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R-LETTER

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CONTENTS

Message from the Review Board

Introduction – Call for Nominations

The Review Board thanks the Wireless Technology in Multimedia Communications Interest Group (WTIG) for the two edited articles in addition to their nominations in this October issue. We also received nominations from Green Multimedia Technology Interest Group (GMTIG) and their articles will be included in the December issue.

We would like to invite MMTC members to participate in the nomination process, which is open at all time. High quality publications deserve recommendation for reading. Simply email the Review Board directors the *paper title, authors, publication venue, brief summary and major contribution of the paper, as well as an electronic copy of the paper when possible*. If accepted as a R-letter, the nominator will be acknowledged and invited to be the guest editor. The annual MMTC best paper awards will be selected from eligible papers recommended in the R-letter.

The Review Board aims at recommending recent (within one and half year) state-of-the-art and emerging topics. The topics, either practical or theoretical, should be of general interest for the MMTC community.

Distinguished Category

Publicly available information communication channels benefit society but can also cause security concern. In this issue, the **first article**, published in IEEE ISAC, investigates how to effectively prevent attackers for collaborative spectrum sensing in cognitive radio network and introduces a collision penalty to protect the primary users. The **second article**, published in IEEE Transactions on Mobile Computing, discusses how to provide Internet access to road travelers (drive-thru Internet) and proposes enhancement schemes to achieve higher performance.

Regular Category

The term *cloud* and its associated technological concepts are becoming more and more important for multimedia communication services. Hence, some papers of the regular category are dedicated to this topic.

The **first paper**, published in the *IEEE International Conference on Network Protocols*, proposes the usage of cloud infrastructure (computational resources and high-speed inter-connections) to improve the Quality of Experience (QoE) of video conferencing applications. The **second paper**, from *IEEE Transactions on Multimedia*, suggests exploiting images in the cloud to increase compression efficiency by adopting image feature descriptors in order to reconstruct images from those available in the cloud. In the **third paper**, published in *IEEE Wireless Communications*, the authors provide a scheduling algorithm for mobile cloud environments.

Other R-Letters in this issue are related to crowd density estimations, learning the optimal view rectangle from aesthetics of images, and finding an efficient distributed representation for correlated images.

The **fourth paper** is a paper from International Workshop on Advances in Automated Multimedia Surveillance for Public Safety, collocated with ICME 2013, and proposes means to estimate the density of a crowd using computer vision techniques. The **fifth paper**, published in *IEEE Transactions on Multimedia*, is about optimal view rectangular learning in photography from human aesthetics, which, if performance can be optimized, is a candidate technology to be integrated into the auto-focusing module of modern digital cameras. Finally, the **sixth paper,** published in the *IEEE Transactions on Image Processing*, proposes a distributed representation of geometrically correlated images with compressed linear measurements.

We would like to thank all the authors, nominators, reviewers, editors, and others who contribute to the release of this issue.

Design and Analysis of Simple Mechanisms to Achieve Attack Prevention for Spectrum Sensing in Cognitive Radio Networks

A short review for "Attack Prevention for Collaborative Spectrum Sensing in Cognitive Radio Networks"

Edited by Fen Hou

L. Duan, A. W. Min, J. Huang, and K. G. Shin, "Attack Prevention for Collaborative Spectrum Sensing in Cognitive Radio Networks", IEEE Journal on Selected Areas in Communications, vol. 30, no. , pp. 1658-1665, Oct. 2012.

As a promising way to solve the spectrum scarcity and low spectrum utilization, cognitive radio network has been widely studied [1][2]. In order to achieve no-harmful interference on primary users, the efficient spectrum sensing plays a critical role. Collaborative spectrum sensing has been widely used to improve the accuracy of the sensing result for secondary networks. By exploiting the location diversity of different secondary users, the collaborative sensing can achieve a better detection performance [3]. However, collaborative sensing is vulnerable to falsification attacks, in which attackers may report distorted sensing results in order to manipulate the sensing detection result [4]. The malicious behavior of attackers will result in a waste of spectrum opportunity, interference on the primary users, and unfairness to honest secondary users. Therefore, how to prevent attacks for collaborative spectrum sensing in cognitive radio networks is a very challenging and critical issue.

This paper focuses on the prevention of sensing data falsification attacks in cognitive radio networks, where multiple attackers cooperatively maximize their aggregate utilization by manipulating the results of the sensing decision.

In this paper, the authors first describe the spectrum sensing and opportunistic access model. A time-slotted channel access model is used for secondary users to opportunistically access the channel. Meanwhile, direct punishment and collision penalty are introduced to protect the privilege of primary users. A simple OR-rule is adopted in the paper as the decision fusion rule.

Based on the time-slotted channel access model, the paper presents a comprehensive study on the attack prevention for collaborative spectrum in cognitive ratio networks. It considers two different scenarios: "attack-and-run" and "stay-with-attack", and proposes two attack-prevention mechanisms: the direct punishment scheme and the indirect punishment scheme. Unlike the previous work, the proposed mechanisms do not require the decision center to identify and exclude attackers, which make the mechanism simple and easy to implement.

This paper also investigates the impacts of attack-prevention mechanism on the behavior of cooperative attackers. First, the paper analyzes the behavior of cooperative attackers when the system lacks attack-prevention mechanisms. The authors discuss aggregate reward achieved by the attackers and honest users in different cases: (1) all SUs sense the channel idle; (2) all honest SUs sense the channel idle, but some attackers sense the channel busy; (3) some honest SUs sense the channel busy. The results without attack-prevention mechanisms can be used as comparison and benchmark for the proposed attack-prevention mechanisms.

Then, the paper proposes and analyzes two attack-prevention mechanisms. In the direct punishment mechanism, the fusion center can directly charge a punishment to the SUs when attacks are identified. In the indirect punishment mechanism, the fusion center terminates the collaborative sensing once it detects an attack. Without collaborative sensing, the attackers cannot overhear honest SUs' sensing reports, which will result in an increase in attackers' missed detection probability. Therefore, the indirect punishment of terminating the collaborative sensing can reduce the attackers' motivation to attack. With this innovative idea, the proposed indirect punishment mechanism can effectively prevent the "say-with-attacks" when the attackers care enough about their future utilities. A punishment threshold to prevent all attack scenarios is proposed and provided in the direct punishment mechanism. The analysis result shows that the threshold is a function of the numbers of honest SUs and attackers. For the indirect punishment mechanism, the authors formulate the attack prevention problem in the long-term "stay-with-attacks" scenario as a Markov decision process. Then, the paper discusses and analyzes several cases: aggressive transmission, non-aggressive transmission, weak cooperation, and strong cooperation. Finally, the paper discusses the impact of network size and collision penalty on the proposed mechanism.

In summary, the paper proposes two mechanisms to prevent the attacks for collaborative spectrum sensing in cognitive radio network. The detail and complete analysis shows that the direct punishment mechanism can effectively prevent all attacks in both "attack-and-run" and "stay-with-attacks," and the indirect punishment mechanism can prevent all attacks in the long-run as long as the attackers care about their future rewards.

Acknowledgement:

This paper is nominated by the MMTC Wireless Technology for Multimedia Communications (WTMC) Interest Group.

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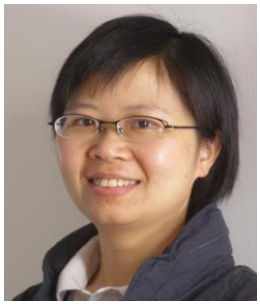

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Dr. Hou has served as the chair of an Interest Group in IEEE MMTC, as well as a technical program committee member for IEEE WiOpt 2012, IEEE ICC 2011, IEEE WCNC 2011, IEEE GLOBECOM 2010, etc. Dr. Hou has also served as a technical reviewer for IEEE Transactions on Wireless Communications, IEEE Transactions on Vehicular Technology, IEEE Journal on Selected Areas in Communications, IEEE INFOCOM, etc.

Analysis of Mobility Impact on the Throughput Performance and MAC Design of Enhancement Schemes in Drive-Thru Internet

A short review for " MAC in Motion: Impact of Mobility on the MAC of Drive-Thru Internet"

Edited by Bin Lin

H. Luan, X. Ling, and X. (Sherman) Shen,, " in Motion: Impact of Mobility on the MAC of Drive-Thru Internet ", IEEE Transactions on mobile computing, vol. 11, no. 2,pp.305-319, Feb. 2012

The demand of high-rate Internet access from vehicles is ever-increasing due to the fact that people are spending more and more time in their vehicles currently. However, traditional cellular or satellite wireless communications can only provide limited available data rate which is far from enough to deliver the media-rich Internet contents. Driven by this, the plethora IEEE 802.11b access points APs have been deployed in cities so as to address the issue of high-rate cheap Internet access from vehicles [1][2].

Although related performance studies in IEEE 802.11 has been well investigated previously, the performance of IEEE 802.11 in the high-speed large-scale drive-thru Internet scenario is still not clear and very challenging. The reasons are two-fold. One is that the drive-thru Internet is typically a much larger network composed of tens or hundreds of users, compared with the small-scale indoor scenarios. The other is that the IEEE 802.11 was originally designed for low-mobility scenarios [3]. Thus, the IEEE 802.11 adopts the contention-based distributed coordination function (DCF) as its MAC. In the case of drive-thru Internet, as vehicles have volatile connectivity due to the fast mobility, whether DCF can fully utilize the cherished access time of users and provide them the guaranteed throughput is questionable.

To address these issues, the key questions facing the authors are: how the performance of DCF is in the high-speed large-scale drive-thru Internet; in what fashion the mobility affects the MAC throughput and, more importantly, how to remedy that?

Compared with reported research, the novelty and challenge of this paper are that the authors provide an elaborate MAC analysis of DCF performance by taking high-node mobility into account, and model the specific DCF in detail, especially, the quantified impacts of mobility on the MAC throughput are shown. In addition, the authors target to propose enhancement schemes based on the legacy IEEE 802.11 DCF in the newly emerged vehicular environment, instead of proposing new MAC schemes [4] [5]. The consideration is more practical for the plethora IEEE 802.11b APs deployment situation.

In this paper, the authors contributed at both performance evaluation and protocol enhancement. For performance evaluation, the authors provide a theoretical treatment based on a Markov chain model which incorporates the mobility of vehicles in the analysis of DCF. The developed model is accurate and scalable. It can investigate the throughput performance under different velocities and network scales. The results have shown that due to the mobility, the network size of the drive-thru Internet is solely dependent on the node velocity, which can be applied to optimally configure the DCF by knowing the node velocity only.

For the protocol enhancement, which is based on the developed model, the authors propose to further enhance the MAC throughput by adaptively adjusting the MAC in tune with the node mobility. In particular, the authors propose three assertions as the guidelines of the DCF design in the highly mobile vehicular environment, and describe the optimal schemes to determine the channel access opportunity to fully utilize the transient connectivity of vehicles. Simulations results have shown the effectiveness of the scheme to mitigate the impacts of mobility.

In summary, the paper focuses on the DCF performance by considering high-node mobilities. A systematic and theoretical model is first developed based on the Markov model to analysis the quantified impact of mobility (characterized by the node velocity and moving direction) on the resultant system throughput. Then, protocol enhancement scheme is discussed as the guideline of the selection of CW_{min} in different zones to boost the performance of DCF by accommodating the

high mobility of nodes. Following this research direction, future work includes the extension of this framework to evaluate the QoS performance for multimedia applications and the QoS provision schemes in the high-speed drive-thru Internet scenario.

Acknowledgement:

This paper is nominated by the MMTC Wireless Technology for Multimedia Communications (WTMC) Interest Group.

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Improving the Video Conferencing QoE using the Cloud

A short review for "Airlift: Video Conferencing as a Cloud Service using Inter-Datacenter Networks"

Edited by Jiang Zhu

Y. Feng, B. Li, and B. Li, "Airlift: Video Conferencing as a Cloud Service using Inter-Datacenter Networks", in Proceedings of the 2012 IEEE International Conference on Network Protocols (ICNP12), pp. 1-11, 2012.

Our way of communication has been fundamentally changed with the introduction of the Internet, by using emails, tweets, VoIP, and now video conferencing. Existing video conferencing services like Skype [1], Google+ Hangout [2], and iChat [3] have attracted millions of users. Video conferencing, specifically multi-party video conferencing, requires high bitrates and low-delay voice/video transmission. With todays' network infrastructure, it is still very challenging to deliver high-quality video conferencing services to consumers through the best-effort Internet.

Existing solutions in the literature have traditionally focused on the use of peer-to-peer (P2P) [4,5,7] or simple client-server architectures (e.g., Microsoft Lync). In order to maximize the video bitrate from a single source to the remaining participants in a video conferencing application, Steiner tree packing can be employed for video multicast. However, the problem is NP-complete and, thus, only depth-1 and depth-2 trees are generally considered to reduce complexity [4,5]. Another approach is to use intra-session network coding as advocated in this paper. With the help of network coding, it is possible to formulate the problem of maximizing the total throughput across all sessions as a linear program, which is easily solvable using a standard LP solver.

A new trend for multi-party video conferencing is offering it as a cloud-based service. The more popular ones, for example, Google+ and Skype, rely on proxy servers residing inside datacenters that will relay the video flows to all other users in the conference [6]. The proposed Airlift also takes advantage of the computational power of the datacenters as well as the high-capacity inter-datacenter network. Each datacenter is responsible for aggregating incoming video flows from users attaching to it, and forwarding them to the other datacenter, eventually reaching other participants. With such aggregation, the number of video flows traversing the network is naturally minimized, without the complexity of tree packing and flow scheduling.

There are a number of important objectives when designing a new protocol for multi-party video conferencing. The first one is performance. It is in the users' best interest, if the system can provide higher video bitrates while still maintaining an acceptable end-to-end delay. From the service point of view, the system should be simple, and work as a full-service broker inside the datacenter. Last but not the least, the system should be scalable. In other words, it should be able to handle thousands of flows on one inter-datacenter link.

With these considerations in mind, the authors designed the Airlift protocol as follows. First, a LP problem is solved to obtain conceptual flow rates on each inter-datacenter link with delay bound. The solution provides the complete plan to start actual packet transmission. It is non-trivial to realize the complete plan, simply due to the bandwidth overhead and additional decoding delay. The authors proposed to decouple generation (n packets unit) from sliding window, so that coded packets are generated within a small generation (low decoding delay), while a sliding window represents all the packets that have been sent but not yet acknowledged by the destination. By doing this, the link utilization can be maintained as high as possible. The final step will be realizing conceptual flows by replicating, splitting, and merging depending on cases. It is also worth to notice that each session can be weighted by some factor to achieve basic fairness across participants when their video sources share the bottleneck link.

The implementation of Airlift is evaluated with PlanetLab and Amazon EC2 datacenters, where a broker is running as a VM executing network coding, packet processing, and forwarding. A central optimizer periodically collects network statistics from all brokers and refactors the system operation. Experimental results show substantial performance advantage over the Celerity [4] system with up to 24x throughput gain with similar end-to-end delay.

This work is uniquely positioned for high data rate and delay stringent applications with practical network coding implementation. It does not only provide a promising application layer protocol for high quality multi-party video conferencing, but can also inspire others in the research areas of network coding, mobile cloud services, and multimedia adaptations.

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Exploiting Cloud Images for Compression

A short review for "Cloud-Based Image Coding for Mobile Devices – Toward Thousands to One Compression"

Edited by Carl James Debono

H. Yue, X. Sun, J. Yang, and F. Wu, "Cloud-Based Image Coding for Mobile Devices – Toward Thousands to One Compression," IEEE Transactions on Multimedia, vol. 15, no. 4, pp. 845-857, June 2013.

It is becoming customary to place images on the cloud which has become a huge repository for such data. The emergence of cloud images has posed demands for the development and implementation of content-based image retrieval. Furthermore, this is facilitating advances, amongst others, on image completion, object recognition, content annotation, and scene modeling. An open question tackled by this paper is how to exploit cloud images for image compression. High compression of images is desirable for both storage and transmission of this data, especially in memory-limited devices and bandwidth-limited networks.

The biggest challenge when dealing with cloud-based image compression comes from the indefiniteness of cloud images. Existing compression techniques, such as those based on prediction and transforms, require fixed correlated images to compress an image. These correlated images have to remain unaltered and cannot be deleted once they have been used as reference in compression. However, this requirement is very difficult to guarantee in clouds as the images can be changing frequently. New images are becoming available while others in the cloud can be modified or deleted in very short periods of time.

The authors of this paper propose a method of cloud-based image coding that is different from the methods that are currently in use for image coding. Rather than compressing images in a pixel-by-pixel fashion, this algorithm tries to provide a description of the images and reconstructs them from available cloud images by exploiting these descriptors. They first utilize the Scale-Invariant Feature Transform (SIFT) descriptors [1] to characterize the local features available in an image. Previous work, such as [2] and [3], has shown that using local features of one image can provide enough information to approximately interpret its content. However, it is not sufficient enough to reconstruct a visually pleasing image. Thus, the authors apply global information in the description of one image, which is constituted of a down-sampled version of the image.

In the authors' proposed image description, the SIFT descriptors are extracted from the original images and are used to retrieve near and partial duplicate images in clouds and identify corresponding patches. The down-sampled images play an important role in enhancing the reconstructed images making them visually pleasing. They are utilized to verify every retrieved image patch and guide the algorithm on how to stitch image patches together to form the required image described by the descriptors.

The authors of this paper also solve two important technical problems. They first propose to use the correlation between the down-sampled image and the SIFT descriptors to greatly reduce the size of the feature vectors determined by the SIFT algorithm. The down-sampled image was first compressed using traditional image coding techniques or intra-frame coding in video compression. Then the locations, scales, and orientations of the SIFT descriptors are coded. Secondly, based on the coded feature information, predictive vectors are extracted from the down-sampled image. These are then used as predictions to the high-dimension SIFT vectors. The residual vectors generated can then be efficiently compressed using transform and entropy coding.

In order to reconstruct high quality images from the cloud data, the authors propose to first group decoded local features to retrieve duplicate or near duplicate images and patches. Following this step, stitching of the retrieved patches is done in relation to the down-sampled image. Further enhancement of the consistence of the retrieved patches is done by estimating a perspective transformation for each patch using the RANdom SAmple Consensus (RANSAC) algorithm [4].

Experimental results reported in the paper show that the visual quality of the reconstructed images is significantly better than that obtained with intra-frame coding using High Efficiency Video Coding (HEVC) and Joint Photographic Experts Group (JPEG), at thousands to one compression ratio. When highly correlated images exist, a significant amount of bit saving is achieved while still presenting high levels of visual quality. Tests reported on original test images having average sizes of 4.69MB show that the method proposed by the authors gives an average

compression ratio of 1885:1. The maximum value of compression ratio that the authors report is 4000:1.

One should not consider this technique as a replacement for traditional image coding methods. However, when huge amounts of cloud images are readily available, the solution reported by the original authors can exploit the correlations of the external images to significantly reduce the size of the compressed data. An example of a cloud-mobile scenario that can exploit such a solution is photo sharing on a social network. In such a case, a low-resolution image can be transmitted to a number of users at very low bit rates who will view them on their displays with high quality and resolution, through the use of this solution and the similar images on the cloud.

Future work in this field is need to further improve the accuracy of the predictors to continue improving both the compression that can be achieved and the quality of the reconstructed images. Faster algorithms are also desirable, and a trade-off between speed and the quality of the reconstructed images has to be found. Furthermore, new feature descriptors can be investigated for better identification of similar portions of the images.

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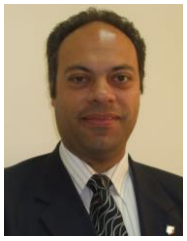

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Between 1997 and 2001 he was employed as a Research Engineer in the area of Integrated Circuit Design with the Department of Microelectronics at the University of Malta. In 2000 he was also engaged as a Research Associate with Texas A&M University, Texas, USA. In 2001 he was appointed Lecturer with the Department of Communications and Computer Engineering at the University of Malta and is now an Associate Professor. He is currently the Deputy Dean of the Faculty of ICT at the University of Malta.

Prof. Debono is a senior member of the IEEE and served as chair of the IEEE Malta Section between 2007 and 2010. He is the IEEE Region 8 Vice-Chair of Technical Activities for 2013. He has served on various technical program committees of international conferences and as a reviewer in journals and conferences. His research interests are in wireless systems design and applications, multi-view video coding, resilient multimedia transmission, and modeling of communication systems.

How to Realize the Blind Scheduling for Practical Mobile Media Cloud

A short review for "Exploring Blind Online Scheduling for Mobile Cloud Multimedia Services"

Edited by Hao Hu

L. Zhou, Z. Yang, J. Rodrigues, and M. Guizani, "Exploring Blind Online Scheduling for Mobile Cloud Multimedia Services", IEEE Wireless Communications, vol. 20, no. 3, pp. 54-61, June 2013.

With the rapid development of wireless communication technologies, users are expecting to enjoy more and more multimedia services from the mobile cloud. Clearly, when all the multimedia services move to the cloud, which keeps scaling and becomes more complicated, it is necessary to design an efficient scheduling scheme that dynamically allocates appropriate user service request to the available multimedia servers without the help of a centralized controller [1-2].

Basically, since various service requests usually come from different users and the scheduling policies are typically delay-sensitive, the users are intuitively allocated to the servers with less service time to reduce transmission and waiting delays. In this case, however, the faster servers naturally become busy since they possess less free time than the slower ones and, hence, it can lead to significant energy consumption [3-4]. More recently, it is well known that green multimedia service is an irreversible trend. As a result, from this perspective, it is necessary to enable all the servers to have the same or similar free time when assigning heterogeneous services to servers. This encourages researchers to design an exquisite scheduling policy with the following goals: 1) minimizing the delay of the service, and 2) achieving impartial free time among the servers regardless of their service time [5].

Many of the predominant popular cloud-based scheduling algorithms assume that the request rate and service time are available for the system operator. However, this assumption can hardly hold in many practical scenarios, especially for the large-scale mobile cloud [6]. In contrast, this article considers the scheduling problem for a practical mobile cloud in which the above parameters are unavailable and unknown. Essentially, blind online scheduling results in some critical difficulties: 1) Designing the user routing according to the availability and ability of the servers, 2) determining the server assignment without knowing the service request and time, and 3) implementing the scheduling in a distributed way for online operation. These three problems are related to each other and, hence, they should be resolved jointly rather than separately.

In this article, the authors design a simple blind online scheduling scheme by jointly considering routing and assignment but separately developing them. Specifically, one assigns available multimedia servers based on the last time-slot information of the users' requests, and routes the heterogeneous multimedia flows according to the first-come-first-served rule. Basically, the routing algorithm first takes charge of the service time and then controls the practical waiting time for a user requesting a specific multimedia service. The assignment algorithm is responsible for distributing the servers into different classes according to different multimedia service requests.

It is obvious that the proposed blind scheduling algorithm is suitable for practical use in the sense that it does not require the knowledge of the system parameters such as request rates, service rates, etc. This scheme is attractive because the computation that is required for a reasonable approximation grows only linearly with the dimension of the users. Moreover, the results can be used to derive estimates on the system parameters with a desired level of accuracy, and this point is consistent with the probability-constrained model presented in the article.

The proposed scheduling scheme is employed in a practical mobile cloud environment. In general, there are two distinct types: one is to add the algorithm in the virtualization part which attains an approximate solution of the goal function within the cloud, and the other one is to implement it in the task division and mapping part which act as a middleware between the cloud virtualization and multimedia integration. For the former, it focuses on the cloud resource, providing Quality of Service (QoS) in the cloud infrastructure to support heterogeneous multimedia services with unknown user demand and available server. For the latter, it aims at improving cloud QoS in the upper layers, such as QoS in the application layer and QoS mapping between the cloud infrastructure and QoS request.

Following this research direction, future work consists of extending this framework to any kind of traffic region with jointly designed routing and

assignment algorithms, as well as studying system dynamics when the user is allowed to switch multimedia service during the waiting time.

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Estimating the Density of a Crowd using Computer Vision

A short review for "Crowd density analysis using Subspace Learning on Local Binary Pattern"

Edited by Guillaume Lavoué

H. Fradi, X. Zhao, and J.-L. Dugelay, "Crowd density analysis using Subspace Learning on Local Binary Pattern," in Proceedings of IEEE International Workshop on Advances in Automated Multimedia Surveillance for Public Safety, ICME 2013.

There is currently significant interest in visual surveillance systems for crowd analysis. In particular, the automatic monitoring of crowd density is receiving much attention in the security community. It is extremely important information for early detection of unusual situations in large-scale crowd to ensure assistance and emergency contingency plans.

One of the key aspects of crowd density analysis is crowd feature extraction. Early attempts to handle this problem generally made use of texture features. Based on the assumption [1] that high density crowd has fine patterns of texture, whereas images of low density have coarse patterns of texture, many texture features have been proposed to address the problem of crowd density estimation such as: GLCM [1, 2], GOCM [3], and wavelet. Recently, the use of local texture features has been an active topic, especially some variants of Local Binary Pattern (LBP) [4], e.g., Dual-Histogram LBP [5], spatio-temporal LBP [6], GLCM on LBP image [7], and an improved uniform LBP [7].

These methods generally perform crowd density level classification directly using the high dimensional LBP-based feature vector, which might contain some components irrelevant to crowd density. And the use of the whole feature vector without a feature selection process could lead to unsatisfactory classification performances. Therefore, in this paper, the authors propose to learn a discriminant subspace of the high-dimensional LBP instead of using raw LBP feature vector. It consists of a combination of Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA) to find a low dimensional discriminative subspace where samples of different crowd density levels are optimally separated. This process is favourable for the later Support Vector Machine (SVM) classification step.

As additional contribution of this paper, the authors propose to estimate crowd density at patch level, where the size of each patch varies in such a way to compensate the effects of perspective distortions. This patch level processing involves the estimation of patch size in the real-world coordinates.

The performance of the proposed approach is evaluated on PETS dataset in two steps. First, for each test sample, the feature vector using block-based LBP is projected into the learned PCA and LDA subspaces, and is identified as one of the crowd levels by the multi-class SVM classifiers following One-against-One strategy. The top-1 identification accuracy is reported. Second, the Receiver Operating Characteristics (ROC) curve of each class is reported to demonstrate the discriminative power of the proposed feature for each crowd density level separately. Furthermore, in the experiments, both linear and RBF SVM kernels are evaluated. Their performances are compared to K-Nearest Neighbour (KNN) classifier. The authors also compare the proposed feature (i.e., customized LBP) to other texture features, namely, HOG, Gabor wavelet, and GLCM.

The results show that effective dimensionality reduction (DR) techniques significantly enhance the classification accuracy. Additionally, the proposed approach is robust enough to perform well in different levels of the crowd.

The comparison to other frequently used features in crowd density estimation showed that the proposed feature provides excellent results regarding the state-of-the-art methods.

For future works, there is still untapped potential to reduce the complexity of the step related to the multi-classification problem. Also for tests, since jammed crowd level could not be investigated using PETS, additional experiments on other datasets could be of interest.

To conclude, crowd density estimation becomes a major component in the visual surveillance

domain. This paper brings some smart ideas like using local regions and incorporating real-world coordinates. They should stimulate further research is this emerging domain.

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Optimal View Rectangle Learning in Photography from Human Aesthetics

A short review for "Learning to photograph: a compositional perspective"

Edited by Jun Zhou

Bingbing Ni, Mengdi Xu, Meng Wang, Shuicheng Yan, and Qi Tian, "Learning to photograph: a compositional perspective ", IEEE Transactions on Multimedia, Vol. 15, No. 5, pages 1138-1150, 2013.

Computational photography is a research area on extending the capabilities of traditional digital photography by computational methods. It covers the entire process of photography, from image capture, processing, to analysis. The core idea is to estimate parameters of the imaging environment so as to retrieve information and produce novel functions that are not achievable by traditional photography process. This is an important emerging research area due to its multidisciplinary challenging nature and huge potential in commercial imaging products including digital cameras.

While many books and tutorials have been offered on how to produce high quality photos [1], it is often complex to transform photo techniques, especially those related to subjective judgment and experiences, into computational models. One of the examples is automatic perspective and viewpoint determination, which requires full exploration even for experienced photographers.

In this paper, authors tried to tackle this problem by learning the optimal view rectangle from aesthetics of images that have been recognized as high quality by human raters. Aesthetics of images can be influenced by many factors. For example, Datta *et al.* defined nine features to describe different aspects of aesthetics, which included exposure of light and colorfulness, saturation and hue, the rule of thirds, familiarity measure, familiarity measure, wavelet-based texture, size and aspect ratio, region composition, low depth of field indicators, and shape convexity [2]. These features were further extended to spectral domain to perform optimal color transfer [3].

The focus of this paper, however, is rather straightforward. It learns a model to describe the composition of image segments that correspond to various object classes in landscape images. Then the optimal view rectangle of a new image can be searched by a probabilistic approach that utilizes the trained model and features extracted from the new image.

In the learning process, collected training images are first divided into several groups to reduce the learning complexity. Such grouping is based on a bag of words model, whose dictionary is constructed from Histogram of Gradient [4] and color features. Then each image is segmented into several patches that correspond to visual elements such as sky, ground, sea, and human. Image descriptors are extracted from these patches and grouped into visual words, such that each visual element can be mapped to the nearest visual word.

The essential idea of this paper is learning composition rules based on omni-range context modeling. This enables estimation of both single and pairwise spatial and geometric probabilistic distributions of visual elements, even when two image patches are extracted from arbitrary locations of an image. Each visual word is described by its distribution with respect to the center, the normalized width, height, and area of the image rectangles defined on image segments. Joint distribution of two visual words is also learned from the differences between centers of image segments, and the ratios of widths, heights, and areas of two image segments.

When a new image is given, the same grouping and segmentation steps as in the training stage are executed. Then MAP estimation is performed by calculating the optimal view rectangle given the image and the learned probability distributions.

The proposed method was evaluated both qualitatively and quantitatively. In particular, user studies were performed so that human subjects can give scores to the view rectangles generated by several methods being compared. The results from the proposed method have

shown to be consistent with the human judgment.

The only disadvantage of this method is the relatively low efficient optimization step in view rectangle inference on new images. If a faster searching algorithm can be developed to replace this step, a very interesting and useful function is ready to be integrated into the auto-focusing module of modern digital cameras.

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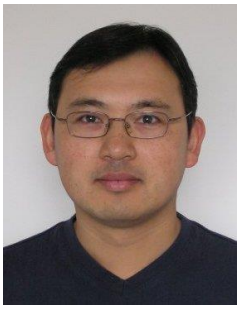

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Distributed Image Representation with Compressed Linear Measurements

A short review for "Distributed Representation of Geometrically Correlated Images with Compressed Linear Measurements"

Edited by Pradeep K. Atrey

V. Thirumalai and P. Frossard, "Distributed Representation of Geometrically Correlated Images with Compressed Linear Measurements," IEEE Transactions on Image Processing, vol. 21, no. 7, July 2012.

Vision sensor networks and video cameras find widespread usage in several applications that rely on the effective representation of 3D scenes. Distributed processing solutions present several advantages for processing the highly redundant visual information captured in such systems, since they require only minimal inter-sensor communication and low computational power. In these settings, the visual information is compressed and transmitted independently from each sensor node to a common decoder that jointly processes the correlated information streams. The modeling and estimation of the image correlation at joint decoder becomes however crucial in order to achieve a good rate-distortion tradeoff in the representation of the multi-view video information.

In this paper, the authors have tackled the problem of finding an efficient distributed representation for correlated images, where the common objects are displaced due to the viewpoint changes or motion in dynamic scenes. In particular, they have considered a scenario where the images are given under the form of few quantized linear measurements computed by very simple sensors. Even with such a simple acquisition stage, the images can be reconstructed under the condition that they have a sparse representation in a particular basis (e.g., DCT, wavelet), which is sufficiently different from the sensing matrices [1, 2]. Rather than independent image reconstruction, the authors are however interested in the joint reconstruction of the images and particularly in the estimation of their correlation from the compressed measurements.

The key in effective distributed representation certainly lies in the definition of good correlation models. Duarte *et al.* [3] have proposed different joint sparsity models (JSMs) for distributed compression that exploit the correlation between signals. These simple joint sparsity models are however not ideal for natural images, as the correlation for natural images can be effectively represented through displacement of scene objects. The distributed compressive schemes presented in the literature (e.g., [4, 5]) usually estimate the correlation model from reconstructed reference images, where the reference frames are reconstructed from the respective linear measurements by solving an l_2-l_1 or l_2-TV optimization problem. Unfortunately, reconstructing the reference images based on solving an l_2-l_1 or l_2-TV optimization problem is computationally expensive [1, 2]. Also, the correlation model estimated from highly compressed reference images usually fails to capture the actual geometrical relationship between images, since the non-linearities are not handled properly due to quantization. Motivated by these issues, the authors have proposed to estimate a robust correlation model directly from the highly compressed linear measurements, without explicitly reconstructing the compressed images.

While block-based translational models are commonly used in state-of-the-art coding solutions, the authors have rather modeled the correlation between images through geometric transformations of visual features. The most prominent visual features of a reference image are first identified by computing a sparse approximation with a dictionary of geometric basis functions [6]. As the images are correlated through displacement of scene objects, it is likely that the visual features in the reference image are present in the compressed images too, possibly with geometric transformations (e.g., translation, rotation). The corresponding visual features that are related through local transformations form the geometric correlation model [7].

Hence, a regularized optimization problem is proposed at the joint decoder in order to identify the features in the compressed images that correspond to the prominent visual features in the reference image. The regularization term ensures that the estimated correlation is consistent and corresponds to the actual motion of visual objects. The estimated correlation is then used in a new joint decoding algorithm that approximates multiple images such that the estimated images are consistent with the respective quantized measurements. Experiments show that the proposed algorithm computes a good estimation of the correlation between multi-view images. Additionally, the proposed algorithm provides effective decoding performance that compares advantageously to independent coding solutions based on JPEG 2000, as well as state-of-the-art distributed coding schemes based on disparity learning.

Certainly, this framework provides an original and effective solution for distributed processing of visual information in vision sensor networks with low encoding complexity.

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