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MMTC Communications – Review

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Message from the Review Board Directors

Welcome to the June 2018 issue of the IEEE ComSoc MMTC Communications – Review.

This issue comprises four reviews that cover multiple facets of multimedia communication research including video distribution over D2D network, visual balance, multimedia content delivery over challenged networks and image reflection suppression. These reviews are briefly introduced below.

The first paper, published in IEEE Transactions on Mutimedia and edited by Qing Yang, investigated how to encourage mobile users to help each other on delivering video contents over D2D communications.

The second paper is published in IEEE Transactions on Multimedia and edited by Dr. D. It proposed to use graph-based spring-electric system to model the complex combination of balance in color, size, and shape of visual elements, to achieve better visual balance.

The third paper, published in IEEE Transactions on Multimedia and edited by Roger Zimmermann, investigates how to achieve reliable multimedia content dissemination in challenged mobile networks.

The fourth paper, published in IEEE Conference on Computer Vision and Pattern Recognition and edited by Jun Zhou studies the approach to remove reflections when taking photo through a window.

All the authors, nominators, reviewers, editors, and others who contribute to the release of this issue deserve appreciation with thanks.

IEEE ComSoc MMTC Communications – Review Directors

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An Incentive Mechanism for Device-to-Device Video Distribution

A short review for "Social Attribute Aware Incentive Mechanism for Device-to-Device Video Distribution"

Edited by Qing Yang

D. Wu. J. Yan, H. Wang, D. Wu and R. Wang, " Social Attribute Aware Incentive Mechanism for Device-to-Device Video Distribution," IEEE Transactions on Multimedia, vol. 19, vo. 8, Aug. 2017.

Due to the limited radio spectrum resources of cellular communication systems, the ever-growing number of users and user demands for mobile video services consequently cause severe base station (BS) load. To offload the heavy BS traffic load, device to-device (D2D) communication, as one of the most indispensable technologies of the future cellular networks, can be potentially exploited by mobile users to distribute videos for a BS [1]. In particular, in many network scenarios where certain videos are repeatedly and frequently requested, multicast transmissions can be employed to enhance the video delivery efficiency by selectively forwarding video and avoiding unnecessary transmissions [2].

However, the multicast video transmissions can be affected by the users' selfish behaviors which are mainly due to the objective reasons such as the device malfunctions and insufficient buffer and energy, and the subjective reasons such as the privacy, social relationship [3], social interest of Internet video sharing [4], [5], trust issues [6], [7] and active degrees. The exiting research works rarely considered multicast user selection strategies for mobile network scenarios with the incentive mechanism to reduce selfish behaviors by D2D multicast manner. Therefore, an incentive mechanism should be designed to encourage selfish users to reduce their selfish behaviors, by which the benefits of the BS and users can be both maximized.

In this paper, a master-slave video distribution structure is proposed in this paper, which consists of a BS (i.e., leader) as the video services provider, and some core users (i.e., core users) as video distributors and some requesting users as video buyers. This "supply-chain" of video services should comprehensively consider users' mobility and social characteristics so that the connection stability of the requesting users and the core users are derived by measuring the user stay probability and familiarity between users. As mentioned above, the core users, after receiving the multicast videos from the BS, will distribute videos to the multicast users through intra-cluster D2D multicast. In particular, intra-cluster D2D multicast communication is applied to allow one representative user to provide a multicast services to multiple users who have the same video requirements. Besides, to achieve the active participation of the core users in the video distribution, the Stackelberg game model is employed in this paper to maximize the benefits between the BS and the core users and motivate the core users to distribute videos for the BS.

Thus, the authors' major contribution is to propose an incentive mechanism of forming a master-slave structure is proposed in this paper to reduce selfish behaviors of core users and maximize the benefits between the BS and the core users. The Stackelberg game model is employed to dynamically price the video services, effectively motivate core users and enhance the system resource utilization.

To satisfy the QoS requirement of requesting users, two different video transmission manners should be applied for different users: the direct communication with the BS and the core user assisted communication. Due to the mobility and social attributes of users, some users in a given cluster may have short stay time and cannot establish a stable link with core users. As a result, users who fail to receive the videos from core users have to reestablish the communication link with the BS, which wastes network resource and increases transmission delay. To avoid the frequent interrupt of communication links caused by user mobility during the core user assisted communication, multicast users' selection should meet the stability requirements in each intra-cluster. In addition, the infrequent encounter between core users and other users may determine the level of willingness to forward data. Therefore, proper core users are selected in this paper to achieve improved intra-cluster video

transmission efficiency transmission according to the familiarity between user and other users in a given cluster.

Furthermore, the Stackelberg game-based pricing mechanism is proposed in this paper. The Stackelberg game consists of two game sides, namely the leader and the follower. In the considered network scenario, the BS serves as the provider of video, namely the leader in the game model and the core users serve as the distributors for videos, namely the follower in the game model. The BS firstly determines the initial price and sends it to the core users, and then the core users give their strategies to the BS. Through multiple negotiations and adjustments, the balance of the maximum benefits between the BS and the core users can be finally achieved.

Extensive experiments demonstrate the improved performance of the proposed solutions. Simulation results show that the proposed mechanism can achieve better performance for both video distribution and load balance. Compared with other existing schemes, the proposed solution can achieve the highest average quality peak signal-to-noise ratio (PSNR) and video frame rate.

In summary, the proposed Stackelberg game-based pricing mechanism is demonstrated to achieve the optimal benefit balance between core users and the BS through a negotiation. Core users are motivated to perform video distribution and further reduce the transmission load of the BS.

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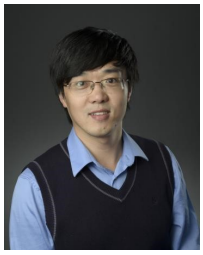

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Visual Arts Inspired Aesthetic Quality for Photography Recommendation

A short review for "A Spring-Electric Graph Model for Socialized Group Photography"

Edited by Debashis Sen

Y. S. Rawat, M. Song and M. S. Kankanhalli, "A Spring-Electric Graph Model for Socialized Group Photography", IEEE Transactions on Multimedia, Vol. 20(3), pp.754-766, 2018.

When elements within a work of art are arranged in a balanced compositional way, it is considered aesthetically pleasing to humans [1]. Photographers capturing scenes as images also intend to make them aesthetically pleasing by arranging the pictorial elements in a way that the picture feels visually balanced [2], [3]. Hence, visual balance is an important aspect of an image which indicates its aesthetic quality [4][5]. Visual balance is represented by a complex combination of balance in color, size, shape, etc., of visual elements. Among them, color energy is an attribute which is often used by artists to obtain visual balance. Color energy of a visual element measures the relative aesthetic impact of a color on a viewer [3].

The complex combination of balance in different attributes of visual elements has been studied as interplay between virtual forces among the visual elements in drawing aesthetic planar graphs [6]–[8]. This interplay of forces in structuring a two-dimensional visual field is also considered important in the field of visual arts [3]. A graph-based spring-electric system, where balance is achieved by balancing mechanical and electric forces acting of the graph's node, has been considered to simulate the complex combination leading to visual balance.

The authors have drawn inspiration from the use of graph-based spring-electric system in modeling the complex combination leading to visual balance and the concept of color energy playing an important role in visual balance. They have modified the spring-electric graph model by embedding color energy to obtain framework for visual balance. They intend this work inspired from visual arts to be useful in a wide range of computational media aesthetics applications.

The authors express color energy through linear combination of three quantities: (1) hue, saturation and brightness attributes of a color; (2) size of the colored area; and (3) relative contrast between foreground and the background colors. They then deduce the following three criteria for optimizing the spring-electric graph model to achieve visual balance:

1. High color energy visual elements should not be close to each other.
2. High color energy visual elements should be close to low color energy elements.
3. For a balanced composition the overall color energy should be balanced at the center of the layout.

The spring-electric graph model is modified by embedding color energy into graph nodes. Color energy is applied to determine the magnitude of forces acting on the nodes. In graph-based system obtained, high energy nodes repel each other with a greater force and nodes with high energy attract the nodes with low energy. The graph is optimized by minimizing a function of color energy using a force directed placement method to achieve optimal visual balance.

The authors apply the spring-electric model embedded with color energy in real-time photography assistance. Group photography, where multiple people are present in an image with a scenic view in the background is mainly considered. Multiple parameters affect the aesthetic quality of images captured in group photography. Some of the factors include arrangement of people, their position and distance from the camera. Professional photographers use their experience and knowledge to visualize how the visual elements in image frame could be better arranged, sized or positioned.

The authors using their spring-electric model along with color energy provide a strategy to generate real-time recommendation for users so that a visually balanced group photograph can be captured that is of high aesthetic quality. Their method makes use of social media images to estimate an initial position, where a group of people should stand, and their relative sizes in the photograph. The estimated position and size of the people are further optimized and their arrangement is determined. They also provide a

computation time analysis which reveals that their algorithm implemented using python code takes around 1.5 sec to analyze an image. The authors also develop a mobile application in Android platform implementing their group photography recommendation using a cloud based system.

Qualitative experiments along with user studies were conducted to evaluate the novel method of obtaining visual balance for aesthetic quality. Experimental results and user studies showed the effectiveness of the proposed model in obtaining aesthetic quality. It was also found that the recommendation algorithm can provide effective real-time feedback to the user regarding arrangement of people, their position on image frame and relative size. It was suggested that the concept of spring-electric graph modeling can be further explored by considering additional aesthetic principles such as shape, texture, etc., and can possibly be used for a variety of other applications in computational media aesthetics.

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Multimedia Content Dissemination in Challenged Mobile Networks

A review for "Disseminating Multi-layer Multimedia Content over Challenged Networks"
(Edited by Roger Zimmermann)

Hua-Jun Hong, Tarek El-Ganainy, Cheng-Hsin Hsu, Khaled A. Harras, Mohamed Hefeeda, "Disseminating Multi-layer Multimedia Content over Challenged Networks", IEEE Transactions on Multimedia, vol. 20, no.2, pp. 345–360, Feb. 2018.

The authors consider the case of multimedia content delivery to mobile devices in situations where an Internet connection may not always exist and where a user may not even subscribe to a data plan. Quite often researchers are most familiar with regions and countries where Internet connectivity is ubiquitous and always available, however, that is still not the case in many low-resource settings (e.g., underdeveloped countries). Hence it is refreshing to see that the proposed algorithms and system called mBridge are specifically designed to operate in *challenged networks* [1] which suffer from frequent link downs, long queueing delays, high dynamics, and scarce resources. As such, this study provides an important contribution to overcome the digital divide that still exists among various populations around the globe.

In the mBridge system the authors propose to deliver multimedia content in different representations with increasing quality, namely text, audio, 240p, 360p, and 480p videos, which require from fewer to more resources (i.e., disk space, battery energy), but it is also assumed that the higher representations provide a better user experience. In order to gain a better understanding of how the representations translate to a corresponding user experience the authors first performed a crowdsourcing user study which revealed that there is an increase in user satisfaction when a news report is transmitted starting from text, to audio, to video, but that there is a diminishing return.

The authors assume an environment where content is delivered to various proxies which offer WiFi connectivity within a certain range. Users, as part of their daily activities, will come in contact with these proxies and are thus able to acquire multimedia content. Furthermore, users may come in contact with other users and then be able to pass on content in an opportunistic ad-hoc manner. Given this environment, the proposed mBridge system consists of three components, namely the content matcher, the contact predictor, and the distribution planning algorithm. The content matcher collects user interests and provides a matching with the available multimedia content. The contact predictor tries to estimate when and for how long two users or a user and a distribution proxy will be in contact. For these first two components the authors use existing techniques and algorithms. The main focus of the authors' work is on the distribution planning which is formulated as a an optimization problem that considers various constraints such as maximizing the expected overall user experience, ensuring that contact durations are long enough for data transfers, ensuring that disk budgets are not exceeded, etc. With this formulation the problem is shown to be equivalent to a Multiple Knapsack Problem (MKP), which is NP-Complete in its complexity. The authors then provide two solutions: (i) a dynamic programming (DP) based algorithm that is able to compute an optimal solution but becomes computationally infeasible at larger problem scales, and (ii) an efficient heuristic algorithm, called Contact-Driven Round Robin (CDRR), which is shown to be much faster as it can be executed in polynomial time. Since CDRR is not guaranteed to be optimal the authors investigate its accuracy and find that it achieves at least 93% of the user experience compared to DP, and therefore that it is an excellent compromise of speed versus accuracy.

In the extensive evaluation of mBridge the authors first start with trace-driven simulations. They utilize three quite diverse contact datasets that they call GeoLife [2], San Francisco [3], and SIGCOMM [4]. These datasets are all quite different in the number of contacts per day and the contact durations. Hence, they ensure diverse evaluation settings. The authors also use various other datasets to provide, for example, the keywords that are used for user preference matching and to provide the news data sources, etc. Overall all the experiments are very well designed with all the parameters and datasets well justified and appropriately referenced. The authors compare their CDRR algorithm with two other algorithms, namely Epidemic which transmits all the media units when a contact occurs and CSI that sends the units of interested multimedia content to mobile users based on mobile similarity. The first experiments are performed under unlimited resource conditions and the authors show that CDRR is near-optimal, even in this scenario for which it is not

explicitly designed. The authors then go on to show that CDRR can improve the service quality and that it is in fact resource efficient, by at least 39% over Epidemic and CSI.

As a significant additional evaluation, the authors also present results from a real implementation of mBridge. They utilized Raspberry PI devices to implement the local proxies and smartphones loaded with their developed mBridge Android app. Experiments were conducted in three different rural villages and a city (on the authors' university campus). The results show that even in such practical settings when one usually would expect a slight drop in performance due to all manner of real-world overheads, the proposed CDRR algorithm still consistently outperforms Epidemic and CSI by significant margins for user experience, disk and energy efficiency, in the range of 42% up to 349%.

Overall the proposed framework and system is very interesting and is applicable in settings that are less often considered in mainstream research. The results of mBridge demonstrate that such systems are very feasible and could have a significant impact in this world.

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Reducing Reflection in An Image Taken Through A Glass Window

A short review for "Single Image Reflection Suppression"

Edited by Jun Zhou

Nikolaos Arvanitopoulos, Radhakrishna Achanta and Sabine Susstrunk, "Single Image Reflection Suppression," The IEEE Conference on Computer Vision and Pattern Recognition, pages 1752-1760, 2017.

Capturing photos through glass windows requires some skills. It is probably a common experience for many people that reflection artefacts appear in the photos taken by a mobile phone or a digital SLR camera. Removing the reflection is not a trivial task, no matter doing it manually using an image-editing tool, or exploring automatic image recovery solutions.

Automatic reflection removal or suppression is an active research topic. The main idea is to separate an image into transmission and reflection layers. When multiple images on the same scene are available, this task can be tackled by building physical reflection models on polarization [1] or flash images [2]. Extended to video data, the motion difference between the transmission and reflection layers can be effectively estimated [3].

The challenge comes from the cases when only a single image is available which often happens in the real world. The difficulty lies in that both transmission and reflection layers have to be estimated from a single image, making it an ill-posed problem. A solution to this problem is adding priors or constraints to the objective function and solving it as an optimization problem [4,5]. However, the performance of existing methods still need to be improved in order to make these approaches useful. An attempt in this direction is using deep learning approaches such as conditional adversarial networks [6] to encode characteristics of images in the transmission layers.

This paper addresses the reflectance suppression problem with single image. The idea is to 1) add an sparsity prior on the gradient of the transmission layer, and 2) use a Laplacian fidelity term to constrain the difference between the input image and expected transmission layer.

The motivation for the first contribution of this paper comes from two observations. First, the camera normally focuses on the target objects that are further to the camera than the glass window. Therefore, reflection edges are normally not as prominent as the transmission edges, which can be modelled by applying a blurring kernel to the reflection layer. Second, human can easily distinguish reflectance with from the background, and perceive the continuity of the scene. This implies that a smoothing approach can be adopted to force the number of pixels with low gradient to be large. An option to implement this idea is adding an L0 prior to the gradient of the image.

Another consideration is that the smoothing operation leads to loss of high frequency details of the transmission layer. In order to retain such details in the reconstructed image, a Laplacian operation is applied to the original image and the transmission layer before calculating their difference to form the data fidelity term. This operation improve the consistency of structures between the original image and the output of the estimation. The final optimization problem is solved by alternatively minimizing the objective function over the gradient of image and the estimated transmission layer.

The authors demonstrated the effectiveness of the reported method on both synthetic and real-world data. On synthetic image, the influence of the reflection layer is controlled by a weight in the image generation. The method in this paper has clearly outperformed several alternative approaches with superior color reproduction and reflection suppression in both qualitative and quantitative evaluations. On real-world images, the proposed method also shows its effectiveness on the suppression task.

In summary, the idea in this paper is based on the consideration that both smoothness and high frequency details have to be maintained in the reflection suppression. These are actually contradictory goals. The optimization scheme

enables finding the optimal balance between these two requirements.

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Paper Nomination Policy

Following the direction of MMTC, the Communications – Review platform aims at providing research exchange, which includes examining systems, applications, services and techniques where multiple media are used to deliver results. Multimedia includes, but is not restricted to, voice, video, image, music, data and executable code. The scope covers not only the underlying networking systems, but also visual, gesture, signal and other aspects of communication. Any HIGH QUALITY paper published in Communications Society journals/magazine, MMTC sponsored conferences, IEEE proceedings, or other distinguished journals/conferences within the last two years is eligible for nomination.

Nomination Procedure

Paper nominations have to be emailed to Review Board Directors: Pradeep K. Atrey (patrey@ albany.edu), Qing Yang (qing.yang@unt.edu), Wei Wang (wwang@mail.sdsu.edu), and Jun Wu (wujun@tongji.edu.cn). The nomination should include the complete reference of the paper, author information, a brief supporting statement (maximum one page) highlighting the contribution, the nominator information, and an electronic copy of the paper, when possible.

Review Process

Members of the IEEE MMTC Review Board will review each nominated paper. In order to avoid potential conflict of interest, guest editors external to the Board will review nominated papers co-authored by a Review Board member. The reviewers' names will be kept confidential. If two reviewers agree that the paper is of Review quality, a board editor will be assigned to complete the review (partially based on the nomination supporting document) for publication. The review result will be final (no multiple nomination of the same paper). Nominators external to the board will be acknowledged in the review.

Best Paper Award

Accepted papers in the Communications – Review are eligible for the Best Paper Award competition if they meet the election criteria (set by the MMTC Award Board). For more details, please refer to http://mmc.committees.comsoc. org/.

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