MULTIMEDIA COMMUNICATIONS TECHNICAL COMMITTEE
IEEE COMMUNICATIONS SOCIETY
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R-LETTER

Vol. 4, No. 6, December 2013

IEEE COMMUNICATIONS SOCIETY

CONTENTS

Message from the Review Board

Introduction

Following the example pioneered by the Wireless Technology in Multimedia Communications Interest Group (WTIG), who helped editing two articles in the October issue, in this R-letter two edited articles were facilitated by the Multimedia Technology Interest Group (GMTIG) and Dr. Liang Zhou. The Review Board would like to thank their support and anticipate more participation from MMTC members in the nominating, reviewing and editing processes.

Distinguished Category

With the exponential growing of wireless and mobile traffic in recent years, the spectrum efficiency has become an interesting and important research topic. To increase the spectrum efficiency, some researchers provide better and more efficient algorithms to increase link capacity and network throughput. Others propose to use more small devices to offload traffic from traditional cellular networks.

The **first paper**, published in ACM International Conference on Mobile Computing and Networking (MobiCom) (pp. 173-184, 2012), proposed to leverage millions of personal smartphones and a near-pervasive wireless network infrastructure to collect and analyze sensed data. This paper set an important theoretical foundation for practical crowd-sensing systems that want to utilize sensing capabilities of millions of smartphones. The **second paper**, published in IEEE Journal on Selected Areas in Communications (JSAC), (vol. 31, no. 5, pp. 981-991, May 2013), provided a theoretical analysis of the fundamental EE-SE tradeoff in the context of video streaming over a MANET. The authors proposed an energy-spectrum-aware scheduling (ESAS scheme, which outperforms previous minimum-distortion video scheduling methods. This paper also derived an achievable EE-SE tradeoff range, and tight upper and lower bounds for the enery-spectrum efficiency index under various node velocities.

Regular Category

Topics like energy-awareness or "green computing" in general are becoming more and more attention within the multimedia communication research community. In this issue of the regular category, some paper are dedicated to this topic.

The **first paper**, published in *IEEE Transactions on Wireless Communication* and *edited by Koichi Adachi*, deals with energy- and content-aware scheduling for multi-homing video transmission within heterogeneous networks. That is, using multiple network interfaces within mobile terminals is becoming state-of-the-art, e.g., for video streaming, but impacts the power consumption which is discussed in this paper. The **second paper**, published in the proceedings of the *ACM Multimedia 2012* and *edited by Xin Li and Hao Hu*, presents GreenTube enabling power optimizations for mobile video streaming adopting dynamic cache management techniques. This could be seen complementary to the first paper in this issue.

The **third paper** is *edited by Carl James Debono* and comes from the *IEEE Transactions on Circuits and Systems for Video Technology*. It presents an adaptive algorithm for the intra prediction of the High-Efficiency Video Coding (HEVC) standard with reduced timing and signaling efforts. The **forth paper**, published in proceedings of the *IEEE ICIP 2013* and edited by *Jun Zhou*, proposes a method for the image noise reduction in both spatial and transform domains. The **fifth paper** comes from the *IEEE Transactions on Image Processing* and has also been edited by *Jun Zhou*. It proposes improvements for a 3D digital watermarking system with respect to perceptibility and robustness. Finally, the **sixth paper**, published in *IEEE Transactions on Multimedia*, describes a trusted framework for crowdsourcing multimedia Quality of Experience (QoE) evaluations.

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

Making Crowdsensing Possible

A short review for "Crowdsourcing to Smartphones: Incentive Mechanism Design for Mobile Phone Sensing"

Edited by Pavel Korshunov

D. Yang, G. Xue, X. Fang, and J. Tang, "Crowdsourcing to Smartphones: Incentive Mechanism Design for Mobile Phone Sensing," in Proceedings of ACM International Conference on Mobile Computing and Networking (MobiCom), pp. 173-184, 2012.

The number of smartphones in use globally has reached the 1-billion milestone in the third quarter of 2012. It is projected that this number will double by 2015 [1]. Meanwhile, smartphones are programmable and equipped with a set of cheap but powerful embedded sensors, such as accelerometer, digital compass, gyroscope, GPS, microphone, and camera. These sensors can collectively monitor a diverse range of human activities and surrounding environment. One can leverage millions of personal smartphones and a near-pervasive wireless network infrastructure to collect and analyze sensed data far beyond the scale of what was possible before, without the need to deploy thousands of static sensors. The term *crowdsensing* is coined specifically for this type of sensing paradigm [2].

Realizing the great potential of crowdsensing, many researchers have developed numerous applications and systems, such as Sensorly [3] for making cellular/WiFi network coverage maps, Nericell [4] and VTrack [5] for providing traffic information, PIER [6] for calculating personalized environmental impact and exposure, and Ear-Phone [7] for creating noise maps. However, most of such systems are based on voluntary participation, which is not a fair model of crowdsensing for the users providing the information.

When smartphone users participate in a crowdsensing task, they consume their own resources such as battery and computing power. The users also expose themselves to potential privacy threats by sharing their sensed data with embedded location tags. Therefore, an incentive-based model of crowdsensing would be fairer to the participating users.

In this paper, the authors consider two main types of incentive mechanisms for crowdsensing systems: platform-centric and user-centric. In a more conventional platform-centric incentive based system, the total payment is set by the platform and users can only choose their actions accordingly. In systems adapting the user-centric incentive mechanism, a user sets a reserve price, the lowest price at which he is willing to sell a service, and the platform selects a subset of users that it can afford to pay them not lower than the specified reserve price.
The paper presents important theoretical foundations for two incentive mechanisms under consideration, presenting proofs, algorithms, and approximations for optimal or near optimal behavior strategies of the platform and users. A set of desirable properties for such strategies is also provided with simulation experiments evaluating different parameters of the approximation algorithms.

Platform-centric incentive mechanism is modeled after Stackelberg game [8], and, hence, finding optimal strategies for the platform and the users is reduced to efficient algorithms for computing Stackelberg Equilibrium. The authors provide proofs and algorithms for the platform to efficiently, with complexity similar to sorting, compute an optimal value of the overall incentive. Similar, an optimal strategy for the users is provided, which maximizes their payment when a known overall incentive value is set by the platform.

For a user-centric incentive mechanism, the authors prove, using reverse auction model [9], that the problem of finding optimal strategy is NP-hard. Therefore, two approximation strategies are presented: Local Search-Based (LSB) and MSensing. Simulation experiments demonstrated that both strategies satisfy the following set of desirable properties: 1) computational efficiency: the platform is able to compute the outcome of the auction in polynomial time; 2) individual rationality: each honest participating user can expect a non-negative utility value; 3) profitability: the value contributed by the selected smartphone users is not less than the total payment paid to the winning users; and 4) truthfulness: each smartphone user maximizes its utility by reporting its true cost.

To summarize the overall contribution, the paper sets an important theoretical foundation for practical crowdsensing systems that want to utilize sensing capabilities of millions of smartphones. The authors consider platform-centric and user-centric models of incentive mechanism for motivating smartphones users to participate in crowdsensing. Necessary

algorithms and guidelines are provided that can help in designing efficient incentive-driven scalable crowdsensing applications.

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Optimizing Energy and Spectrum Efficiencies for Streaming Video over Mobile Ad Hoc Networks

A short review for "Energy-Spectrum Efficiency Tradeoff for Video Streaming over Mobile Ad Hoc Networks"

Edited by Wee Peng Tay

Liang Zhou, Rose Qingyang Hu, Yi Qian, and Hsiao-Hwa Chen, " Energy-Spectrum Efficiency Tradeoff for Video Streaming over Mobile Ad Hoc Networks", IEEE Journal on Selected Areas in Communications, vol. 31, no. 5, pp. 981-991, May 2013.

Mobile ad hoc networks (MANETs) have many applications in areas like environmental monitoring, transportation, and industrial operations. Many of these applications involve transmitting video streams and other multimedia content over the MANET. The nodes in the network are however often energy constrained so that energy efficiency (EE) is an important consideration when designing scheduling schemes for the MANET. Furthermore, spectrum for wireless communications is scarce, and spectrum efficiency (SE) is another important consideration in the design of MANET communications. However, it has been shown in [1] and [2] that there is a tradeoff between EE and SE, and scheduling schemes that achieves an optimal tradeoff while satisfying a given video stream quality requirement need to be designed.

Many works have investigated EE, SE, or a combination thereof in the framework of wireless communications. For example, optimal scheduling for image transmission to maximize EE is studied in [3], and [4] and [5] consider routing algorithms for wireless networks to improve the SE. Tradeoffs between EE and SE are investigated in [1], which also provides a scheduling scheme to optimize the energy consumption and end-to-end transmission rate in a multi-hop wireless network, while [2] considers the tradeoffs between EE and SE in an OFDM system. These works however, only consider static wireless networks. The authors of the reviewed paper argue that node mobility has an impact on the EE-SE tradeoff, as suggested by the works [6] and [7], which show that throughput can be enhanced in mobile networks. Indeed, simulation results show that as node velocities increase under a random mobility model, EE improves while SE deteriorates. There is therefore a need to characterize the relationship between EE and SE in a MANET.

The objective of this work is to provide a theoretical analysis of the fundamental EE-SE tradeoff in the context of video streaming over a MANET. Specifically, to describe a practical mobile scenario, a random walk mobility model is adopted in which each node randomly and independently selects its mobility direction and velocity at each time slot. The two main contributions of this work are the following: 1) It proposes an energy-spectrum-aware scheduling (ESAS) scheme, which outperforms the previous minimum-distortion video scheduling method on which ESAS is based, from the perspective of joint EE and SE performance. This is achieved by dynamically adjusting the transmission range according to node velocities, and choosing the best nodes as relays in the video transmission. In contrast, previous works only consider a static wireless network with a single source-destination pair, while this work studies multi-user wireless video transmission with random mobility velocity, which is obviously much more complicated. 2) It derives an achievable EE-SE tradeoff range, and tight upper and lower bounds for the energy-spectrum efficiency index under various node velocities. This work therefore provides fundamental insights to building an energy and spectrum efficient MANET.

The authors demonstrate the effectiveness of their proposed ESAS scheme by performing extensive simulations benchmarked against two other schemes for wireless video transmissions given in [3] and [8], which maximizes EE and minimizes distortion, respectively. It is shown that the proposed ESAS scheme outperforms the benchmarks in terms of joint EE-SE tradeoffs.

A future research direction is the extension of the analysis to more realistic heterogeneous mobility models that incorporate cooperative MIMO channel models [8]. Advanced signal processing techniques like error correction coding have also not been considered in this work, and are fruitful future research investigations into EE and SE improvements.

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Energy and Content Aware Scheduling for Multi-Homing Video Transmission

A short review for "Energy and Content Aware Multi-Homing Video Transmission in Heterogeneous Networks"

Edited by Koichi Adachi

M. Ismail, W. Zhuang, and S. Elhedhli, "Energy and Content Aware Multi-Homing Video Transmission in Heterogeneous Networks", IEEE Transactions on Wireless Communications, vol. 12, no. 7, pp. 3600-3610, Jul. 2013.

Mobile terminals (MTs) equipped with multiple radio interfaces enable *a multi-homing service* in a heterogeneous wireless access medium [10], [11], [12]. With multi-homing capabilities, MT can utilize all its radio interfaces simultaneously and aggregate the offered resources from different networks so as to support the same application with improved quality-of-service (QoS). An application of multi-homing service to video streaming, which has gained an increasing popularity, can improve service quality in many aspects [13], [14]. Sending video packets over multiple networks *(1)* increases the amount of aggregate bandwidth available to the application, *(2)* reduces the correlation between consecutive packet losses due to transmission errors or network congestion, and *(3)* allows for mobility support. It can reduce the probability of an outage when a communication link is lost with the current serving network as the user moves out of its coverage area.

A video packet scheduling algorithm for multi-homing service should be both content- and energy-aware in order to transmit the most valuable packets and drop the least valuable ones with limited battery capacity of the MT. The high energy consumption of using multiple radio interfaces of the MT may offset the benefits of multi-homing video transmission. Therefore, it is important how to exploit multiple radio interfaces efficiently while satisfying the battery/energy limitation. State-of-the-art works do not consider how to exploit the channel conditions and bandwidths at different networks to support uplink multi-homing video transmission with limited battery capacity. In this paper, the authors propose an energy- and content-aware video transmission framework using a multi-homing service in a heterogeneous wireless access medium.

A time slotted system is considered, where the MT makes a power allocation decision for each radio interface and packet scheduling decision at the beginning of each time slot. Firstly, the authors formulate the problem in order to minimize the video quality distortion under the MT energy constraint through optimizing the power allocation to each radio interface and packet scheduling/dropping. A piecewise linearization approach [15] is employed to relax the obtained mixed integer nonlinear programming (MINLP) which is then solved by the cutting plane algorithm. However, this solution requires a powerful optimization solver such as CPLEX [16] at the MT.

In order to alleviate the above requirement, a greedy algorithm with simple operation is considered by the authors. The original problem is decoupled into two sub-problems in order to obtain the performance close to the optimal solution. In the first sub-problem, the power allocation is optimized to maximize the achieved data rate, subjected to the MT battery energy limitation. This sub-problem is solved by Lagrangian dual approach, which is guaranteed to converge to the optimal solution. The packet scheduling considered in the second sub-problem is a new variant of the knapsack problem and is referred to as precedence-constrained multiple knapsack problem (PC-MKP). PC-MKP contains MKP [17], [18] as a special case, which is known to be NP-hard. This paper is the first work which studies the MKP with precedence constraints. The authors propose a greedy algorithm to solve PC-MLP in polynomial time [18]. The greedy algorithm sequentially tries *(1)* to find a feasible solution for the problem through assigning items (video packets) to different knapsacks (radio interfaces) while considering their precedence constraints and importance and *(2)* to improve the obtained feasible solution in the first part by considering the exchange of packed items (video packets) so that an additional item can be inserted. During the assignment, the root items (packets of I and P frames) have higher priority than the leaf items (packets of B frames) as they have higher distortion impact [19]. Each leaf item can be packed into the knapsack only if its root item is packed.

The numerical evaluation was conducted according to the parameters in [20], [21], [22]. The performance of the proposed greedy approach (GA) is compared with

the exact solution using the cutting plane approach (CPA), an energy-independent approach (EIA), and an earliest deadline first approach (EDFA) [20] with equal power allocation (EPA) [23]. The GA exhibit the performance very close to CPA in terms of the perceived video quality with fixed energy budget at the MT while the computational complexity burden is greatly reduced. The EDFA with EPA achieves lower performance than the content-aware approaches (CPA and GA) as it does not schedule packets according to their distortion impact. Furthermore, the proposed GA adapts its power allocation for each radio interface based on the channel condition for the interface, hence maximizing the achieved transmission capacity and the achieved video quality.

In current work, the energy budget is fixed per time slot. A further extension of this work includes the application to a variable energy budget per time slot, which depends on the current energy and the channel conditions.

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Using Dynamic Cache Management to Optimize Power Consumption for Mobile Video

A short review for "GreenTube: Power Optimization for Mobile Video Streaming via Dynamic Cache Management"

Edited by Xin Li and Hao Hu

Xin Li, Mian Dong, Zhan Ma, and Felix C.A. Fernandes. GreenTube: Power Optimization for Mobile Video Streaming via Dynamic Cache Management. In Proceedings of the 20th ACM international conference on Multimedia (MM '12), Nov. 2012

Power optimization for smartphones has drawn significant attention recently, especially with the rapid growth of mobile data usage for a large variety of multimedia applications, including games, music, videos, etc. The 3G/4G networks, such as HSPA, HSPA+, and LTE, offer users much faster mobile data access speeds and enable data-intensive applications such as HD video streaming. However, on the other hand, the wireless communications also impose a significant power cost on smartphones [1].

The goal is to make mobile video streaming more power efficient over 3G/4G networks. Not only is video streaming among the most popular smartphone apps according to recent studies [2] [3], but also its data-intensive nature indeed leads to extremely high power consumption. For example, the average power consumption by Galaxy Nexus is 2.3W to play a 720p video from HTTP streaming via Verizon LTE network according to the authors' measurement. As a result, a battery of full capacity (1850 mAh) can only support three hours of video streaming. Such prohibitively high power consumption severely hurts user experience.

In order to understand the characteristics of power consumption in mobile video streaming, the authors perform several controlled mobile video streaming experiments and obtain the power trace. The analysis reveals that a significant amount of power is consumed due to the conflict between the video streaming support in state-of-the-art smartphone operating systems and the power control mechanism in 3G/4G networks. That is, the time interval between successive downloading sessions is too short for the radio to enter power saving mode, or idle state, defined in 3G/4G networks. As a result, the 3G/4G radio has to remain active throughout the video streaming session even if there is no downloading session going on.

The intuitive and straightforward solution for the problem is to use a large downloading cache which downloads all streaming data in one shot. The wireless radio will be active for the minimum possible time and the power consumption can be hugely reduced. This approach will work if the user chooses to watch through the whole video. However, according to the authors' study, 80% of YouTube sessions in smartphones are less than half of the corresponding video durations. As a result, downloading the whole video will lead to waste in both data usage and power.

Pioneer research works on WiFi power optimization [4][5] have proposed to reshape the wireless traffic and create sufficient long periods for WiFi radios to enter power saving mode. Directly using this approach, however, does not work for 3G/4G networks because the 3G/4G radios, unlike their WiFi counterparts, simply cannot enter power saving mode immediately after traffic ends as defined in 3G/4G standards. Instead, they need to wait for a fairly long period, e.g., 10 seconds in Verizon LTE network, before entering power saving mode. The length of such period is comparable to that of each downloading session. Therefore, it requires judicious scheduling of each downloading session to effectively reduce power consumption of 3G/4G radios.

In this paper, the authors present GreenTube, a system that optimizes power consumption for mobile video streaming by judiciously scheduling downloading activities to minimize unnecessary active period of 3G/4G radios. GreenTube achieves this via dynamically managing the downloading cache based on user viewing history and network condition. The authors implemented GreenTube on Android-based smartphones and experimental results show large power reductions of more than 70% (on the 3G/4G radio) and 40% (for the whole system).

In particular, GreenTube fetches a video file from the HTTP server in multiple downloading sessions and disconnects from the server after each downloading session ends. The starting and ending time of each downloading session, except for the first and last one, is determined by cache size. GreenTube will adaptively adjust the cache size according to user viewing history and real-time network condition. The cache upper limit is calculated at certain frequency and corresponds to minimal energy consumption assuming that the user will stop viewing at some expected time.

Promising power improvements provide confidence that GreenTube is an important step towards energy-efficient mobile video streaming via 3G/4G networks. Following this research direction, future work includes the extension of this framework for cross platform support and fine-grained mobile client feedback based power control mechanism through wireless communication protocols.

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Reducing Intra Prediction Time and Signaling in HEVC

A short review for "Novel Adaptive Algorithm for Intra Prediction with Compromised Modes Skipping and Signaling Process in HEVC"

Edited by Carl James Debono

L.-L. Wang, and W.-C. Siu, "Novel Adaptive Algorithm for Intra Prediction with Compromised Modes Skipping and Signaling Process in HEVC," IEEE Transactions on Circuits and Systems for Video Technology, vol. 23, no. 10, pp. 1686-1694, October 2013.

The High Efficiency Video Coding (HEVC) standard has been developed as a joint project by the International Telecommunication Union – Telecommunication standardization sector (ITU-T) Video Coding Experts Group (VCEG) and the International Organization for Standardization/ International Electrotechnical Commission (ISO/IEC) Moving Picture Experts Group (MPEG). This collaborative team of experts is known as Joint Collaborative Team on Video Coding (JCT-VC) [1]. The aim of this standard is to significantly improve the compression efficiency of the video codec compared to currently available standards. In particular, this new standard targets bit-rate reductions of the order of 50% less than the H.264/AVC (Advanced Video Coding) standard for the same perceptual video quality [2]. This improvement can be exploited to either transmit better quality video with higher definition or for better use of the available bandwidth in bandwidth-limited environments.

The work presented in the paper being reviewed deals with intra coding. HEVC has a block-based intra prediction structure similar to H.264/AVC and this coding scheme exploits spatial redundancy within regions of an image which allows reconstruction at the receiver through prediction from a reference block. Intra coding is improved in HEVC by supporting 35 luminance intra prediction modes compared to the 9 available in H.264/AVC [3]. Moreover, the prediction has a choice of Prediction Units (PU) sizes which range from 4×4 to 64×64 pixels. This large set of possibilities allows better representations of complex structures and result in much more accurate predictions. The end result is a substantial improvement in its coding efficiency compared to H.264/AVC. However, this enhancement comes at a price, where the codec has to iteratively go through all the modes to find the best representation. Furthermore, the use of different PUs demands its signaling to the receiver to identify the index used, adding transmission overhead. To eliminate some of this complexity, a Rough Mode Decision (RMD) [4] can be used during Rate Distortion Optimization (RDO) [5] and has been implemented in the HEVC test Model (HM) [6]. The Residual Quad-Tree (RQT) is then used to select the optimal transform structure. Several research work, such as [7][8], has been done to reduce either the coding complexity or improve the rate distortion optimization.

To simplify the intra coding process, the authors of the paper propose an adaptive mode skipping algorithm for mode decision and signaling processing. It must be noted that the smoothness of the referred sample values is an important factor for the mode selection of the current PU. For example, if all referred samples have the same or similar values, the resulting 35 predicted PUs are always the same or quite similar no matter what the prediction mode is. In such a case only one mode needs to be checked for the current PU. According to this observation, three candidate sets with 1, 19 and 35 modes are specified for the Intra coding process and implemented in HM [6]. By analyzing the smoothness of the referred samples, the proposed algorithm adaptively selects the optimal one from the three candidate sets for each PU. Consequently, the intra mode selection process can be speeded up due to less number of modes involved when the sets with 1 and 19 modes are selected. Furthermore, the bits assigned to signal the mode index can also be reduced in the case of 1 or 19 candidate modes. At the decoder side, the referred samples have to be reconstructed before the current PU is decoded. Therefore, the same operation can be performed to adaptively determine which candidate set is used. With this technique there is no extra bit required to indicate the candidate set used at the encoder side.

The experimental results presented in the paper show that the proposed algorithm not only reduces the encoding complexity, but also achieves better rate distortion performance. In the conclusion, the authors point out that further improvement in terms of both rate distortion performance and encoding complexity should still be feasible by investigating adaptive

thresholds for different sizes of PUs. Furthermore, other feature descriptors, such as edge detector, could also be used to measure the smoothness of the referred samples. Moreover, the proposed algorithm has the potential to be integrated with other Intra related algorithms to make further improvements in both compression efficiency and encoding complexity.

The complexity of HEVC needs further attention to meet the stringent demands of low latency transmission and to make its implementation in limited processing environments, such as portable devices, feasible. Speeding up the decision making process during prediction and providing better rate distortion metrics to enhance quality are areas that are still open for further research. The coding efficiency demands will keep on growing as more and more multimedia applications appear in the market and new technologies are deployed. Therefore, the demand for low complexity and fast coding schemes will always be high.

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Image Noise Reduction in Both Spatial and Transform Domains

A short review for "Dual-domain image denoising"

Edited by Jun Zhou

Claude Knaus and Matthias Zwicker. "Dual-domain image denoising", Proceedings of the IEEE International Conference on Image Processing, 2013.

Noise reduction, or denoising, is an important research topic in image processing. Depending on which domain the algorithms are operated on, image denoising methods can be classified into spatial filtering and transform domain filtering approaches [1]. Spatial filters include mean filter, Wiener filter, median filter, and their variations. Transform domain filters can be divided into data adaptive or no-adaptive depending on the basis functions used. Typical examples are a wide range of wavelet domain filters, including soft thresholding method that has been proved to be very successful in fulfilling this task [2].

Methods from both domains have their pros and cons. The spatial domain filters remove high frequency noises but blur the edges. On the other hand, transform domain counterparts maintain details of images, but may generate artifacts in the images and are normally time consuming. A trend in the denoising research is to combine methods in both domains. For example, wavelet and bilateral filters have been hybridized to enhance the performance of noise reduction [3].

The ICIP 2013 award winning paper by Knaus and Zwicker follows the same rationale in algorithm design as [3]. The so-called dual domain image denoising method [4] combines the bilateral filter with short-time Fourier transform with wavelet shrinkage. The bilateral filter is first applied to the original image generate a high contrast layer, then the residual image forms the low contrast layer to be processed by the transform domain filter. The sum of the two filtered layers forms the reconstructed image which is an approximation of the original image.

In the first step, a joint bilateral kernel is defined over a square neighborhood at every pixel. This kernel is applied to both guide and noisy images in parallel. In the second step, the difference between the original images and the filtered images are multiplied with a bilateral kernel. The spatial Gaussian of the bilateral kernel is used as a window function, followed by a Discrete Fourier transform (DFT) to enable operation on the transformed frequency domain. Then shrinkage factors are applied to the image to retain the signal and remove the noise. Finally, an inverse DFT is applied to convert image back to the spatial domain.

The method in [5] is also a hybrid denoising approach. It first groups similar 2D image patches into 3D data array, then collaborating filtering is applied to transform the groups so that the noise can be attenuated by hard–thresholding. An inverse 3D transform is then applied to make blocks back to their original positions. This process is repeated to enable final estimate, however, using Wiener filtering instead of hard-thresholding. Compared with [5], the method proposed in [4] is easier to implement because only 2D filtering is required. Note that [3] also adopted similar steps as [4], however, it has not fully integrated the bilateral filter and DFT.

Several examples are given in this paper to show the effectiveness of the proposed method on both synthetic data and real images. The performance of this approach is very close to that of [5] in terms of signal to noise ratio. One concern is on the efficiency of this approach because domain transformation is quite time consuming. This paper shows that this problem can be alleviated by using parallel computing techniques.

In summary, this paper has introduced an effective noise reduction method. It is easy to implement and has shown excellent performance compared with the state-of-the-art approaches. It is expected that more methods following the similar idea of combining dual domain filtering will be developed in the near future.

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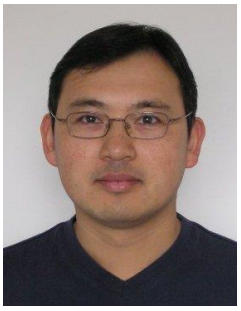

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Towards Imperceptible and Robust 3D Digital Watermarking

A short review for "Optimized 3D watermarking for minimal surface distortion"

Edited by Jun Zhou

Adrian G Bors, and Ming Luo "Optimized 3D watermarking for minimal surface distortion", IEEE Transactions on Image Processing, Vol. 22, No. 5, pages 1822-1835, 2013.

Digital watermarking is a technique for copyright protection of multimedia data. It embeds markers, which normally contain copyright or licensing information, into digital multimedia materials. With its success in image, video and audio applications, digital watermarking has also been introduced for 3D models [1][2].

A digital watermarking system consists of two main steps [3]. The first step uses an algorithm to convert a message into a signal that can be inserted into a carrier signal. Note that the watermarked digital signal may be modified, i.e., attacked, due to data compression, filtering, or other changes made during the data storage and transmission stage. Then the second step employees an algorithm to extract or detect the watermark from the modified signals.

Three properties need to be considered during the development of digital watermarking systems. The first property is the perceptibility of the digital watermark. It is desirable that the differences between the original signal and the watermarked signal are very close to each other, especially under visual inspection. This requires low distortion of the original signal. The second one is the robustness. This determines whether a watermark is still detectable after modifications of the embedded signals. The last property is the capacity, i.e., how much information can be embedded into the watermarked system.

The paper written by Bors and Luo addresses how to improve the first two properties of a 3D digital watermarking system. The goal is to preserve the shape of 3D surfaces in the watermarking, while allowing robustness to common mesh attacks. Minimizing the total distortion after displacement by watermarking enforces the surface preservation.

This paper starts from the definition of statistical watermarking of mesh-based representation of 3D objects. One of the key parameter to be estimated in this representation is the object center location which is calculated as the weights sum of the surface vertices, where the weight for a vertex is determined by the area of all triangular faces containing the vertex. Then the vertices are grouped in to several sets according to their distances to the object center. This step generates a statistical variable that stores the number of vertices located in an identical range of distances from the object center.

Once the statistical representation is ready, a histogram mapping function can be used to embed a message bit into a bin containing a set of vertex norms. Two embedding methods are introduced in this paper, which are based on the expected mean value and the expected variance of the statistical variable, respectively. These two embedding methods also correspond to two watermark extraction algorithms.

The second part of this paper describes a method to minimize the surface errors caused by the watermarking. The total surface distortion is defined by a cost function with three components. The first component is the metric to calculate the squared distance from the watermarked vertices to the original surface. The second component is defined for measuring the distance of the watermarked vertex to the updated surface. This component is defined to allow smooth object surface after watermarking. The last component measures the Euclidean distance between the watermarked and the original vertex location, i.e., the vertex displacement. In order to displace a vertex such that it minimizes the total surface error, an iterative method based on the Levenberg-Marquardt optimization [4][5] is adopted, which leads to the final watermarked 3D models.

An analysis on watermark security is also given in this paper. When the watermark system is constructed with only one parameter, that is, the parameter defined for outlier removal in the statistical variable generation step, the value of

this parameter can be guessed in a small number of trials if the watermark system is known to a crypto-attacker. This implies that more parameters shall be introduced in the statistical representation of the watermarking step in order to construct highly secure watermarking system.

Several variations of the proposed method have been evaluated on commonly used 3D objects. The experimental results show that the error minimization step can effectively reduce the surface distortion. The robustness of this method has been verified on common mesh attacks. In summary, this is an interesting paper on 3D watermarking. The proposed method seems to be practical, and can be promising for a variety of applications in information security and copyright protection.

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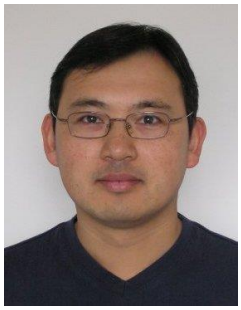

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Toward Cheap, Fast QoE Evaluation of Videos on Any Device

A short review for "Crowdsourcing Multimedia QoE Evaluation: A Trusted Framework"

Edited by Gwendal Simon

Chen-Chi Wu, Kuan-Ta Chel, Yu-Chun Chang and Chin-Laung Lei, "Crowdsourcing Multimedia QoE Evaluation: A Trusted Framework", IEEE Transactions on Multimedia, vol. 15, no. 5, pp. 1121-1137, July 2013.

Most researchers in the multimedia community, especially multimedia systems, ultimately aim at improving the Quality of Experience (QoE) of video consumers. QoE is not only an academic obsession but also a key business lever, which drives many moves from economic actors. When new delivery strategies or new technologies have to be evaluated, the only metric that really matters is the QoE. In other words, QoE evaluation is a crucial topic, which is unsurprisingly studied for years.

I have however the feeling that subjective evaluation of QoE has become more challenging over the last decade. First the range of video "types" is broader. From game streams to unstabilized user-generated videos via 3D half-synthetic blockbuster, videos can differ a lot. Consequently subjective QoE evaluation over a so wide range of videos requires both more time and more representative videos. Second, the set of resolutions and bit-rates for videos are also growing. To deal with the more heterogeneous population of video consumers, content providers can now deliver videos from 224p at 100 kbps to 4k at 10Mbps. QoE evaluation of such wide range of possible videos requires both more time and more devices. Third, large-scale QoE evaluation in a lab is expensive. It is an expense that is always hard to justify during crisis and budget cuts.

The multimedia community needs new techniques to evaluate video QoE. More generally, we need *scalable* QoE evaluation techniques because we actually need to evaluate a lot of videos. And we need these new techniques to be *cheaper*. This paper falls right in time with regard to this demand.

In this paper the authors present a framework for a crowdsourced QoE evaluation. The general idea is to implement paired comparison of videos in a simple online tool, which can thus be broadly run by any people anywhere. I found this idea quite brilliant, even if others before the authors thought about it (in different domains though).

This paper is the last one of a series of publications from the same team about that topic. Readers can feel that authors actually master the topic. The bibliography is comprehensive and does not elude the fact that the literature is abundant in the topics of QoE evaluation, of crowdsourcing and of paired comparison. In my opinion, this reinforces the interest for the paper because the main contributions are emphasized.

In this paper, authors focus on the reliability of their approach vis-à-vis cheaters. Anybody having dealt with systems based on crowdsourcing knows that getting rid of bad results from those who either intentionally or carelessly gave wrong answers is difficult. It is at the point that trust should be part of the initial design of any crowdsourcing mechanism.

The technique that is presented in the paper is again not a revolution, but it is simple to implement and efficient. Credits can be given to authors for preserving the simplicity of their original crowdsourced QoE evaluation tool while introducing a mechanism that should make their framework trustworthy.

Since the paper does not include any stellar theoretical results, readers are awaiting an extensive evaluation based on real measurements and experiments. In my opinion, what is shown in the paper meets this demand. A long part of the paper is about the evaluation of the framework, highlighting that a crowdsourcing tool based on paired comparisons and featuring cheat detection mechanism succeeds in obtaining video QoE evaluation results that are actually very close to the QoE results obtained in a lab.

In my opinion, this paper opens interesting perspectives for multimedia researchers. Not the kind of perspectives when a brand new approach or technique appears. This paper will never be called seminal. However this paper offers the community a tool that has the potential to be part of every multimedia researcher in the near future. Instead of relying on flawed objective QoE evaluation, researchers have here an approach to obtain trustworthy subjective QoE results in a shorter delay, in a cheaper way, and on a wider scale (population, video, device).

Gwendal Simon is Associate Professor at Telecom Bretagne. He received his Master Degree in Computer Science in 2000 and his PhD degree in Computer Science in December 2004 from University of Rennes 1 (France). From 2001 to 2006 he was a researcher at Orange Labs, where he worked on peer-to-peer networks and social media innovations. Since 2006, he has been Associate Professor at Telecom Bretagne, a graduate engineering school within the Institut Mines-Telecom. He has been a visiting researcher at University of Waterloo from September 2011 to September 2012. His research interests include large-scale networks, distributed systems, optimization problems and video delivery systems.

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