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Project Code	MATLAB IEEE PAPERS -2016 PROJECT TITLES WITH ABSTRACT
	BIO MEDICAL
BM16NXT01	**TITLE: Fusion of Quantitative Image and Genomic Biomarkers to Improve Prognosis Assessment of Early Stage Lung Cancer Patients.** **ABSTRACT:** This study aims to develop a new quantitative image feature analysis scheme and investigate its role along with 2 genomic biomarkers namely, protein expression of the excision repair cross-complementing 1 (ERCC1) genes and a regulatory subunit of ribonucleotide reductase (RRM1), in predicting cancer recurrence risk of Stage I non-small-cell lung cancer (NSCLC) patients after surgery. Methods: By using chest computed tomography images, we developed a computer-aided detection scheme to segment lung tumors and computed tumor-related image features. After feature selection, we trained a Naïve Bayesian network based classifier using 8 image features and a Multilayer Perceptron classifier using 2 genomic biomarkers to predict cancer recurrence risk, respectively. Two classifiers were trained and tested using a dataset with 79 Stage I NSCLC cases, a synthetic minority oversampling technique and a leave-one-case-out validation method. A fusion method was also applied to combine prediction scores of two classifiers. Results: AUC (areas under ROC curves) values are 0.78±0.06 and 0.68±0.07 when using the image feature and genomic biomarker based classifiers, respectively. AUC value significantly increased to 0.84±0.05 ($p<0.05$) when fusion of two classifier-generated prediction scores using an equal weighting factor.

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BM16NXT02	**TITLE: Robust Sclera Recognition System With Novel Sclera Segmentation and Validation Techniques** **ABSTRACT:**Sclera blood veins have been investigated recently as a biometric trait which can be used in a recognition system. The sclera is the white and opaque outer protective part of the eye. This part of the eye has visible blood veins which are randomly distributed. This feature makes these blood veins a promising factor for eye recognition. The sclera has an advantage in that it can be captured using a visible-wavelength camera. Therefore, applications which may involve the sclera are wide ranging. The contribution of this paper is the design of a robust sclera recognition system with high accuracy. The system comprises of new sclera segmentation and occluded eye detection methods. We also propose an efficient method for vessel enhancement, extraction, and binarization. In the feature extraction and matching process stages, we additionally develop an efficient method, that is, orientation, scale, illumination, and deformation invariant.
BM16NXT03	**TITLE:Visualization of Tumor Response to Neoadjuvant Therapy for Rectal Carcinoma by Nonlinear Optical Imaging** **ABSTRACT:** The continuing development of nonlinear optical imaging techniques has opened many new windows in biological exploration. In this study, a nonlinear optical microscopy-multiphoton microscopy (MPM) was expanded to detect tumor response in rectal carcinoma after neoadjuvant therapy; especially normal tissue, pre- and post-therapeutic cancerous tissues were investigated in order to present more detailed information and make comparison. It was found that the MPM has ability not only to directly visualize histopathologic changes in rectal carcinoma, including stromal fibrosis, colloid response, residual tumors, blood vessel hyperplasia, and inflammatory reaction, which had been proven to have important influence on estimation of the prognosis and the effect of neoadjuvant treatment, but also

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	to provide quantitative optical biomarkers including the intensity ratio of SHG over TPEF and collagen orientation index. These results show that the MPM will become a useful tool for clinicians to determine whether neoadjuvant therapy is effective or treatment strategy is approximate, and this study may provide the groundwork for further exploration into the application of MPM in a clinical setting.
BM16NXT04	**TITLE: Robust Edge-Stop Functions for Edge-Based Active Contour Models in Medical Image Segmentation** **ABSTRACT:** Edge-based active contour models are effective in segmenting images with intensity inhomogeneity but often fail when applied to images containing poorly defined boundaries, such as in medical images. Traditional edge-stop functions (ESFs) utilize only gradient information, which fails to stop contour evolution at such boundaries because of the small gradient magnitudes. To address this problem, we propose a framework to construct a group of ESFs for edge-based active contour models to segment objects with poorly defined boundaries. In our framework, which incorporates gradient information as well as probability scores from a standard classifier, the ESF can be constructed from any classification algorithm and applied to any edge-based model using a level set method. Experiments on medical images using the distance regularized level set for edge-based active contour models as well as the k-nearest neighbors and the support vector machine confirm the effectiveness of the proposed approach.
BM16NXT05	**TITLE: Active Learning Methods for Efficient Hybrid Biophysical Variable Retrieval** **ABSTRACT:** Kernel-based machine learning regression algorithms (MLRAs) are potentially powerful methods for being implemented into operational biophysical variable retrieval schemes. However, they face difficulties in coping with large training data sets. With the increasing amount of optical

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	remote sensing data made available for analysis and the possibility of using a large amount of simulated data from radiative transfer models (RTMs) to train kernel MLRAs, efficient data reduction techniques will need to be implemented. Active learning (AL) methods enable to select the most informative samples in a data set. This letter introduces six AL methods for achieving optimized biophysical variable estimation with a manageable training data set, and their implementation into a Matlab-based MLRA toolbox for semiautomatic use. The AL methods were analyzed on their efficiency of improving the estimation accuracy of the leaf area index and chlorophyll content based on PROSAIL simulations. Each of the implemented methods outperformed random sampling, improving retrieval accuracy with lower sampling rates. Practically, AL methods open opportunities to feed advanced MLRAs with RTM-generated training data for the development of operational retrieval models.
BM16NXT06	**TITLE: Red Lesion Detection Using Dynamic Shape Features for Diabetic Retinopathy Screening** **ABSTRACT:** The development of an automatic telemedicine system for computer-aided screening and grading of diabetic retinopathy depends on reliable detection of retinal lesions in fundus images. In this paper, a novel method for automatic detection of both microaneurysms and hemorrhages in color fundus images is described and validated. The main contribution is a new set of shape features, called Dynamic Shape Features, that do not require precise segmentation of the regions to be classified. These features represent the evolution of the shape during image flooding and allow to discriminate between lesions and vessel segments. The method is validated per-lesion and per-image using six databases, four of which are publicly available. It proves to be robust with respect to variability in image resolution, quality and acquisition system. On the Retinopathy Online Challenge's database, the

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	method achieves a FROC score of 0.420 which ranks it fourth. On the Messidor database, when detecting images with diabetic retinopathy, the proposed method achieves an area under the ROC curve of 0.899, comparable to the score of human experts, and it outperforms state-of-the-art approaches.
BM16NXT07	**TITLE: Real-Time Automatic Artery Segmentation, Reconstruction and Registration for Ultrasound-Guided Regional Anaesthesia of the Femoral Nerve** **ABSTRACT:** The goal is to create an assistant for ultrasound- guided femoral nerve block. By segmenting and visualizing the important structures such as the femoral artery, we hope to improve the success of these procedures. This article is the first step towards this goal and presents novel real-time methods for identifying and reconstructing the femoral artery, and registering a model of the surrounding anatomy to the ultrasound images. The femoral artery is modelled as an ellipse. The artery is first detected by a novel algorithm which initializes the artery tracking. This algorithm is completely automatic and requires no user interaction. Artery tracking is achieved with a Kalman filter. The 3D artery is reconstructed in real-time with a novel algorithm and a tracked ultrasound probe. A mesh model of the surrounding anatomy was created from a CT dataset. Registration of this model is achieved by landmark registration using the centerpoints from the artery tracking and the femoral artery centerline of the model. The artery detection method was able to automatically detect the femoral artery and initialize the tracking in all 48 ultrasound sequences. The tracking algorithm achieved an average dice similarity coefficient of 0.91, absolute distance of 0.33 mm, and Hausdorff distance 1.05 mm. The mean registration error was 2.7 mm, while the average maximum error was 12.4 mm. The average runtime was measured to be 38, 8, 46 and 0.2 milliseconds for the artery detection, tracking, reconstruction and registration methods respectively.

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BM16NXT08

TITLE: Interactive Cell Segmentation Based on Active and Semi-Supervised Learning

ABSTRACT: Automatic cell segmentation can hardly be flawless due to the complexity of image data particularly when time-lapse experiments last for a long time without biomarkers. To address this issue, we propose an interactive cell segmentation method by classifying feature-homogeneous superpixels into specific classes, which is guided by human interventions. Specifically, we propose to actively select the most informative superpixels by minimizing the expected prediction error which is upper bounded by the transductive Rademacher complexity, and then query for human annotations. After propagating the user-specified labels to the remaining unlabeled superpixels via an affinity graph, the error-prone superpixels are selected automatically and request for human verification on them; once erroneous segmentation is detected and subsequently corrected, the information is propagated efficiently over a gradually-augmented graph to un-labeled superpixels such that the analogous errors are fixed meanwhile. The correction propagation step is efficiently conducted by introducing a verification propagation matrix rather than rebuilding the affinity graph and re-performing the label propagation from the beginning. We repeat this procedure until most superpixels are classified into a specific category with high confidence. Experimental results performed on three types of cell populations validate that our interactive cell segmentation algorithm quickly reaches high quality results with minimal human interventions and is significantly more efficient than alternative methods, since the most informative samples are selected for human annotation/verification early.

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BM16NXT09	**TITLE: First Robotic SPECT for Minimally Invasive Sentinel Lymph Node Mapping** **ABSTRACT:** In this paper we present the usage of a drop-in gamma probe for intra-operative Single-Photon Emission Computed Tomography (SPECT) imaging in the scope of minimally invasive robot-assisted interventions. The probe is designed to be inserted and reside inside the abdominal cavity during the intervention. It is grasped during the procedure using a robotic laparoscopic gripper enabling full six degrees of freedom handling by the surgeon. We demonstrate the first deployment of the tracked probe for intra-operative in-patient robotic SPECT enabling augmented-reality image guidance. The hybrid mechanical- and image-based in-patient probe tracking is shown to have an accuracy of 0.2 mm. The overall system performance is evaluated and tested with a phantom for gynecological sentinel lymph node interventions and compared to ground-truth data yielding a mean reconstruction accuracy of 0.67 mm.
BM16NXT10	**TITLE: Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images** **ABSTRACT:** Among brain tumors, gliomas are the most common and aggressive, leading to a very short life expectancy in their highest grade. Thus, treatment planning is a key stage to improve the quality of life of oncological patients. Magnetic resonance imaging (MRI) is a widely used imaging technique to assess these tumors, but the large amount of data produced by MRI prevents manual segmentation in a reasonable time, limiting the use of precise quantitative measurements in the clinical practice. So, automatic and reliable segmentation methods are required; however, the large spatial and structural variability among brain tumors make automatic segmentation a challenging problem. In this paper, we propose an automatic segmentation method based on Convolutional Neural Networks (CNN), exploring small 3 ×3

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	kernels. The use of small kernels allows designing a deeper architecture, besides having a positive effect against overfitting, given the fewer number of weights in the network. We also investigated the use of intensity normalization as a pre-processing step, which though not common in CNN-based segmentation methods, proved together with data augmentation to be very effective for brain tumor segmentation in MRI images. Our proposal was validated in the Brain Tumor Segmentation Challenge 2013 database (BRATS 2013), obtaining simultaneously the first position for the complete, core, and enhancing regions in Dice Similarity Coefficient metric (0.88, 0.83, 0.77) for the Challenge data set. Also, it obtained the overall first position by the online evaluation platform. We also participated in the on-site BRATS 2015 Challenge using the same model, obtaining the second place, with Dice Similarity Coefficient metric of 0.78, 0.65, and 0.75 for the complete, core, and enhancing regions, respectively.
BM16NXT11	**TITLE: Locality Sensitive Deep Learning for Detection and Classification of Nuclei in Routine Colon Cancer Histology Images** **ABSTRACT:** Detection and classification of cell nuclei in histopathology images of cancerous tissue stained with the standard hematoxylin and eosin stain is a challenging task due to cellular heterogeneity. Deep learning approaches have been shown to produce encouraging results on histopathology images in various studies. In this paper, we propose a Spatially Constrained Convolutional Neural Network (SC-CNN) to perform nucleus detection. SC-CNN regresses the likelihood of a pixel being the center of a nucleus, where high probability values are spatially constrained to locate in the vicinity of the centers of nuclei. For classification of nuclei, we propose a novel Neighboring Ensemble Predictor (NEP) coupled with CNN to more accurately predict the class label of detected cell nuclei. The proposed approaches for detection and classification do not require segmentation of nuclei. We have evaluated them

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	on a large dataset of colorectal adenocarcinoma images, consisting of more than 20,000 annotated nuclei belonging to four different classes. Our results show that the joint detection and classification of the proposed SC-CNN and NEP produces the highest average F1 score as compared to other recently published approaches. Prospectively, the proposed methods could offer benefit to pathology practice in terms of quantitative analysis of tissue constituents in whole-slide images, and potentially lead to a better understanding of cancer.
BM16NXT12	**TITLE: Combining Generative and Discriminative Representation Learning for Lung CT Analysis With Convolutional Restricted Boltzmann Machines** **ABSTRACT:** The choice of features greatly influences the performance of a tissue classification system. Despite this, many systems are built with standard, predefined filter banks that are not optimized for that particular application. Representation learning methods such as restricted Boltzmann machines may outperform these standard filter banks because they learn a feature description directly from the training data. Like many other representation learning methods, restricted Boltzmann machines are unsupervised and are trained with a generative learning objective; this allows them to learn representations from unlabeled data, but does not necessarily produce features that are optimal for classification. In this paper we propose the convolutional classification restricted Boltzmann machine, which combines a generative and a discriminative learning objective. This allows it to learn filters that are good both for describing the training data and for classification. We present experiments with feature learning for lung texture classification and airway detection in CT images. In both applications, a combination of learning objectives outperformed purely discriminative or generative learning, increasing, for instance, the lung tissue classification accuracy by 1 to 8 percentage points. This shows that discriminative learning

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	can help an otherwise unsupervised feature learner to learn filters that are optimized for classification.
BM16NXT13	**TITLE: Compressive Deconvolution in Medical Ultrasound Imaging** **ABSTRACT:** The interest of compressive sampling in ultrasound imaging has been recently extensively evaluated by several research teams. Following the different application setups, it has been shown that the RF data may be reconstructed from a small number of measurements and/or using a reduced number of ultrasound pulse emissions. Nevertheless, RF image spatial resolution, contrast and signal to noise ratio are affected by the limited bandwidth of the imaging transducer and the physical phenomenon related to US wave propagation. To overcome these limitations, several deconvolution-based image processing techniques have been proposed to enhance the ultrasound images. In this paper, we propose a novel framework, named compressive deconvolution, that reconstructs enhanced RF images from compressed measurements. Exploiting an unified formulation of the direct acquisition model, combining random projections and 2D convolution with a spatially invariant point spread function, the benefit of our approach is the joint data volume reduction and image quality improvement. The proposed optimization method, based on the Alternating Direction Method of Multipliers, is evaluated on both simulated and in vivo data.
BM16NXT14	**TITLE: Histopathological Image Classification Using Discriminative Feature-Oriented Dictionary Learning** **ABSTRACT:** In histopathological image analysis, feature extraction for classification is a challenging task due to the diversity of histology features suitable for each problem as well as presence of rich geometrical structures. In this paper, we propose an automatic feature discovery framework via learning class-specific dictionaries and present a low-complexity method for

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	classification and disease grading in histopathology. Essentially, our Discriminative Feature-oriented Dictionary Learning (DFDL) method learns class-specific dictionaries such that under a sparsity constraint, the learned dictionaries allow representing a new image sample parsimoniously via the dictionary corresponding to the class identity of the sample. At the same time, the dictionary is designed to be poorly capable of representing samples from other classes. Experiments on three challenging real-world image databases: 1) histopathological images of intraductal breast lesions, 2) mammalian kidney, lung and spleen images provided by the Animal Diagnostics Lab (ADL) at Pennsylvania State University, and 3) brain tumor images from The Cancer Genome Atlas (TCGA) database, reveal the merits of our proposal over state-of-the-art alternatives. Moreover, we demonstrate that DFDL exhibits a more graceful decay in classification accuracy against the number of training images which is highly desirable in practice where generous training is often not available.
BM16NXT15	**TITLE: Carotid Artery Wall Segmentation in Multispectral MRI by Coupled Optimal Surface Graph Cuts.** **ABSTRACT:** We present a new three-dimensional coupled optimal surface graph-cut algorithm to segment the wall of the carotid artery bifurcation from Magnetic Resonance (MR) images. The method combines the search for both inner and outer borders into a single graph cut and uses cost functions that integrate information from multiple sequences. Our approach requires manual localization of only three seed points indicating the start and end points of the segmentation in the internal, external, and common carotid artery. We performed a quantitative validation using images of 57 carotid arteries. Dice overlap of 0.86 ± 0.06 for the complete vessel and 0.89 ± 0.05 for the lumen compared to manual annotation were obtained. Reproducibility tests were performed in 60 scans acquired with an interval of 15 ± 9 days, showing good

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	agreement between baseline and follow-up segmentations with intraclass correlations of 0.96 and 0.74 for the lumen and complete vessel volumes respectively.
BM16NXT16	**TITLE: Kernel Bundle Diffeomorphic Image Registration Using Stationary Velocity Fields and Wendland Basis Functions** **ABSTRACT:** In this paper, we propose a multi-scale, multi-kernel shape, compactly supported kernel bundle framework for stationary velocity field-based image registration (Wendland kernel bundle stationary velocity field, wKB-SVF). We exploit the possibility of directly choosing kernels to construct a reproducing kernel Hilbert space (RKHS) instead of imposing it from a differential operator. The proposed framework allows us to minimize computational cost without sacrificing the theoretical foundations of SVF-based diffeomorphic registration. In order to recover deformations occurring at different scales, we use compactly supported Wendland kernels at multiple scales and orders to parameterize the velocity fields, and the framework allows simultaneous optimization over all scales. The performance of wKB-SVF is extensively compared to the 14 non-rigid registration algorithms presented in a recent comparison paper. On both MGH10 and CUMC12 datasets, the accuracy of wKB-SVF is improved when compared to other registration algorithms. In a disease-specific application for intra-subject registration, atrophy scores estimated using the proposed registration scheme separates the diagnostic groups of Alzheimer's and normal controls better than the state-of-the-art segmentation technique. Experimental results show that wKB-SVF is a robust, flexible registration framework that allows theoretically well-founded and computationally efficient multi-scale representation of deformations and is equally well-suited for both inter- and intra-subject image registration**3D**

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BM16NXT17	**TITLE: Fast Automatic Segmentation of Kidney Based on Modified AAM and Random Forest** **ABSTRACT:** In this paper, a fully automatic method is proposed to segment the kidney into multiple components: renal cortex, renal column, renal medulla and renal pelvis, in clinical 3D CT abdominal images. The proposed fast automatic segmentation method of kidney consists of two main parts: localization of renal cortex and segmentation of kidney components. In the localization of renal cortex phase, a method which fully combines 3D Generalized Hough Transform (GHT) and 3D Active Appearance Models (AAM) is applied to localize the renal cortex. In the segmentation of kidney components phase, a modified Random Forests (RF) method is proposed to segment the kidney into four components based on the result from localization phase. During the implementation, a multithreading technology is applied to speed up the segmentation process. The proposed method was evaluated on a clinical abdomen CT data set, including 37 contrast-enhanced volume data using leave-one-out strategy. The overall true-positive volume fraction and false-positive volume fraction were 93.15%, 0.37% for renal cortex segmentation; 83.09%, 0.97% for renal column segmentation; 81.92%, 0.55% for renal medulla segmentation; and 80.28%, 0.30% for renal pelvis segmentation, respectively. The average computational time of segmenting kidney into four components took 20 seconds.
BM16NXT18	**TITLE: Myocardial Infarct Segmentation From Magnetic Resonance Images for Personalized Modeling of Cardiac Electrophysiology** **ABSTRACT:** Accurate representation of myocardial infarct geometry is crucial to patient-specific computational modeling of the heart in ischemic cardiomyopathy. We have developed a methodology for segmentation of left ventricular (LV) infarct from clinically acquired, two-dimensional (2D), late-gadolinium enhanced cardiac magnetic resonance (LGE-CMR) images, for

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	personalized modeling of ventricular electrophysiology. The infarct segmentation was expressed as a continuous min-cut optimization problem, which was solved using its dual formulation, the continuous max-flow (CMF). The optimization objective comprised of a smoothness term, and a data term that quantified the similarity between image intensity histograms of segmented regions and those of a set of training images. A manual segmentation of the LV myocardium was used to initialize and constrain the developed method. The three-dimensional geometry of infarct was reconstructed from its segmentation using an implicit, shape-based interpolation method. The proposed methodology was extensively evaluated using metrics based on geometry, and outcomes of individualized electrophysiological simulations of cardiac dys(function). Several existing LV infarct segmentation approaches were implemented, and compared with the proposed method. Our results demonstrated that the CMF method was more accurate than the existing approaches in reproducing expert manual LV infarct segmentations, and in electrophysiological simulations. The infarct segmentation method we have developed and comprehensively evaluated in this study constitutes an important step in advancing clinical applications of personalized simulations of cardiac electrophysiology.
BM16NXT19	**TITLE: Computer-Assisted Screw Size and Insertion Trajectory Planning for Pedicle Screw Placement Surgery** **ABSTRACT:** Pathological conditions that cause instability of the spine are commonly treated by vertebral fixation involving pedicle screw placement surgery. However, existing methods for preoperative planning are based only on geometrical properties of vertebral structures (i.e., shape) without taking into account their structural properties (i.e., appearance). We propose a novel automated method for computer-assisted preoperative planning of the thoracic pedicle screw size and insertion trajectory. The proposed method

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	extracts geometrical properties of vertebral structures by parametric modeling of vertebral bodies and pedicles in three dimensions (3D), and combines them with structural properties, evaluated through underlying image intensities in computed tomography (CT) images while considering the guidelines for pedicle screw design. The method was evaluated on 81 pedicles, obtained from 3D CT images of 11 patients that were appointed for pedicle screw placement surgery. In terms of mean absolute difference (MAD) and corresponding standard deviation (SD), the resulting high modeling accuracy of 0.39±0.31 mm for 3D vertebral body models and 0.31±0.25 mm for 3D pedicle models created an adequate anatomical frame for 3D pedicle screw models. When comparing the automatically obtained and manually defined plans for pedicle screw placement, a relatively high agreement was observed, with MAD ±SD of 0.4±0.4 mm for the screw diameter, 5.8±4.2 mm for the screw length, 2.0±1.4 mm for the pedicle crossing point and 7.6±5.8° for screw insertion angles. However, a statistically significant increase of 48±26% in the screw fastening strength in favor of the proposed automated method was observed in 99% of the cases.
BM16NXT20	**TITLE: Improving Computer-Aided Detection Using Convolutional Neural Networks and Random View Aggregation** **ABSTRACT:** Automated computer-aided detection (CADe) has been an important tool in clinical practice and research. State-of-the-art methods often show high sensitivities at the cost of high false-positives (FP) per patient rates. We design a two-tiered coarse-to-fine cascade framework that first operates a candidate generation system at sensitivities ~ 100% of but at high FP levels. By leveraging existing CADe systems, coordinates of regions or volumes of interest (ROI or VOI) are generated and function as input for a second tier, which is our focus in this study. In this second stage, we generate 2D (two-dimensional) or 2.5D views via sampling through scale transformations,

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	random translations and rotations. These random views are used to train deep convolutional neural network (ConvNet) classifiers. In testing, the ConvNets assign class (e.g., lesion, pathology) probabilities for a new set of random views that are then averaged to compute a final per-candidate classification probability. This second tier behaves as a highly selective process to reject difficult false positives while preserving high sensitivities. The methods are evaluated on three data sets: 59 patients for sclerotic metastasis detection, 176 patients for lymph node detection, and 1,186 patients for colonic polyp detection. Experimental results show the ability of ConvNets to generalize well to different medical imaging CADe applications and scale elegantly to various data sets. Our proposed methods improve performance markedly in all cases. Sensitivities improved from 57% to 70%, 43% to 77%, and 58% to 75% at 3 FPs per patient for sclerotic metastases, lymph nodes and colonic polyps, respectively.
BM16NXT21	**TITLE: Human Visual System-Based Fundus Image Quality Assessment of Portable Fundus Camera Photographs** **ABSTRACT:** Telemedicine and the medical “big data” era in ophthalmology highlight the use of non-mydriatic ocular fundus photography, which has given rise to indispensable applications of portable fundus cameras. However, in the case of portable fundus photography, non-mydriatic image quality is more vulnerable to distortions, such as uneven illumination, color distortion, blur, and low contrast. Such distortions are called generic quality distortions. This paper proposes an algorithm capable of selecting images of fair generic quality that would be especially useful to assist inexperienced individuals in collecting meaningful and interpretable data with consistency. The algorithm is based on three characteristics of the human visual system-multi-channel sensation, just noticeable blur, and the contrast sensitivity function to detect illumination and color distortion, blur, and low contrast distortion, respectively. A total of 536

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	retinal images, 280 from proprietary databases and 256 from public databases, were graded independently by one senior and two junior ophthalmologists, such that three partial measures of quality and generic overall quality were classified into two categories. Binary classification was implemented by the support vector machine and the decision tree, and receiver operating characteristic (ROC) curves were obtained and plotted to analyze the performance of the proposed algorithm. The experimental results revealed that the generic overall quality classification achieved a sensitivity of 87.45% at a specificity of 91.66%, with an area under the ROC curve of 0.9452, indicating the value of applying the algorithm, which is based on the human vision system, to assess the image quality of non-mydriatic photography, especially for low-cost ophthalmological telemedicine applications.
	DIGITAL IMAGE PROCESSING
DIP16NXT01	**TITLE: Dynamic Facial Expression Recognition with Atlas Construction and Sparse Representation** **ABSTRACT:** In this paper, a new dynamic facial expression recognition method is proposed. Dynamic facial expression recognition is formulated as a longitudinal groupwise registration problem. The main contributions of this method lie in the following aspects: 1) subject-specific facial feature movements of different expressions are described by a diffeomorphic growth model; 2) salient longitudinal facial expression atlas is built for each expression by a sparse groupwise image registration method, which can describe the overall facial feature changes among the whole population and can suppress the bias due to large intersubject facial variations; and 3) both the image appearance information in spatial domain and topological evolution information in temporal domain are used to guide recognition by a sparse representation method. The proposed framework has been extensively evaluated on five databases for different applications: the extended Cohn-

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	Kanade, MMI, FERA, and AFEW databases for dynamic facial expression recognition, and UNBC-McMaster database for spontaneous pain expression monitoring. This framework is also compared with several state-of-the-art dynamic facial expression recognition methods. The experimental results demonstrate that the recognition rates of the new method are consistently higher than other methods under comparison.
DIP16NXT02	**TITLE: Lossless Compression of JPEG Coded Photo Collections** **ABSTRACT:** The explosion of digital photos has posed a significant challenge to photo storage and transmission for both personal devices and cloud platforms. In this paper, we propose a novel lossless compression method to further reduce the size of a set of JPEG coded correlated images without any loss of information. The proposed method jointly removes inter/intra image redundancy in the feature, spatial, and frequency domains. For each collection, we first organize the images into a pseudo video by minimizing the global prediction cost in the feature domain. We then present a hybrid disparity compensation method to better exploit both the global and local correlations among the images in the spatial domain. Furthermore, the redundancy between each compensated signal and the corresponding target image is adaptively reduced in the frequency domain. Experimental results demonstrate the effectiveness of the proposed lossless compression method. Compared with the JPEG coded image collections, our method achieves average bit savings of more than 31%.
DIP16NXT03	**TITLE: Layer-Based Approach for Image Pair Fusion** **ABSTRACT:** Recently, image pairs, such as noisy and blurred images or infrared and noisy images, have been considered as a solution to provide high-quality photographs under low lighting conditions. In this paper, a new method for decomposing the image pairs into two layers, i.e., the base layer and the detail layer, is proposed for image pair fusion. In the case of infrared and noisy images, simple naive fusion leads to unsatisfactory results due to the

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	discrepancies in brightness and image structures between the image pair. To address this problem, a local contrast-preserving conversion method is first proposed to create a new base layer of the infrared image, which can have visual appearance similar to another base layer, such as the denoised noisy image. Then, a new way of designing three types of detail layers from the given noisy and infrared images is presented. To estimate the noise-free and unknown detail layer from the three designed detail layers, the optimization framework is modeled with residual-based sparsity and patch redundancy priors. To better suppress the noise, an iterative approach that updates the detail layer of the noisy image is adopted via a feedback loop. This proposed layer-based method can also be applied to fuse another noisy and blurred image pair. The experimental results show that the proposed method is effective for solving the image pair fusion problem.
DIP16NXT04	**TITLE: Adaptive Pairing Reversible Watermarking** **ABSTRACT:** This letter revisits the pairwise reversible watermarking scheme of Ou et al., 2013. An adaptive pixel pairing that considers only pixels with similar prediction errors is introduced. This adaptive approach provides an increased number of pixel pairs where both pixels are embedded and decreases the number of shifted pixels. The adaptive pairwise reversible watermarking outperforms the state-of-the-art low embedding bit-rate schemes proposed so far.
DIP16NXT05	**TITLE: Adaptive Part-Level Model Knowledge Transfer for Gender** **ABSTRACT:** In this letter, we propose an adaptive part-level model knowledge transfer approach for gender classification of facial images based on Fisher vector (FV). Specifically, we first decompose the whole face image into several parts and compute the dense FVs on each face part. An adaptive transfer learning model is then proposed to reduce the discrepancies between the training data and the testing data for enhancing classification performance. Compared to the existing gender classification methods, the proposed

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	approach is more adaptive to the testing data, which is quite beneficial to the performance improvement. Extensive experiments on several public domain face data sets clearly demonstrate the effectiveness of the proposed approach.
DIP16NXT06	**TITLE: Patch-Based Video Denoising With Optical Flow Estimation** **ABSTRACT:** A novel image sequence denoising algorithm is presented. The proposed approach takes advantage of the selfsimilarity and redundancy of adjacent frames. The algorithm is inspired by fusion algorithms, and as the number of frames increases, it tends to a pure temporal average. The use of motion compensation by regularized optical flow methods permits robust patch comparison in a spatiotemporal volume. The use of principal component analysis ensures the correct preservation of fine texture and details. An extensive comparison with the state-of-the-art methods illustrates the superior performance of the proposed approach, with improved texture and detail reconstruction.
DIP16NXT07	**TITLE: 2D Orthogonal Locality Preserving Projection for Image Denoising** **ABSTRACT:** S parse representations using transform-domain techniques are widely used for better interpretation of the raw data. Orthogonal locality preserving projection (OLPP) is a linear technique that tries to preserve local structure of data in the transform domain as well. Vectorized nature of OLPP requires high-dimensional data to be converted to vector format, hence may lose spatial neighborhood information of raw data. On the other hand, processing 2D data directly, not only preserves spatial information, but also improves the computational efficiency considerably. The 2D OLPP is expected to learn the transformation from 2D data itself. This paper derives mathematical foundation for 2D OLPP. The proposed technique is used for image denoising task. Recent state-of-the-art approaches for image denoising work on two major hypotheses, i.e., non-local self-similarity and sparse linear

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	approximations of the data. Locality preserving nature of the proposed approach automatically takes care of self-similarity present in the image while inferring sparse basis. A global basis is adequate for the entire image. The proposed approach outperforms several state-of-the-art image denoising approaches for gray-scale, color, and texture images.
DIP16NXT08	**TITLE: Microwave Unmixing With Video Segmentation for Inferring Broadleaf and Needleleaf Brightness Temperatures and Abundances From Mixed Forest Observations** **ABSTRACT:** Passive microwave sensors have better capability of penetrating forest layers to obtain more information from forest canopy and ground surface. For forest management, it is useful to study passive microwave signals from forests. Passive microwave sensors can detect signals from needleleaf, broadleaf, and mixed forests. The observed brightness temperature of a mixed forest can be approximated by a linear combination of the needleleaf and broadleaf brightness temperatures weighted by their respective abundances. For a mixed forest observed by an N-band microwave radiometer with horizontal and vertical polarizations, there are 2 N observed brightness temperatures. It is desirable to infer 4 N + 2 unknowns: 2 N broadleaf brightness temperatures, 2 N needleleaf brightness temperatures, 1 broadleaf abundance, and 1 needleleaf abundance. This is a challenging underdetermined problem. In this paper, we devise a novel method that combines microwave unmixing with video segmentation for inferring broadleaf and needleleaf brightness temperatures and abundances from mixed forests. We propose an improved Otsu method for video segmentation to infer broadleaf and needleleaf abundances. The brightness temperatures of needleleaf and broadleaf trees can then be solved by the nonnegative least squares solution. For our mixed forest unmixing problem, it turns out that the ordinary least squares solution yields the desired positive brightness temperatures. The experimental results demonstrate that the proposed

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	method is able to unmix broadleaf and needleleaf brightness temperatures and abundances well. The absolute differences between the reconstructed and observed brightness temperatures of the mixed forest are well within 1 K.
DIP16NXT09	**TITLE: Spectral–Spatial Adaptive Sparse Representation for Hyperspectral Image Denoising** **ABSTRACT:** In this paper, a novel spectral-spatial adaptive sparse representation (SSASR) method is proposed for hyperspectral image (HSI) denoising. The proposed SSASR method aims at improving noise-free estimation for noisy HSI by making full use of highly correlated spectral information and highly similar spatial information via sparse representation, which consists of the following three steps. First, according to spectral correlation across bands, the HSI is partitioned into several nonoverlapping band subsets. Each band subset contains multiple continuous bands with highly similar spectral characteristics. Then, within each band subset, shape-adaptive local regions consisting of spatially similar pixels are searched in spatial domain. This way, spectral-spatial similar pixels can be grouped. Finally, the highly correlated and similar spectral-spatial information in each group is effectively used via the joint sparse coding, in order to generate better noise-free estimation. The proposed SSASR method is evaluated by different objective metrics in both real and simulated experiments. The numerical and visual comparison results demonstrate the effectiveness and superiority of the proposed method.
DIP16NXT10	**TITLE: A Decomposition Framework for Image Denoising Algorithms** **ABSTRACT:** In this paper, we consider an image decomposition model that provides a novel framework for image denoising. The model computes the components of the image to be processed in a moving frame that encodes its local geometry (directions of gradients and level lines). Then, the strategy we develop is to denoise the components of the image in the moving frame in order to preserve its local geometry, which would have been more affected if

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	processing the image directly. Experiments on a whole image database tested with several denoising methods show that this framework can provide better results than denoising the image directly, both in terms of Peak signal-to-noise ratio and Structural similarity index metrics.
DIP16NXT11	**TITLE: Scalable Feature Matching by Dual Cascaded Scalar Quantization for Image Retrieval** **ABSTRACT:** In this paper, we investigate the problem of scalable visual feature matching in large-scale image search and propose a novel cascaded scalar quantization scheme in dual resolution. We formulate the visual feature matching as a range-based neighbor search problem and approach it by identifying hyper-cubes with a dual-resolution scalar quantization strategy. Specifically, for each dimension of the PCA-transformed feature, scalar quantization is performed at both coarse and fine resolutions. The scalar quantization results at the coarse resolution are cascaded over multiple dimensions to index an image database. The scalar quantization results over multiple dimensions at the fine resolution are concatenated into a binary super-vector and stored into the index list for efficient verification. The proposed cascaded scalar quantization (CSQ) method is free of the costly visual codebook training and thus is independent of any image descriptor training set. The index structure of the CSQ is flexible enough to accommodate new image features and scalable to index large-scale image database. We evaluate our approach on the public benchmark datasets for large-scale image retrieval. Experimental results demonstrate the competitive retrieval performance of the proposed method compared with several recent retrieval algorithms on feature quantization.
DIP16NXT12	**TITLE: ACE–An Effective Anti-forensic Contrast Enhancement Technique** **ABSTRACT:** Detecting Contrast Enhancement (CE) in images and anti-forensic approaches against such detectors have gained much attention in multimedia forensics lately. Several contrast enhancement detectors analyze the first

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	order statistics such as gray-level histogram of images to determine whether an image is CE or not. In order to counter these detectors various anti-forensic techniques have been proposed. This led to a technique that utilized second order statistics of images for CE detection. In this letter, we propose an effective anti-forensic approach that performs CE without significant distortion in both the first and second order statistics of the enhanced image. We formulate an optimization problem using a variant of the well known Total Variation (TV) norm image restoration formulation. Experiments show that the algorithm effectively overcomes the first and second order statistics based detectors without loss in quality of the enhanced image.
DIP16NXT13	**TITLE: Rotation Invariant Texture Description Using Symmetric Dense Microblock Difference** **ABSTRACT:** This letter is devoted to the problem of rotation invariant texture classification. Novel rotation invariant feature, symmetric dense microblock difference (SDMD), is proposed which captures the information at different orientations and scales. N -fold symmetry is introduced in the feature design configuration, while retaining the random structure that provides discriminative power. The symmetry is utilized to achieve a rotation invariance. The SDMD is extracted using an image pyramid and encoded by the Fisher vector approach resulting in a descriptor which captures variations at different resolutions without increasing the dimensionality. The proposed image representation is combined with the linear SVM classifier. Extensive experiments are conducted on four texture data sets [Brodatz, UMD, UIUC, and Flickr material data set (FMD)] using standard protocols. The results demonstrate that our approach outperforms the state of the art in texture classification. The MATLAB code is made available.11

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DIP16NXT14	**TITLE: PiCode: a New Picture-Embedding 2D Barcode** **ABSTRACT:** Nowadays, 2D barcodes have been widely used as an interface to connect potential customers and advertisement contents. However, the appearance of a conventional 2D barcode pattern is often too obtrusive for integrating into an aesthetically designed advertisement. Besides, no human readable information is provided before the barcode is successfully decoded. This paper proposes a new picture-embedding 2D barcode, called PiCode, which mitigates these two limitations by equipping a scannable 2D barcode with a picturesque appearance. PiCode is designed with careful considerations on both the perceptual quality of the embedded image and the decoding robustness of the encoded message. Comparisons with the existing beautified 2D barcodes show that PiCode achieves one of the best perceptual qualities for the embedded image, and maintains a better tradeoff between image quality and decoding robustness in various application conditions. PiCode has been implemented in the MATLAB on a PC and some key building blocks have also been ported to Android and iOS platforms. Its practicality for real-world applications has been successfully demonstrated.
DIP16NXT15	**TITLE: OCR Based Feature Extraction and Template Matching Algorithms for Qatari Number Plate** **ABSTRACT:** There are several algorithms and methods that could be applied to perform the character recognition stage of an automatic number plate recognition system; however, the constraints of having a high recognition rate and real-time processing should be taken into consideration. In this paper four algorithms applied to Qatari number plates are presented and compared. The proposed algorithms are based on feature extraction (vector crossing, zoning, combined zoning and vector crossing) and template matching techniques. All four proposed algorithms have been implemented and tested using MATLAB. A total of 2790 Qatari binary character images were used to test the

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	algorithms. Template matching based algorithm showed the highest recognition rate of 99.5% with an average time of 1.95 ms per character.
DIP16NXT16	**TITLE: HD Qatari ANPR System** **ABSTRACT:** Recently, Automatic Number Plate Recognition (ANPR) systems have become widely used in safety, security, and commercial aspects. The whole ANPR system is based on three main stages: Number Plate Localization (NPL), Character Segmentation (CS), and Optical Character Recognition (OCR). In recent years, to provide better recognition rate, High Definition (HD) cameras have started to be used. However, most known techniques for standard definition are not suitable for real-time HD image processing due to the computationally intensive cost of localizing the number plate. In this paper, algorithms to implement the three main stages of a high definition ANPR system for Qatari number plates are presented. The algorithms have been tested using MATLAB and two databases as a proof of concept. Implementation results have shown that the system is able to process one HD image in 61 ms, with an accuracy of 98.0% in NPL, 99.75% per character in CS, and 99.5% in OCR.
DIP16NXT17	**TITLE: Secure magnetic resonance image transmission and tumor detection techniques** **ABSTRACT:** The transmission of important medical diagnostic, MRI (Magnetic Resonance Imaging) images are vulnerable to third party hackers who does spoofing and they are able to introduce faulty and noisy data that damage the transmission data, which hinders the proper medical diagnostics, research and credibility of labs and doctors, there is a clear lack of awareness and lack of proper security measures taken in transmission of MRI images in the present labs, hospitals and research centers. This project is helpful to reduce the problem of secure transmission of medical images. There are many algorithms which can be applied to these medical images. This project is helpful to

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	provide good security to medical images during transmission. Tumor detection or prediction in medical science is a very complex and expensive job, which is not yet been addressed properly and no proper graphical user interface exists in an open source environment. This project is dedicated to analyze the best tumor detection from an MRI brain image after several segmentation methods such as K-means Clustering and Watershed segmentation. Security is realized considering various techniques for encryption and decryption of the image. The encryption technique finally selected after the survey was based on Rivest, Shamir & Adleman [RSA] algorithm.
DIP16NXT18	**TITLE: Multi-View Object Extraction With Fractional Boundaries** **ABSTRACT:** This paper presents an automatic method to extract a multi-view object in a natural environment. We assume that the target object is bounded by the convex volume of interest defined by the overlapping space of camera viewing frustums. There are two key contributions of our approach. First, we present an automatic method to identify a target object across different images for multi-view binary co-segmentation. The extracted target object shares the same geometric representation in space with a distinctive color and texture model from the background. Second, we present an algorithm to detect color ambiguous regions along the object boundary for matting refinement. Our matting region detection algorithm is based on the information theory, which measures the Kullback-Leibler divergence of local color distribution of different pixel bands. The local pixel band with the largest entropy is selected for matte refinement, subject to the multi-view consistent constraint. Our results are high-quality alpha mattes consistent across all different viewpoints. We demonstrate the effectiveness of the proposed method using various examples.
DIP16NXT19	**TITLE: Noise Power Spectrum Measurements in Digital Imaging With Gain**

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	Nonuniformity Correction **ABSTRACT:** The noise power spectrum (NPS) of an image sensor provides the spectral noise properties needed to evaluate sensor performance. Hence, measuring an accurate NPS is important. However, the fixed pattern noise from the sensor's nonuniform gain inflates the NPS, which is measured from images acquired by the sensor. Detrending the low-frequency fixed pattern is traditionally used to accurately measure NPS. However, detrending methods cannot remove high-frequency fixed patterns. In order to efficiently correct the fixed pattern noise, a gain-correction technique based on the gain map can be used. The gain map is generated using the average of uniformly illuminated images without any objects. Increasing the number of images n for averaging can reduce the remaining photon noise in the gain map and yield accurate NPS values. However, for practical finite n, the photon noise also significantly inflates NPS. In this paper, a nonuniform-gain image formation model is proposed and the performance of the gain correction is theoretically analyzed in terms of the signal-to-noise ratio (SNR). It is shown that the SNR is O (√n). An NPS measurement algorithm based on the gain map is then proposed for any given n. Under a weak nonuniform gain assumption, another measurement algorithm based on the image difference is also proposed. For real radiography image detectors, the proposed algorithms are compared with traditional detrending and subtraction methods, and it is shown that as few as two images (n = 1) can provide an accurate NPS because of the compensation constant (1 + 1/n)..
DIP16NXT20	**TITLE: Dimension Reduction With Extreme Learning Machine** **ABSTRACT:** Data may often contain noise or irrelevant information, which negatively affect the generalization capability of machine learning algorithms. The objective of dimension reduction algorithms, such as principal component analysis (PCA), non-negative matrix factorization (NMF), random projection

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	(RP), and auto-encoder (AE), is to reduce the noise or irrelevant information of the data. The features of PCA (eigenvectors) and linear AE are not able to represent data as parts (e.g. nose in a face image). On the other hand, NMF and non-linear AE are maimed by slow learning speed and RP only represents a subspace of original data. This paper introduces a dimension reduction framework which to some extend represents data as parts, has fast learning speed, and learns the between-class scatter subspace. To this end, this paper investigates a linear and non-linear dimension reduction framework referred to as extreme learning machine AE (ELM-AE) and sparse ELM-AE (SELM-AE). In contrast to tied weight AE, the hidden neurons in ELM-AE and SELM-AE need not be tuned, and their parameters (e.g, input weights in additive neurons) are initialized using orthogonal and sparse random weights, respectively. Experimental results on USPS handwritten digit recognition data set, CIFAR-10 object recognition, and NORB object recognition data set show the efficacy of linear and non-linear ELM-AE and SELM-AE in terms of discriminative capability, sparsity, training time, and normalized mean square error.
	IMAGE ANALYSIS APPLICATIONS
IA16NXT01	**TITLE: Multivideo Object Cosegmentation for Irrelevant Frames Involved Videos** **ABSTRACT**: Even though there have been a large amount of previous work on video segmentation techniques, it is still a challenging task to extract the video objects accurately without interactions, especially for those videos which contain irrelevant frames (frames containing no common targets). In this essay, a novel multivideo object cosegmentation method is raised to cosegment common or similar objects of relevant frames in different videos, which includes three steps: 1) object proposal generation and clustering within each video; 2) weighted graph construction and common objects selection; and 3) irrelevant frames detection and pixel-level segmentation

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	refinement. We apply our method on challenging datasets and exhaustive comparison experiments demonstrate the effectiveness of the proposed method.
IA16NXT02	**TITLE: Multi-Viewpoint Panorama Construction with Wide-Baseline Images** **ABSTRACT:** We present a novel image stitching approach, which can produce visually plausible panoramic images with input taken from different viewpoints. Unlike previous methods, our approach allows wide baselines between images and non-planar scene structures. Instead of 3D reconstruction, we design a mesh based framework to optimize alignment and regularity in 2D. By solving a global objective function consisting of alignment and a set of prior constraints, we construct panoramic images, which are locally as perspective as possible and yet nearly orthogonal in the global view. We improve composition and achieve good performance on misaligned area. Experimental results on challenging data demonstrate the effectiveness of the proposed method.
IA16NXT03	**TITLE: Enhancing Sketch-Based Image Retrieval by Re-Ranking and Relevance Feedback** **ABSTRACT:** A sketch-based image retrieval often needs to optimize the tradeoff between efficiency and precision. Index structures are typically applied to large-scale databases to realize efficient retrievals. However, the performance can be affected by quantization errors. Moreover, the ambiguousness of user-provided examples may also degrade the performance, when compared with traditional image retrieval methods. Sketch-based image retrieval systems that preserve the index structure are challenging. In this paper, we propose an effective sketch-based image retrieval approach with re-ranking and relevance feedback schemes. Our approach makes full use of the semantics in query sketches and the top ranked images of the initial results. We also apply relevance feedback to find

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	more relevant images for the input query sketch. The integration of the two schemes results in mutual benefits.
IA16NXT04	**TITLE: Detection of Moving Objects Using Fuzzy Color Difference Histogram Based Background Subtraction** **ABSTRACT:** Detection of moving objects in the presence of complex scenes such as dynamic background (e.g, swaying vegetation, ripples in water, spouting fountain), illumination variation, and camouflage is a very challenging task. In this context, we propose a robust background subtraction technique with three contributions. First, we present the use of color difference histogram (CDH) in the background subtraction algorithm. This is done by measuring the color difference between a pixel and its neighbors in a small local neighborhood. The use of CDH reduces the number of false errors due to the non-stationary background, illumination variation and camouflage. Secondly, the color difference is fuzzified with a Gaussian membership function. Finally, a novel fuzzy color difference histogram (FCDH) is proposed by using fuzzy c-means (FCM) clustering and exploiting the CDH. The use of FCM clustering algorithm in CDH reduces the large dimensionality of the histogram bins in the computation and also lessens the effect of intensity variation generated due to the fake motion or change in illumination of the background. The proposed algorithm is tested with various complex scenes of some benchmark publicly available video sequences. It exhibits better performance over the state-of-the-art background subtraction techniques available in the literature in terms of classification accuracy metrics like MCC and PCC.
IA16NXT05	**TITLE: A Hands-on Application-Based Tool for STEM Students to Understand Differentiation** **ABSTRACT:** The main goal of this project is to illustrate to college students in science, technology, engineering, and mathematics (STEM) fields some

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	fundamental concepts in calculus. A high-level technical computing language - MATLAB, is the core platform used in the construction of this project. A graphical user interface (GUI) is designed to interactively explain the intuition behind a key mathematical concept: differentiation. The GUI demonstrates how a derivative operation (as a form of kernel) can be applied on one-dimensional (1D) and two-dimensional (2D) images (as a form of vector). The user can interactively select from a set of predetermined operations and images in order to show how the selected kernel operates on the corresponding image. Such interactive tools in calculus courses are of great importance and need, especially for STEM students who seek an intuitive and visual understanding of mathematical notions that are often presented to them as abstract concepts. In addition to students, instructors can greatly benefit from using such tools to elucidate the use of fundamental concepts in mathematics in a real world context.
IA16NXT06	**TITLE: A DCT-based Total JND Profile for Spatio-Temporal and Foveated Masking Effects** **ABSTRACT:** In image and video processing fields, DCT-based just noticeable difference (JND) profiles have effectively been utilized to remove perceptual redundancies in pictures for compression. In this paper, we solve two problems that are often intrinsic to the conventional DCT-based JND profiles: (i) no foveated masking (FM) JND model has been incorporated in modeling the DCT-based JND profiles; and (ii) the conventional temporal masking (TM) JND models assume that all moving objects in frames can be well tracked by the eyes and that they are projected on the fovea regions of the eyes, which is not a realistic assumption and may result in poor estimation of JND values for untracked moving objects (or image regions). To solve these two problems, we first propose a generalized JND model for joint effects between TM and FM effects. With this model, called the temporal-foveated masking (TFM) JND

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	model, JND thresholds for any tracked/untracked and moving/still image regions can be elaborately estimated. Finally, the TFM-JND model is incorporated into a total DCT-based JND profile with a spatial contrast sensitivity function, luminance masking, and contrast masking JND models. In addition, we propose a JND adjustment method for our total JND profile to avoid overestimation of JND values for image blocks of fixed sizes with various image characteristics. To validate the effectiveness of the total JND profile, an experiment involving a subjective distortionvisibility assessment has been conducted. The experiment results show that the proposed total DCT-based JND profile yields significant performance improvement with much higher capability of distortion concealment (average 5.6 dB lower PSNR) compared to state-of-the-art JND profiles.
IA16NXT07	**TITLE: Image enhancement in ultrasound imaging** **ABSTRACT:** In this paper, two different methods are suggested in order to provide image enhancement in ultrasonic B-mode imaging. By obtaining RF data from two different phantom used to form B-mode image, their spectral characteristics were observed. Then by forming RF envelope from obtained data, conversion of envelope to color image is provided. Logarithmic compression and histogram equalization methods found in literature are used to improve image quality. From the results obtained, it is observed that both algorithms are effective based on the intended use when they are applied individually.
IA16NXT08	**TITLE: Optimization and Analysis of MPI Collective Communication on Fat-Tree Networks** **ABSTRACT:** We explore new collective algorithms to optimize MPIBcast, MPIReduce and MPIAllreduce on InfiniBand clusters. Our algorithms are specifically designed for fat-tree networks. We present multi-color k-ary trees

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	with a novel mapping scheme to map the colors to fat-tree network nodes. Our multi-color tree algorithms result in better utilization of network links over traditional algorithms on fat-tree networks. We also present optimizations for clusters of SMP nodes as we explore both hybrid and Multi Leader SMP techniques to achieve the best performance. We show the benefits of our algorithms with performance results from micro-benchmarks on POWER8 and X86 InfiniBand clusters. We also show performance optimizations from our algorithms in the PARATEC and QBOX applications.
IA16NXT09	**TITLE: Compression of 3D Point Clouds Using a Region-Adaptive Hierarchical Transform** **ABSTRACT:** In free-viewpoint video, there is a recent trend to represent scene objects as solids rather than using multiple depth maps. Point clouds have been used in computer graphics for a long time, and with the recent possibility of real-time capturing and rendering, point clouds have been favored over meshes in order to save computation. Each point in the cloud is associated with its 3D position and its color. We devise a method to compress the colors in point clouds, which is based on a hierarchical transform and arithmetic coding. The transform is a hierarchical sub-band transform that resembles an adaptive variation of a Haar wavelet. The arithmetic encoding of the coefficients assumes Laplace distributions, one per sub-band. The Laplace parameter for each distribution is transmitted to the decoder using a custom method. The geometry of the point cloud is encoded using the well-established octtree scanning. Results show that the proposed solution performs comparably with the current state-of-the-art, in many occasions outperforming it, while being much more computationally efficient. We believe this paper represents the state of the art in intra-frame compression of point clouds for real-time 3D video.

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IA16NXT10	**TITLE: Discriminant Incoherent Component Analysis** **ABSTRACT:** Face images convey rich information which can be perceived as a superposition of low-complexity components associated with attributes, such as facial identity, expressions, and activation of facial action units (AUs). For instance, low-rank components characterizing neutral facial images are associated with identity, while sparse components capturing non-rigid deformations occurring in certain face regions reveal expressions and AU activations. In this paper, the discriminant incoherent component analysis (DICA) is proposed in order to extract low-complexity components, corresponding to facial attributes, which are mutually incoherent among different classes (e.g., identity, expression, and AU activation) from training data, even in the presence of gross sparse errors. To this end, a suitable optimization problem, involving the minimization of nuclear-and ℓ_1-norm, is solved. Having found an ensemble of class-specific incoherent components by the DICA, an unseen (test) image is expressed as a group-sparse linear combination of these components, where the non-zero coefficients reveal the class(es) of the respective facial attribute(s) that it belongs to. The performance of the DICA is experimentally assessed on both synthetic and real-world data. Emphasis is placed on face analysis tasks, namely, joint face and expression recognition, face recognition under varying percentages of training data corruption, subject-independent expression recognition, and AU detection by conducting experiments on four data sets. The proposed method outperforms all the methods that are compared with all the tasks and experimental settings.
IA16NXT11	**TITLE: Comprehensive and Practical Vision System for Self-Driving Vehicle Lane-Level Localization** **ABSTRACT:** Vehicle lane-level localization is a fundamental technology in autonomous driving. To achieve accurate and consistent performance, a

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	common approach is to use the LIDAR technology. However, it is expensive and computational demanding, and thus not a practical solution in many situations. This paper proposes a stereovision system, which is of low cost, yet also able to achieve high accuracy and consistency. It integrates a new lane line detection algorithm with other lane marking detectors to effectively identify the correct lane line markings. It also fits multiple road models to improve accuracy. An effective stereo 3D reconstruction method is proposed to estimate vehicle localization. The estimation consistency is further guaranteed by a new particle filter framework, which takes vehicle dynamics into account. Experiment results based on image sequences taken under different visual conditions showed that the proposed system can identify the lane line markings with 98.6% accuracy. The maximum estimation error of the vehicle distance to lane lines is 16 cm in daytime and 26 cm at night, and the maximum estimation error of its moving direction with respect to the road tangent is 0.06 rad in daytime and 0.12 rad at night. Due to its high accuracy and consistency, the proposed system can be implemented in autonomous driving vehicles as a practical solution to vehicle lane-level localization.
IA16NXT12	**TITLE: Robust Blur Kernel Estimation for License Plate Images From Fast Moving Vehicles** **ABSTRACT:** As the unique identification of a vehicle, license plate is a key clue to uncover over-speed vehicles or the ones involved in hit-and-run accidents. However, the snapshot of over-speed vehicle captured by surveillance camera is frequently blurred due to fast motion, which is even unrecognizable by human. Those observed plate images are usually in low resolution and suffer severe loss of edge information, which cast great challenge to existing blind deblurring methods. For license plate image blurring caused by fast motion, the blur kernel can be viewed as linear uniform convolution and parametrically modeled with angle and length. In this paper, we propose a

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	novel scheme based on sparse representation to identify the blur kernel. By analyzing the sparse representation coefficients of the recovered image, we determine the angle of the kernel based on the observation that the recovered image has the most sparse representation when the kernel angle corresponds to the genuine motion angle. Then, we estimate the length of the motion kernel with Radon transform in Fourier domain. Our scheme can well handle large motion blur even when the license plate is unrecognizable by human. We evaluate our approach on real-world images and compare with several popular state-of-the-art blind image deblurring algorithms. Experimental results demonstrate the superiority of our proposed approach in terms of effectiveness and robustness.
IA16NXT13	**TITLE: The application of NDT algorithm in sonar image processing** **ABSTRACT:** Image matching technology is an important part of image processing technology. In this paper, the normal distributions transform (NDT) image matching algorithm and its application in the sonar image processing is studied. The NDT algorithm is based on a probability model. It calculates the co-ordinate of the image of the target point instead of the grey value, and this speeds up the sonar image matching process. Previously, before image matching was available, per-processing of the sonar image was necessary. The research of pre-processing of sonar imaging concerns noise reduction and image segmentation of the sonar image. Several classical methods of sonar image noise reduction are studied. The advantages and disadvantages of each method are analyzed. Based on a kind of DSP chip, the NDT image matching algorithm is achieved.
IA16NXT14	**TITLE: BIT: Biologically Inspired Tracker** **ABSTRACT:** Visual tracking is challenging due to image variations caused by various factors, such as object deformation, scale change, illumination change,

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	and occlusion. Given the superior tracking performance of human visual system (HVS), an ideal design of biologically inspired model is expected to improve computer visual tracking. This is, however, a difficult task due to the incomplete understanding of neurons' working mechanism in the HVS. This paper aims to address this challenge based on the analysis of visual cognitive mechanism of the ventral stream in the visual cortex, which simulates shallow neurons (S1 units and C1 units) to extract low-level biologically inspired features for the target appearance and imitates an advanced learning mechanism (S2 units and C2 units) to combine generative and discriminative models for target location. In addition, fast Gabor approximation and fast Fourier transform are adopted for real-time learning and detection in this framework. Extensive experiments on large-scale benchmark data sets show that the proposed biologically inspired tracker performs favorably against the state-of-the-art methods in terms of efficiency, accuracy, and robustness. The acceleration technique in particular ensures that biologically inspired tracker maintains a speed of approximately 45 frames/s.
IA16NXT15	**TITLE: Joint Low-Rank and Sparse Principal Feature Coding for Enhanced Robust Representation and Visual Classification** **ABSTRACT:** Recovering low-rank and sparse subspaces jointly for enhanced robust representation and classification is discussed. Technically, we first propose a transductive low-rank and sparse principal feature coding (LSPFC) formulation that decomposes given data into a component part that encodes low-rank sparse principal features and a noise-fitting error part. To well handle the outside data, we then present an inductive LSPFC (I-LSPFC). I-LSPFC incorporates embedded low-rank and sparse principal features by a projection into one problem for direct minimization, so that the projection can effectively map both inside and outside data into the underlying subspaces to learn more powerful and informative features for representation. To ensure that the

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	learned features by I-LSPFC are optimal for classification, we further combine the classification error with the feature coding error to form a unified model, discriminative LSPFC (D-LSPFC), to boost performance. The model of D-LSPFC seamlessly integrates feature coding and discriminative classification, so the representation and classification powers can be enhanced. The proposed approaches are more general, and several recent existing low-rank or sparse coding algorithms can be embedded into our problems as special cases. Visual and numerical results demonstrate the effectiveness of our methods for representation and classification.
IA16NXT16	**TITLE: A Compressive Multi-Frequency Linear Sampling Method for Underwater Acoustic Imaging** **ABSTRACT:** This paper investigates the use of a qualitative inverse scattering method known as the linear sampling method (LSM) for imaging underwater scenes using limited aperture receiver configurations. The LSM is based on solving a set of unstable integral equations known as the far-field equations and whose stability breaks down even further for under-sampled observation aperture data. Based on the results of a recent study concerning multi-frequency LSM imaging, we propose an iterative inversion method that is founded upon a compressive sensing framework. In particular, we leverage multi-frequency diversity in the data by imposing a partial frequency variation prior on the solution which we show is justified when the frequency bandwidth is sampled finely enough. We formulate an alternating direction method of multiplier approach to minimize the proposed cost function. Proof of concept is established through numerically generated data as well as experimental acoustic measurements taken in a shallow pool facility at the U.S Naval Research Laboratory.

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IA16NXT17	**TITLE: Face Aging Effect Simulation Using Hidden Factor Analysis Joint Sparse Representation** **ABSTRACT:** Face aging simulation has received rising investigations nowadays, whereas it still remains a challenge to generate convincing and natural age-progressed face images. In this paper, we present a novel approach to such an issue using hidden factor analysis joint sparse representation. In contrast to the majority of tasks in the literature that integrally handle the facial texture, the proposed aging approach separately models the person-specific facial properties that tend to be stable in a relatively long period and the age-specific clues that gradually change over time. It then transforms the age component to a target age group via sparse reconstruction, yielding aging effects, which is finally combined with the identity component to achieve the aged face. Experiments are carried out on three face aging databases, and the results achieved clearly demonstrate the effectiveness and robustness of the proposed method in rendering a face with aging effects. In addition, a series of evaluations prove its validity with respect to identity preservation and aging effect generation.
IA16NXT18	**TITLE: Cross-View Action Recognition via Transferable Dictionary Learning** **ABSTRACT:** Discriminative appearance features are effective for recognizing actions in a fixed view, but may not generalize well to a new view. In this paper, we present two effective approaches to learn dictionaries for robust action recognition across views. In the first approach, we learn a set of view-specific dictionaries where each dictionary corresponds to one camera view. These dictionaries are learned simultaneously from the sets of correspondence videos taken at different views with the aim of encouraging each video in the set to have the same sparse representation. In the second approach, we additionally learn a common dictionary shared by different views to model view-shared features. This approach represents the videos in

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	each view using a view-specific dictionary and the common dictionary. More importantly, it encourages the set of videos taken from the different views of the same action to have the similar sparse representations. The learned common dictionary not only has the capability to represent actions from unseen views, but also makes our approach effective in a semi-supervised setting where no correspondence videos exist and only a few labeled videos exist in the target view. The extensive experiments using three public datasets demonstrate that the proposed approach outperforms recently developed approaches for cross-view action recognition.
IA16NXT19	**TITLE: Fast and Provably Accurate Bilateral Filtering** **ABSTRACT:** The bilateral filter is a non-linear filter that uses a range filter along with a spatial filter to perform edge-preserving smoothing of images. A direct computation of the bilateral filter requires O(S) operations per pixel, where S is the size of the support of the spatial filter. In this paper, we present a fast and provably accurate algorithm for approximating the bilateral filter when the range kernel is Gaussian. In particular, for box and Gaussian spatial filters, the proposed algorithm can cut down the complexity to O(1) per pixel for any arbitrary S. The algorithm has a simple implementation involving N+1 spatial filterings, where N is the approximation order. We give a detailed analysis of the filtering accuracy that can be achieved by the proposed approximation in relation to the target bilateral filter. This allows us to estimate the order N required to obtain a given accuracy. We also present comprehensive numerical results to demonstrate that the proposed algorithm is competitive with the state-of-the-art methods in terms of speed and accuracy.

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IA16NXT20	**TITLE: Low-Delay Rate Control for Consistent Quality Using Distortion-Based Lagrange Multiplier** **ABSTRACT:** Video quality fluctuation plays a significant role in human visual perception, and hence, many rate control approaches have been widely developed to maintain consistent quality for video communication. This paper presents a novel rate control framework based on the Lagrange multiplier in high-efficiency video coding. With the assumption of constant quality control, a new relationship between the distortion and the Lagrange multiplier is established. Based on the proposed distortion model and buffer status, we obtain a computationally feasible solution to the problem of minimizing the distortion variation across video frames at the coding tree unit level. Extensive simulation results show that our method outperforms the rate control used in HEVC Test Model (HM) by providing a more accurate rate regulation, lower video quality fluctuation, and stabler buffer fullness. The average peak signal-to-noise ratio (PSNR) and PSNR deviation improvements are about 0.37 dB and 57.14% in the low-delay (P and B) video communication.
	SECURITY APPLICATIONS
SA16NXT01	**TITLE: A Security-Enhanced Alignment-Free Fuzzy Vault-Based Fingerprint Cryptosystem Using Pair-Polar Minutiae Structures** **ABSTRACT:** Alignment-free fingerprint cryptosystems perform matching using relative information between minutiae, e.g., local minutiae structures, is promising, because it can avoid the recognition errors and information leakage caused by template alignment/registration. However, as most local minutiae structures only contain relative information of a few minutiae in a local region, they are less discriminative than the global minutiae pattern. Besides, the similarity measures for trivially/coarsely quantized features in the existing work cannot provide a robust way to deal with nonlinear distortions, a

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	common form of intra-class variation. As a result, the recognition accuracy of current alignment-free fingerprint cryptosystems is unsatisfying. In this paper, we propose an alignment-free fuzzy vault-based fingerprint cryptosystem using highly discriminative pair-polar (P-P) minutiae structures. The fine quantization used in our system can largely retain information about a fingerprint template and enables the direct use of a traditional, well-established minutiae matcher. In terms of template/key protection, the proposed system fuses cancelable biometrics and biocryptography. Transforming the P-P minutiae structures before encoding destroys the correlations between them, and can provide privacy-enhancing features, such as revocability and protection against cross-matching by setting distinct transformation seeds for different applications. The comparison with other minutiae-based fingerprint cryptosystems shows that the proposed system performs favorably on selected publicly available databases and has strong security.
SA16NXT02	**TITLE: Exploring the Usefulness of Light Field Cameras for Biometrics : An Empirical Study on Face and Iris Recognition** **ABSTRACT:** A light field sensor can provide useful information in terms of multiple depth (or focus) images, holding additional information that is quite useful for biometric applications. In this paper, we examine the applicability of a light field camera for biometric applications by considering two prominently used biometric characteristics: 1) face and 2) iris. To this extent, we employed a Lytro light field camera to construct two new and relatively large scale databases, for both face and iris biometrics. We then explore the additional information available from different depth images, which are rendered by light field camera, in two different manners: 1) by selecting the best focus image from the set of depth images and 2) combining all the depth images using super-resolution schemes to exploit the supplementary information available within the set elements. Extensive evaluations are carried out on our

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	newly constructed database, demonstrating the significance of using additional information rendered by a light field camera to improve the overall performance of the biometric system.
SA16NXT03	**TITLE: Distance-Based Encryption: How to Embed Fuzziness in Biometric-Based Encryption** **ABSTRACT:** We introduce a new encryption notion called distance-based encryption (DBE) to apply biometrics in identity-based encryption. In this notion, a ciphertext encrypted with a vector and a threshold value can be decrypted with a private key of another vector, if and only if the distance between these two vectors is less than or equal to the threshold value. The adopted distance measurement is called Mahalanobis distance, which is a generalization of Euclidean distance. This novel distance is a useful recognition approach in the pattern recognition and image processing community. The primary application of this new encryption notion is to incorporate biometric identities, such as face, as the public identity in an identity-based encryption. In such an application, usually the input biometric identity associated with a private key will not be exactly the same as the input biometric identity in the encryption phase, even though they are from the same user. The introduced DBE addresses this problem well as the decryption condition does not require identities to be identical but having small distance. The closest encryption notion to DBE is the fuzzy identity-based encryption, but it measures biometric identities using a different distance called an overlap distance (a variant of Hamming distance) that is not widely accepted by the pattern recognition community, due to its long binary representations. In this paper, we study this new encryption notion and its constructions. We show how to generically and efficiently construct such a DBE from an inner product encryption (IPE) with reasonable size of private keys and ciphertexts. We also propose a new IPE scheme with the shortest private key to build DBE, namely, the need for a

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	short private key. Finally, we study the encryption efficiency of DBE by splitting our IPE encryption algorithm into offline and online algorithms.
SA16NXT04	**TITLE: A Cluster Based Multicast Routing Protocol for Autonomous Unmanned Military Vehicles (AUMVs) Communication in VANET** **ABSTRACT:** Autonomous Unmanned Military Vehicles (AUMVs) became part of numerous military combat operations to meet the challenges of modern warfare techniques and strategies. Hence, there is a need to develop an ad hoc network among AUMVs to perform the military tasks collectively within a war field where infrastructure installation is not possible. Therefore, in this paper a novel AUMVs protocol is proposed to develop a Vehicular Ad Hoc Network (VANET) among unmanned Military Vehicles (MVs). The proposed protocol performs cluster based multicast communication among AUMVs by considering real time and dynamic war field scenario. The AUMVs protocol develops stable clusters and becomes adaptable according to the military environment by using a proposed Priority Based Cluster Head Election Scheme (PCHE) during cluster formation which reduces the network overhead and delay. Additionally, the AUMVs protocol achieves high throughput by combining the multicast approach with a cluster based scheme. The simulation results illustrate that the proposed protocol has achieved the goal of stable and efficient communication among unmanned MVs.
SA16NXT05	**TITLE: A Combined KFDA Method and GUI Realized for Face Recognition** **ABSTRACT:** Traditional face recognition methods such as Principal Components Analysis(PCA), Independent Component Analysis(ICA) and Linear Discriminant Analysis(LDA) are linear discriminant methods, but in the real situation, a lot of problems can't be linear discriminated; therefore, researchers proposed face recognition method based on kernel techniques which can transform the nonlinear problem of inputting space into the linear

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	problem of high dimensional space. In this paper, we propose a recognition method based on kernel function which combines kernel Fisher Discriminant Analysis(KFDA) with kernel Principle Components Analysis(KPCA) and use typical ORL(Olivetti Research Laboratory) face database as our experimental database. There are four key steps: constructing feature subspace, image projection, feature extraction and image recognition. We found that the recognition accuracy has been greatly improved by using nonlinear identification method and combined feature extraction methods. We use MATLAB software as the platform, and use the GUI to demonstrate the process of face recognition in order to achieving human-computer interaction and making the process and result more intuitive
SA16NXT06	**TITLE: A Cost-Effective Minutiae Disk Code For Fingerprint Recognition And Its Implementation** **ABSTRACT:** Fingerprint is one of the unique biometric features for the application of identity security. Minutiae cylinder code (MCC) constructs a cylinder for each minutia to record the contribution of the neighbor minutiae, which has great performance on fingerprint recognition. However, the computation time of the MCC is high. Therefore, we proposed a new disk structure to encode the local structure for each minutia. The proposed minutiae disk code (MDC) clearly illustrates the distribution of the neighbor minutiae and encodes the neighbor minutiae more efficiently by having 280.08× speed faster than the MCC encoding part on Matlab platform. The proposed MDC approach has 96.81% recognition rate on FVC2000 and FVC2002 datasets. The hardware implementation can achieve the operating frequency at 111MHz, which can process 1234 fingerprint images per second with the image size of 255 χ 255 and the maximum of 64 minutiae, under TSMC 90nm CMOS technology. The hardware implementation has 141.27× speed faster than the MCC method.

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SA16NXT07	**TITLE: Template Matching of Aerial Images using GPU** **ABSTRACT:** During the last decade, processor architectures have emerged with hundreds and thousands of high speed processing cores in a single chip. These cores can work in parallel to share a work load for faster execution. This paper presents performance evaluations on such multicore and many-core devices by mapping a computationally expensive correlation kernel of a template matching process using various programming models. The work builds a base performance case by a sequential mapping of the algorithm on an Intel processor. In the second step, the performance of the algorithm is enhanced by parallel mapping of the kernel on a shared memory multicore machine using OpenMP programming model. Finally, the Normalized Cross-Correlation (NCC) kernel is scaled to map on a many-core K20 GPU using CUDA programming model. In all steps, the correctness of the implementation of algorithm is taken care by comparing computed data with reference results from a high level implementation in MATLAB. The performance results are presented with various optimization techniques for MATLAB, Sequential, OpenMP and CUDA based implementations. The results show that GPU based implementation achieves 32x and 5x speed-ups respectively to the base case and multicore implementations respectively. Moreover, using inter-block sub-sampling on an 8-bit 4000×4000 reference gray-scale image achieves the execution time upto 2.8sec with an error growth less than 20% for the selected templates of size 96×96.
SA16NXT08	**TITLE: Analysis of Adaptive Filter and ICA for Noise Cancellation from a Video Frame** **ABSTRACT:** Noise cancellation algorithms have been frequently applied in many fields including image/video processing. Adaptive noise cancellation algorithms exploit the correlation property of noise and remove the noise from the input signal more effectively than non-adaptive algorithms. In this

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	paper different noise cancellation techniques are applied to de-noise a video frame. Three different variants of gradient based adaptive filtering algorithms and independent component analysis (ICA) procedure are implemented and compared on the basis of signal to noise ratio (SNR) and computational time. The common algorithms used in adaptive filters are least mean square (LMS), normalized least means square (NLMS), and recursive least mean square (RLS). The simulation results demonstrates that NLMS algorithm is computationally efficient but cannot handle impulsive noise whereas LMS and RLS can perform better for long duration noise signals. The comparative analysis of adaptive filtering algorithms and ICA shows that ICA can perform better then all three iterative gradient based algorithms because of its non-iterative nature. For testing and simulations, three variants of white Gaussian noise (WGN) are used to corrupt the video frame.
SA16NXT09	**TITLE: Clustered-Dot Screen Design for Digital Multitoning** **ABSTRACT:** Digital multitoning is an extension of halftoning for rendering more than two tones at each pixel for higher image quality. Although a lot of effort has been put in generating dispersed dots previously, the blue-noise feature can hardly be achieved for those printers utilizing the electrophotography (EP) process to avoid the physically unstable isolated dots. To overcome this issue, Chandu et al. proposed a screening method for yielding green-noise dot clusters, yet noisy multitone texture was accompanied. This degrades the visual quality and the stability of tone rendering. In this paper, a significantly improved homogeneity of clustered dots can be achieved by the proposed screening method based upon the new inter-iterative clustered-dot direct multi-bit search algorithm. Compared with the former approaches, the inter-iteration design leads to less error by the updated initial multitone patterns. As demonstrated in the experimental results, both of the high homogenous multitone texture and less noisy

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	perception at all absorptance levels are offered in contrast to the former Chandu et al.'s results. The high-quality output proves it as a very competitive candidate for EP printers, e.g., laser printers.
SA16NXT10	**TITLE: Learning Contextual Dependence With Convolutional Hierarchical Recurrent Neural Networks** **ABSTRACT:** Deep convolutional neural networks (CNNs) have shown their great success on image classification. CNNs mainly consist of convolutional and pooling layers, both of which are performed on local image areas without considering the dependence among different image regions. However, such dependence is very important for generating explicit image representation. In contrast, recurrent neural networks (RNNs) are well known for their ability of encoding contextual information in sequential data, and they only require a limited number of network parameters. Thus, we proposed the hierarchical RNNs (HRNNs) to encode the contextual dependence in image representation. In HRNNs, each RNN layer focuses on modeling spatial dependence among image regions from the same scale but different locations. While the cross RNN scale connections target on modeling scale dependencies among regions from the same location but different scales. Specifically, we propose two RNN models: 1) hierarchical simple recurrent network (HSRN), which is fast and has low computational cost and 2) hierarchical long-short term memory recurrent network, which performs better than HSRN with the price of higher computational cost. In this paper, we integrate CNNs with HRNNs, and develop end-to-end convolutional hierarchical RNNs (C-HRNNs) for image classification. C-HRNNs not only utilize the discriminative representation power of CNNs, but also utilize the contextual dependence learning ability of our HRNNs. On four of the most challenging object/scene image classification benchmarks, our C-HRNNs achieve the state-of-the-art results on Places 205, SUN 397, and MIT indoor, and the competitive results on ILSVRC 2012.

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SA16NXT11	**TITLE: Adaptive Quantization Parameter Cascading in HEVC Hierarchical Coding** **ABSTRACT:** The state-of-the-art High Efficiency Video Coding (HEVC) standard adopts a hierarchical coding structure to improve its coding efficiency. This allows for the quantization parameter cascading (QPC) scheme that assigns quantization parameters (Qps) to different hierarchical layers in order to further improve the rate-distortion (RD) performance. However, only static QPC schemes have been suggested in HEVC test model, which are unable to fully explore the potentials of QPC. In this paper, we propose an adaptive QPC scheme for an HEVC hierarchical structure to code natural video sequences characterized by diversified textures, motions, and encoder configurations. We formulate the adaptive QPC scheme as a non-linear programming problem and solve it in a scientifically sound way with a manageable low computational overhead. The proposed model addresses a generic Qp assignment problem of video coding. Therefore, it also applies to group-of-picture-level, frame-level and coding unit-level Qp assignments. Comprehensive experiments have demonstrated that the proposed QPC scheme is able to adapt quickly to different video contents and coding configurations while achieving noticeable RD performance enhancement over all static and adaptive QPC schemes under comparison as well as HEVC default frame-level rate control. We have also made valuable observations on the distributions of adaptive QPC sets in the videos of different types of contents, which provide useful insights on how to further improve static QPC schemes.
SA16NXT12	**TITLE: Representation Learning of Temporal Dynamics for Skeleton-Based Action Recognition** **ABSTRACT:** Motion characteristics of human actions can be represented by the position variation of skeleton joints. Traditional approaches generally extract the spatial-temporal representation of the skeleton sequences with

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	well-designed hand-crafted features. In this paper, in order to recognize actions according to the relative motion between the limbs and the trunk, we propose an end-to-end hierarchical RNN for skeleton-based action recognition. We divide human skeleton into five main parts in terms of the human physical structure, and then feed them to five independent subnets for local feature extraction. After the following hierarchical feature fusion and extraction from local to global, dimensions of the final temporal dynamics representations are reduced to the same number of action categories in the corresponding data set through a single-layer perceptron. In addition, the output of the perceptron is temporally accumulated as the input of a softmax layer for classification. Random scale and rotation transformations are employed to improve the robustness during training. We compare with five other deep RNN variants derived from our model in order to verify the effectiveness of the proposed network. In addition, we compare with several other methods on motion capture and Kinect data sets. Furthermore, we evaluate the robustness of our model trained with random scale and rotation transformations for a multiview problem. Experimental results demonstrate that our model achieves the state-of-the-art performance with high computational efficiency.
SA16NXT13	**TITLE: Sparse Coding for Alpha Matting** **ABSTRACT:** Existing color sampling-based alpha matting methods use the compositing equation to estimate alpha at a pixel from the pairs of foreground (F) and background (B) samples. The quality of the matte depends on the selected (F,B) pairs. In this paper, the matting problem is reinterpreted as a sparse coding of pixel features, wherein the sum of the codes gives the estimate of the alpha matte from a set of unpaired F and B samples. A non-parametric probabilistic segmentation provides a certainty measure on the pixel belonging to foreground or background, based on which a dictionary is

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	formed for use in sparse coding. By removing the restriction to conform to (F,B) pairs, this method allows for better alpha estimation from multiple F and B samples. The same framework is extended to videos, where the requirement of temporal coherence is handled effectively. Here, the dictionary is formed by samples from multiple frames. A multi-frame graph model, as opposed to a single image as for image matting, is proposed that can be solved efficiently in closed form. Quantitative and qualitative evaluations on a benchmark dataset are provided to show that the proposed method outperforms the current stateoftheart in image and video matting.
SA16NXT14	**TITLE: Layered Coding for Mobile Cloud Gaming Using Scalable Blinn-Phong Lighting** **ABSTRACT:** In a mobile cloud gaming, high-quality, high-frame-rate game images of immense data size need to be delivered to the clients over wireless networks under stringent delay requirement. For good gaming experience, reducing the transmission bit rate of the game images is necessary. Most existing cloud gaming platforms simply employ standard, off-the-shelf video codecs for game image compression. In this paper, we propose the layered coding scheme to reduce transmission bandwidth and latency. We leverage the rendering computation of modern mobile devices to render a low-quality local game image, or the base layer (BL). Instead of sending a high-quality game image, cloud servers can send enhancement layer information, which clients can utilize to improve the quality of the BL. Central to the layered coding scheme is the design of a complexity-scalable BL rendering pipeline that can be executed on a range of power-constrained mobile devices. In this paper, we focus on the lighting stage in modern graphics rendering and propose a method to scale the popular Blinn-Phong lighting for the use in BL rendering. We derive an information-theoretic model on the Blinn-Phong lighting to estimate the rendered image entropy. The analytic model informs

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	the optimal BL rendering design that can lead to maximum bandwidth saving subject to the constraint on the computation capability of the client. We show that the information rate of the enhancement layer could be much less than that of the high-quality game image, while the BL can be generated with only a very small amount of computation. Experiment results suggest that our analytic model is accurate in estimating. For layered coding scheme, up to 84% reduction in bandwidth usage can be achieved by sending the enhancement layer information instead of the original high-quality game images compressed by H.264/AVC.
SA16NXT15	**TITLE: Defocus Blur-Invariant Scale-Space Feature Extractions** **ABSTRACT:** We propose modifications to scale-space feature extraction techniques scale-invariant feature transform (SIFT) and speeded up robust features (SURFs) that make the feature detection and description invariant to defocus blur. Specifically, the scale-space blob detection relies on the second derivative responses of images. Our analysis of circular defocus blur (which sufficiently approximates a real camera blur kernel) and its effect on scale-space blob detection suggests that fourth derivative-and not the usual second derivative-is optimal for detecting the blurred blobs, while multi-scale descriptors of blurred blobs are effective at establishing correspondences between the blurred images. The proposed defocus blur-invariant (DBI) scale-space feature extraction techniques-which we refer to as DBI-SIFT and DBI-SURF-do not require image deblurring nor blur kernel estimation, meaning that their accuracy does not depend on the quality of image deblurring. We offer empirical evidence of blur invariance by establishing interest point correspondences between sharp or blurred reference images and blurred target images.

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SA16NXT16	**TITLE: Semi-Local Scaling Exponent Estimation With Box-Penalty Constraints and Total-Variation Regularization** **ABSTRACT:** We here establish and exploit the result that 2D isotropic self-similar fields beget quasi-decorrelated wavelet coefficients and that the resulting localised log sample second moment statistic is asymptotically normal. This leads to the development of a semi-local scaling exponent estimation framework with optimally modified weights. Furthermore, recent interest in penalty methods for least square problems and generalized Lasso for scaling exponent estimation inspires the simultaneous incorporation of both bounding box constraints and total variation smoothing into an iteratively reweighted least-square estimator framework. Numerical results on fractional Brownian fields with global and piecewise constant, semi-local Hurst parameters illustrate the benefits of the new estimators.
SA16NXT17	**TITLE: Robust Single Image Super-Resolution via Deep Networks With Sparse Prior** **ABSTRACT:** Single image super-resolution (SR) is an ill-posed problem, which tries to recover a high-resolution image from its low-resolution observation. To regularize the solution of the problem, previous methods have focused on designing good priors for natural images, such as sparse representation, or directly learning the priors from a large data set with models, such as deep neural networks. In this paper, we argue that domain expertise from the conventional sparse coding model can be combined with the key ingredients of deep learning to achieve further improved results. We demonstrate that a sparse coding model particularly designed for SR can be incarnated as a neural network with the merit of end-to-end optimization over training data. The network has a cascaded structure, which boosts the SR performance for both fixed and incremental scaling factors. The proposed training and testing schemes can be extended for robust handling of images with additional

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	degradation, such as noise and blurring. A subjective assessment is conducted and analyzed in order to thoroughly evaluate various SR techniques. Our proposed model is tested on a wide range of images, and it significantly outperforms the existing state-of-the-art methods for various scaling factors both quantitatively and perceptually.
SA16NXT18	**TITLE: Multi-Modal Curriculum Learning for Semi-Supervised Image Classification** **ABSTRACT:** Semi-supervised image classification aims to classify a large quantity of unlabeled images by typically harnessing scarce labeled images. Existing semi-supervised methods often suffer from inadequate classification accuracy when encountering difficult yet critical images, such as outliers, because they treat all unlabeled images equally and conduct classifications in an imperfectly ordered sequence. In this paper, we employ the curriculum learning methodology by investigating the difficulty of classifying every unlabeled image. The reliability and the discriminability of these unlabeled images are particularly investigated for evaluating their difficulty. As a result, an optimized image sequence is generated during the iterative propagations, and the unlabeled images are logically classified from simple to difficult. Furthermore, since images are usually characterized by multiple visual feature descriptors, we associate each kind of features with a teacher, and design a multi-modal curriculum learning (MMCL) strategy to integrate the information from different feature modalities. In each propagation, each teacher analyzes the difficulties of the currently unlabeled images from its own modality viewpoint. A consensus is subsequently reached among all the teachers, determining the currently simplest images (i.e., a curriculum), which are to be reliably classified by the multi-modal learner. This well-organized propagation process leveraging multiple teachers and one learner enables our MMCL to outperform five state-of-the-art methods on eight popular image data sets.

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SA16NXT19	**TITLE: Ontology-Based Semantic Image Segmentation Using Mixture Models and Multiple CRFs**

ABSTRACT: Semantic image segmentation is a fundamental yet challenging problem, which can be viewed as an extension of the conventional object detection with close relation to image segmentation and classification. It aims to partition images into non-overlapping regions that are assigned predefined semantic labels. Most of the existing approaches utilize and integrate low-level local features and high-level contextual cues, which are fed into an inference framework such as, the conditional random field (CRF). However, the lack of meaning in the primitives (i.e., pixels or superpixels) and the cues provides low discriminatory capabilities, since they are rarely object-consistent. Moreover, blind combinations of heterogeneous features and contextual cues exploitation through limited neighborhood relations in the CRFs tend to degrade the labeling performance. This paper proposes an ontology-based semantic image segmentation (OBSIS) approach that jointly models image segmentation and object detection. In particular, a Dirichlet process mixture model transforms the low-level visual space into an intermediate semantic space, which drastically reduces the feature dimensionality. These features are then individually weighed and independently learned within the context, using multiple CRFs. The segmentation of images into object parts is hence reduced to a classification task, where object inference is passed to an ontology model. This model resembles the way by which humans understand the images through the combination of different cues, context models, and rule-based learning of the ontologies. Experimental evaluations using the MSRC-21 and PASCAL VOC'2010 data sets show promising results.

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SA16NXT20	**TITLE: Dynamical Spectral Unmixing of Multitemporal Hyperspectral Images**

ABSTRACT: In this paper, we consider the problem of unmixing a time series of hyperspectral images. We propose a dynamical model based on linear mixing processes at each time instant. The spectral signatures and fractional abundances of the pure materials in the scene are seen as latent variables, and assumed to follow a general dynamical structure. Based on a simplified version of this model, we derive an efficient spectral unmixing algorithm to estimate the latent variables by performing alternating minimizations. The performance of the proposed approach is demonstrated on synthetic and real multitemporal hyper spectral images.

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