillance of the physical environment has grown tremendously in the last few years.

This trend has been motivated, in part, by recent technological advances in electronics, communication networking, and signal processing.

Sensor networks are commonly comprised of lightweight distributed sensor nodes such as low-cost video cameras. There is inherent redundancy in the number of nodes deployed and corresponding networking topology. Operation of the network requires autonomous peer-based collaboration amongst the nodes and intermediate data-centric processing amongst local sensors. The intermediate processing known as in-network processing is application-specific. Often, the sensors are untethered so that they must communicate wirelessly and be battery-powered. Initial focus was placed on the design of sensor networks in which scalar phenomena such as temperature, pressure, or humidity were measured.

It is envisioned that much societal use of sensor networks will also be based on employing content-rich vision-based sensors. The volume of data collected as well as the sophistication of the necessary in-network stream content processing provide a diverse set of challenges in comparison with generic scalar sensor network research.

Applications that will be facilitated through the development of visual sensor networking technology include automatic tracking, monitoring and signaling of intruders within a physical area, assisted living for the elderly or physically disabled, environmental monitoring, and command and control of unmanned vehicles.

Many current video-based surveillance systems have centralized architectures that collect all visual data at a central location for storage or real-time interpretation by a human operator. The use of distributed processing for automated event detection would significantly alleviate mundane or time-critical activities performed by human operators, and provide better network scalability. Thus, it is expected that video surveillance solutions of the future will successfully utilize visual sensor networking technologies.

Given that the field of visual sensor networking is still in its infancy, it is critical that researchers from the diverse disciplines including signal processing, communications, and electronics address the many challenges of this emerging field. This special issue aims to bring together a diverse set of research results that are essential for the development of robust and practical visual sensor networks.

Topics of interest include (but are not limited to):

- Sensor network architectures for high-bandwidth vision applications
- Communication networking protocols specific to visual sensor networks
- Scalability, reliability, and modeling issues of visual sensor networks
- Distributed computer vision and aggregation algorithms for low-power surveillance applications
- Fusion of information from visual and other modalities of sensors
- Storage and retrieval of sensor information
- Security issues for visual sensor networks
- Visual sensor network testbed research
- Novel applications of visual sensor networks
- Design of visual sensors

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on
Multirate Systems and Applications

Call for Papers

Filter banks for the application of subband coding of speech were introduced in the 1970s. Since then, filter banks and multirate systems have been studied extensively. There has been great success in applying multirate systems to many applications. The most notable of these applications include subband coding for audio, image, and video, signal analysis and representation using wavelets, subband denoising, and so forth. Different applications also call for different filter bank designs and the topic of designing one-dimensional and multidimentional filter banks for specific applications has been of great interest.

Recently there has been growing interest in applying multirate theories to the area of communication systems such as, transmultiplexers, filter bank transceivers, blind deconvolution, and precoded systems. There are strikingly many dualities and similarities between multirate systems and multicarrier communication systems. Many problems in multicarrier transmission can be solved by extending results from multirate systems and filter banks. This exciting research area is one that is of increasing importance.

The aim of this special issue is to bring forward recent developments on filter banks and the ever-expanding area of applications of multirate systems.

Topics of interest include (but are not limited to):

- Multirate signal processing for communications
- Filter bank transceivers
- One-dimensional and multidimensional filter bank designs for specific applications
- Denoising
- Adaptive filtering
- Subband coding
- Audio, image, and video compression
- Signal analysis and representation
- Feature extraction and classification
- Other applications

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on

Multisensor Processing for Signal Extraction and Applications

Call for Papers

Source signal extraction from heterogeneous measurements has a wide range of applications in many scientific and technological fields, for example, telecommunications, speech and acoustic signal processing, and biomedical pattern analysis. Multiple signal reception through multisensor systems has become an effective means for signal extraction due to its superior performance over the monosensor mode. Despite the rapid progress made in multisensor-based techniques in the past few decades, they continue to evolve as key technologies in modern wireless communications and biomedical signal processing. This has led to an increased focus by the signal processing community on the advanced multisensor-based techniques which can offer robust high-quality signal extraction under realistic assumptions and with minimal computational complexity. However, many challenging tasks remain unresolved and merit further rigorous studies. Major efforts in developing advanced multisensor-based techniques may include high-quality signal extraction, realistic theoretical modeling of real-world problems, algorithm complexity reduction, and efficient real-time implementation.

The purpose of this special issue aims to present state-of-the-art multisensor signal extraction techniques and applications. Contributions in theoretical study, performance analysis, complexity reduction, computational advances, and real-world applications are strongly encouraged.

Topics of interest include (but are not limited to):

- Multiantenna processing for radio signal extraction
- Multimicrophone speech recognition and enhancement
- Multisensor radar, sonar, navigation, and biomedical signal processing
- Blind techniques for multisensor signal extraction
- Computational advances in multisensor processing

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on

Search and Retrieval of 3D Content and Associated Knowledge Extraction and Propagation

Call for Papers

With the general availability of 3D digitizers, scanners, and the technology innovation in 3D graphics and computational equipment, large collections of 3D graphical models can be readily built up for different applications (e.g., in CAD/CAM, games design, computer animations, manufacturing and molecular biology). For such large databases, the method whereby 3D models are sought merits careful consideration. The simple and efficient query-by-content approach has, up to now, been almost universally adopted in the literature. Any such method, however, must first deal with the proper positioning of the 3D models. The two prevalent-in-the-literature methods for the solution to this problem seek either

- Pose Normalization: Models are first placed into a canonical coordinate frame (normalizing for translation, scaling, and rotation). Then, the best measure of similarity is found by comparing the extracted feature vectors, or
- Descriptor Invariance: Models are described in a transformation invariant manner, so that any transformation of a model will be described in the same way, and the best measure of similarity is obtained at any transformation.

The existing 3D retrieval systems allow the user to perform queries by example. The queried 3D model is then processed, low-level geometrical features are extracted, and similar objects are retrieved from a local database. A shortcoming of the methods that have been proposed so far regarding the 3D object retrieval, is that neither is the semantic information (high-level features) attached to the (low-level) geometric features of the 3D content, nor are the personalization options taken into account, which would significantly improve the retrieved results. Moreover, few systems exist so far to take into account *annotation* and *relevance feedback* techniques, which are very popular among the corresponding content-based image retrieval systems (CBIR).

Most existing CBIR systems using knowledge either annotate all the objects in the database (full annotation) or annotate a subset of the database manually selected (partial annotation). As the database becomes larger, full annotation is increasingly difficult because of the manual effort needed. Partial annotation is relatively affordable and trims down the heavy manual labor. Once the database is partially annotated, traditional image analysis methods are used to derive semantics of the objects not yet annotated. However, it is not clear "how much" annotation is sufficient for a specific database and what the best subset of objects to annotate is. In other words how the knowledge *will be propagated*. Such techniques have not been presented so far regarding the 3D case.

Relevance feedback was first proposed as an interactive tool in text-based retrieval. Since then it has been proven to be a powerful tool and has become a major focus of research in the area of content-based search and retrieval. In the traditional computer centric approaches, which have been proposed so far, the "best" representations and weights are fixed and they cannot effectively model high-level concepts and user's perception subjectivity. In order to overcome these limitations of the computer centric approach, techniques based on *relevant feedback*, in which the human and computer interact to refine high-level queries to representations based on low-level features, should be developed.

The aim of this special issue is to focus on recent developments in this expanding research area. The special issue will focus on novel approaches in 3D object retrieval, transforms and methods for efficient geometric feature extraction, annotation and relevance feedback techniques, knowledge propagation (e.g., using Bayesian networks), and their combinations so as to produce a single, powerful, and dominant solution.

Topics of interest include (but are not limited to):

- 3D content-based search and retrieval methods (volume/surface-based)
- Partial matching of 3D objects
- Rotation invariant feature extraction methods for 3D objects

- Graph-based and topology-based methods
- 3D data and knowledge representation
- Semantic and knowledge propagation over heterogeneous metadata types
- Annotation and relevance feedback techniques for 3D objects

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EURASIP JOURNAL ON APPLIED SIGNAL PROCESSING

Special Issue on Robust Speech Recognition

Call for Papers

Robustness can be defined as the ability of a system to maintain performance or degrade gracefully when exposed to conditions not well represented in the data used to develop the system. In automatic speech recognition (ASR), systems must be robust to many forms of signal degradation, including speaker characteristics (e.g., dialect and accent), ambient environment (e.g., cellular telephony), transmission channel (e.g., voice over IP), and language (e.g., new words, dialect switching). Robust ASR systems, which have been under development for the past 35 years, have made great progress over the years closing the gap between performance on pristine research tasks and noisy operational data.

However, in recent years, demand is emerging for a new class of systems that tolerate extreme and unpredictable variations in operating conditions. For example, in a cellular telephony environment, there are many nonstationary forms of noise (e.g., multiple speakers) and significant variations in microphone type, position, and placement. Harsh ambient conditions typical in automotive and mobile applications pose similar challenges. Development of systems in a language or dialect for which there is limited or no training data in a target language has become a critical issue for a new generation of voice mining applications. The existence of multiple conditions in a single stream, a situation common to broadcast news applications, and that often involves unpredictable changes in speaker, topic, dialect, or language, is another form of robustness that has gained attention in recent years.

Statistical methods have dominated the field since the early 1980s. Such systems tend to excel at learning the characteristics of large databases that represent good models of the operational conditions and do not generalize well to new environments.

This special issue will focus on recent developments in this key research area. Topics of interest include (but are not limited to):

- Channel and microphone normalization
- Stationary and nonstationary noise modeling, compensation, and/or rejection
- Localization and separation of sound sources (including speaker segregation)
- Signal processing and feature extraction for applications involving hands-free microphones
- Noise robust speech modeling
- Adaptive training techniques
- Rapid adaptation and learning
- Integration of confidence scoring, metadata, and other alternative information sources
- Audio-visual fusion
- Assessment relative to human performance
- Machine learning algorithms for robustness
- Transmission robustness
- Pronunciation modeling

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EURASIP JOURNAL ON EMBEDDED SYSTEMS

Special Issue on

Signal Processing with High Complexity: Prototyping and Industrial Design

Call for Papers

Some modern applications require an extraordinary large amount of complexity in signal processing algorithms. For example, the 3rd generation of wireless cellular systems is expected to require 1000 times more complexity when compared to its 2nd generation predecessors, and future 3GPP standards will aim for even more number-crunching applications. Video and multimedia applications do not only drive the complexity to new peaks in wired and wireless systems but also in personal and home devices. Also in acoustics, modern hearing aids or algorithms for de-reverberation of rooms, blind source separation, and multichannel echo cancelation are complexity hungry. At the same time, the anticipated products also put on additional constraints like size and power consumption when mobile and thus battery powered. Furthermore, due to new developments in electroacoustic transducer design, it is possible to design very small and effective loudspeakers. Unfortunately, the linearity assumption does not hold any more for this kind of loudspeakers, leading to computationally demanding nonlinear cancelation and equalization algorithms.

Since standard design techniques would either consume too much time or do not result in solutions satisfying all constraints, more efficient development techniques are required to speed up this crucial phase. In general, such developments are rather expensive due to the required extraordinary high complexity. Thus, de-risking of a future product based on rapid prototyping is often an alternative approach. However, since prototyping would delay the development, it often makes only sense when it is well embedded in the product design process. Rapid prototyping has thus evolved by applying new design techniques more suitable to support a quick time to market requirement.

This special issue focuses on new development methods for applications with high complexity in signal processing and on showing the improved design obtained by such methods. Examples of such methods are virtual prototyping, HW/SW partitioning, automatic design flows, float to fix conversions, automatic testing and verification, and power aware designs.

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EURASIP JOURNAL ON EMBEDDED SYSTEMS

Special Issue on
Field-Programmable Gate Arrays in Embedded Systems

Call for Papers

Field-Programmable Gate Arrays (FPGAs) are increasingly used in embedded systems to achieve high performance in a compact area. FPGAs are particularly well suited to processing data straight from sensors in embedded systems. More importantly, the reconfigurable aspects of FPGAs give the circuits the versatility to change their functionality based on processing requirements for different phases of an application, and for deploying new functionality.

Modern FPGAs integrate many different resources on a single chip. Embedded processors (both hard and soft cores), multipliers, RAM blocks, and DSP units are all available along with reconfigurable logic. Applications can use these heterogeneous resources to integrate several different functions on a single piece of silicon. This makes FPGAs particularly well suited to embedded applications.

This special issue focuses on applications that clearly show the benefit of using FPGAs in embedded applications, as well as on design tools that enable such applications. Specific topics of interest include the use of reconfiguration in embedded applications, hardware/software codesign targeting FPGAs, power-aware FPGA design, design environments for FPGAs, system signalling and protocols used by FPGAs in embedded environments, and system-level design targeting modern FPGA's heterogeneous resources.

Papers on other applicable topics will also be considered. All papers should address FPGA-based systems that are appropriate for embedded applications. Papers on subjects outside of this scope (i.e., not suitable for embedded applications) will not be considered.

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EURASIP JOURNAL ON EMBEDDED SYSTEMS

Special Issue on
Formal Methods for GALS Design

Call for Papers

As chips grow in speed and complexity, global control of an entire chip using a single clock is becoming increasingly challenging. In the future, multicore and large-scale systems-on-chip (SoC) designs are therefore likely to be composed of several timing domains.

Global Asynchrony and Local Synchrony (GALS) is emerging as the paradigm of choice for SoC design with multiple timing domains. In GALS systems, each timing domain is locally clocked, and asynchronous communication schemes are used to glue all of the domains together. Thus, unlike purely asynchronous design, GALS design is able to make use of the significant industrial investment in synchronous design tools.

There is an urgent need for the development of sound models and formal methods for GALS systems. In synchronous designs, formal methods and design automation have played an enabling role in the continuing quest for chips with ever greater complexity. Due to the inherent subtleties of the asynchronous circuit design, formal methods are likely to be vital to the success of the GALS paradigm.

We invite original articles for a special issue of the journal to be published in 2006. Articles may cover every aspect related to formal modeling and formal methods for GALS systems and/or target any type of embedded applications and/or architectures combining synchronous and asynchronous notions of timing:

- Formal design and synthesis techniques for GALS systems
- Design and architectural transformations and equivalences
- Formal verification of GALS systems
- Formal methods for analysis of GALS systems
- Hardware compilation of GALS system
- Latency-insensitive synchronous systems
- Mixed synchronous-asynchronous systems
- Synchronous/asynchronous interaction at different levels
- Clocking, interconnect, and interface issues in deep-submicron design
- Modeling of interfaces between multiple timing domains
- System decomposition into GALS systems
- Formal aspects of system-on-chip (SoC) and network-on-chip (NoC) designs
- Motivating case studies, comparisons, and applications

Authors should follow the EURASIP JES manuscript format described at http://www.hindawi.com/journals/es/. Prospective authors should submit an electronic copy of their complete manuscript through the EURASIP JES manuscript tracking system at http://www.mstracking.com/es/, according to the following timetable:

Manuscript Due	December 15, 2005
Acceptance Notification	April 15, 2006
Final Manuscript Due	July 15, 2006
Publication Date	4th Quarter, 2006

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EURASIP JOURNAL ON EMBEDDED SYSTEMS

Special Issue on
Synchronous Paradigm in Embedded Systems

Call for Papers

Synchronous languages were introduced in the 1980s for programming reactive systems. Such systems are characterized by their continuous reaction to their environment, at a speed determined by the latter. Reactive systems include embedded control software and hardware. Synchronous languages have recently seen a tremendous interest from leading companies developing automatic control software and hardware for critical applications. Industrial success stories have been achieved by Schneider Electric, Airbus, Dassault Aviation, Snecma, MBDA, Arm, ST Microelectronics, Texas Instruments, Freescale, Intel .... The key advantage outlined by these companies resides in the rigorous mathematical semantics provided by the synchronous approach that allows system designers to develop critical software and hardware in a faster and safer way.

Indeed, an important feature of synchronous paradigm is that the tools and environments supporting development of synchronous programs are based upon a formal mathematical model defined by the semantics of the languages. The compilation involves the construction of these formal models, and their analysis for static properties, their optimization, the synthesis of executable sequential implementations, and the automated distribution of programs. It can also build a model of the dynamical behaviors, in the form of a transition system, upon which is based the analysis of dynamical properties, for example, through model-checking-based verification, or discrete controller synthesis. Hence, synchronous programming is at the crossroads of many approaches in compilation, formal analysis and verification techniques, and software or hardware implementations generation.

We invite original papers for a special issue of the journal to be published in the first quarter of 2007. Papers may be submitted on all aspects of the synchronous paradigm for embedded systems, including theory and applications. Some sample topics are:

- Synchronous languages design and compiling
- Novel application and implementation of synchronous languages
- Applications of synchronous design methods to embedded systems (hardware or software)
- Formal modeling, formal verification, controller synthesis, and abstract interpretation with synchronous-based tools
- Combining synchrony and asynchrony for embedded system design and, in particular, globally asynchronous and locally synchronous systems
- The role of synchronous models of computations in heterogeneous modeling
- The use of synchronous modeling techniques in model-driven design environment
- Design of distributed control systems using the synchronous paradigm

Authors should follow the EURASIP JES manuscript format described at http://www.hindawi.com/journals/es/. Prospective authors should submit an electronic copy of their complete manuscripts through the EURASIP JES's manuscript tracking system at http://www.mstracking.com/es/, according to the following timetable:

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Publication Date	1st Quarter, 2007

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EURASIP JOURNAL ON EMBEDDED SYSTEMS

Special Issue on

Embedded Systems for Portable and Mobile Video Platforms

Call for Papers

Video coding systems have been assuming an increasingly important role in application areas other than the traditional video broadcast and storage scenarios. Several new applications have emerged focusing on personal communications (such as video-conferencing), wireless multimedia, remote video-surveillance, and emergency systems. As a result, a number of new video compression standards have emerged addressing the requirements of these kinds of applications in terms of image quality and bandwidth. For example, the ISO/MPEG and ITU standardization bodies have recently jointly established the new AVC/H.264 video coding standard.

In such a wide range of applications scenarios, there is the need to adapt the video processing in general, and in particular video coding/decoding, to the restrictions imposed by both the applications themselves and the terminal devices. This problem is even more important for portable and battery-supplied devices, in which low-power considerations are important limiting constraints. Examples of such application requirements are currently found in 3G mobile phones, CMOS cameras and tele-assistance technologies for elderly/disabled people.

Therefore, the development of new power-efficient encoding algorithms and architectures suitable for mobile and battery-supplied devices is fundamental to enabling the widespread deployment of multimedia applications on portable and mobile video platforms. This special issue is focused on the design and development of embedded systems for portable and mobile video platforms. Topics of interest cover all aspects of this type of embedded system, including, not only algorithms, architectures, and specific SoC design methods, but also more technological aspects related to wireless-channels, power-efficient optimizations and implementations, such as encoding strategies, data flow optimizations, special coprocessors, arithmetic units, and electronic circuits.

Papers suitable for publication in this special issue must describe high-quality, original, unpublished research. Prospective authors are invited to submit manuscripts on topics including but not limited to:

- Power-efficient algorithms and architectures for motion estimation, discrete transforms (e.g., SA-DCT, WT), integer transforms, and entropy coding
- Architectural paradigms for portable multimedia systems
- Low-power techniques and circuits, memory, and data flow optimizations for video coding
- Adaptive algorithms and generic configurable architectures for exploiting intrinsic characteristics of image sequences and video devices
- Aspects specifically important for portable and mobile video platforms, such as video transcoding, video processing in the compressed domain, and error resilience (e.g., MDC)
- Ultra-low-power embedded systems for video processing and coding
- Heterogeneous architectures, multithreading, MP-SoC, NoC implementations
- Design space exploration tools, performance evaluation tools, coding efficiency and complexity analysis tools for video coding in embedded systems

Authors should follow the EURASIP JES manuscript format described at http://www.hindawi.com/journals/es/. Prospective authors should submit an electronic copy of their complete manuscript through the EURASIP JES manuscript tracking system at http://www.mstracking.com/es/, according to the following timetable:

Manuscript Due	June 1, 2006
Acceptance Notification	October 1, 2006
Final Manuscript Due	January 1, 2007
Publication Date	2nd Quarter, 2007

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Institute of Acoustics

NEWS RELEASE

Nominations Invited for the Institute of Acoustics 2006 A B Wood Medal

The Institute of Acoustics, the UK's leading professional body for those working in acoustics, noise and vibration, is inviting nominations for its prestigious A B Wood Medal for the year 2006.

The A B Wood Medal and prize is presented to an individual, usually under the age of 35, for distinguished contributions to the application of underwater acoustics. The award is made annually, in even numbered years to a person from Europe and in odd numbered years to someone from the USA/Canada. The 2005 Medal was awarded to Dr A Thode from the USA for his innovative, interdisciplinary research in ocean and marine mammal acoustics.

Nominations should consist of the candidate's CV, clearly identifying peer reviewed publications, and a letter of endorsement from the nominator identifying the contribution the candidate has made to underwater acoustics. In addition, there should be a further reference from a person involved in underwater acoustics and not closely associated with the candidate. Nominees should be citizens of a European Union country for the 2006 Medal. Nominations should be marked confidential and addressed to the President of the Institute of Acoustics at 77A St Peter's Street, St. Albans, Herts, AL1 3BN. The deadline for receipt of nominations is **15 October 2005**.

Dr Tony Jones, President of the Institute of Acoustics, comments, "A B Wood was a modest man who took delight in helping his younger colleagues. It is therefore appropriate that this prestigious award should be designed to recognise the contributions of young acousticians."

Further information and an nomination form can be found on the Institute's website at www.ioa.org.uk.

A B Wood

Albert Beaumont Wood was born in Yorkshire in 1890 and graduated from Manchester University in 1912. He became one of the first two research scientists at the Admiralty to work on antisubmarine defence. He designed the first directional hydrophone and was well known for the many contributions he made to the science of underwater acoustics and for the help he gave to younger colleagues. The medal was instituted after his death by his many friends on both sides of the Atlantic and was administered by the Institute of Physics until the formation of the Institute of Acoustics in 1974.

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EDITORS NOTES

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society (a daughter society of the Institution of Mechanical Engineers). The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has some 2500 members from a rich diversity of backgrounds, with engineers, scientists, educators, lawyers, occupational hygienists, architects and environmental health officers among their number. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, underwater acoustics, together with a variety of environmental aspects. The lively nature of the Institute is demonstrated by the breadth of its learned society programmes.

For more information please visit our site at www.ioa.org.uk.