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Reviewer's opinion
on Ph.D. dissertation authored by

Jaroslaw Samelak

entitled:

Prediction Techniques for Compression of Multiview Video Acquired using Systems with Various Camera Arrangements

1. Problem and its impact

Importance. In his dissertation, the author addresses the limitations of existing prediction methods in multiview video compression and proposes several original contributions in this field. The domain of multiview video coding is of paramount importance in numerous applications, including VR/AR/XR, free viewpoint TV, immersive media, media broadcasting, healthcare, entertainment, etc.

Scientific contributions. I deem the scientific contributions to be important, as demonstrated by the numerous scientific publications (co-)authored by the candidate in well known journals, international conferences and contributions to MPEG. It is important to highlight the publication in IEEE Trans. on Multimedia, which is a leading journal in the field, with a high impact factor (6.51).

Practical relevance. The proposed ARC-HEVC method outperforms the 3D extension of the HEVC standard which is a standard method for multiview video encoding. The SCC and ASCC codecs proposed by the author were employed in MPEG's Immersive Video coding, replacing HEVC. The results demonstrate substantial objective and subjective improvements over the standard codecs. The improved performance and faster execution time of the proposed coding solutions recommend them for many applications that do not require standardized coding solutions. In addition, the candidate has promoted the results of his research in numerous contributions to the MPEG standardization activities, which demonstrates the practical relevance of his PhD work.

2. Contribution

Contributions: In a first contribution, the author investigates the limitations of the 3D-HEVC video coding standard and proposes a novel rectification method and a novel prediction method that improve the coding performance relative to the standard reference codec while reducing the coding time.
An important limitation of current solutions for multiview video coding is that the camera arrangements are assumed to be linear. The assumption of a linear camera arrangement adopted by 3D-HEVC enables complexity reduction for inter-view prediction. Existing inter-view prediction methods prove to be inefficient in camera arrangements other than linear. The fundamental contribution brought by the candidate in this field was to propose a novel inter-view prediction method based on point mapping in 3D which is generic and applicable for any camera arrangement. The

proposed ANY-HEVC codec substantially improves inter-view prediction for arbitrary non-linear camera arrangements at the expense of substantial increase of encoding time.

To reduce complexity, the author assumes a near-circular camera arrangement and proposes a novel circular rectification of a multiview video acquired by near-circular camera arrays. This enables the author to design a novel codec called ARC-HEVC which reduces rate compared to classical 3D-HEVC (average 6%), yields a substantially faster execution compared to ANY-HEVC (8.8% gain) and even to a faster execution compared to 3D-HEVC thanks to substantially improved inter-view prediction.

A second major contribution focuses on the design of novel methods for multiview video coding based on the screen content coding (SCC) extension of HEVC. The author groups multiple views in a single frame and proposes the use of the intra-block copy (IBC) mode from SCC for inter-view prediction. The proposed method yields substantial coding gains relative to HEVC Main profile in stereo- and multiview coding (20% rate gains compared to simulcast). In addition, the author demonstrates the practical applicability of the proposed HEVC SCC codec in immersive video coding while maintaining standard compatibility.

The author further investigates the idea of using SCC for multiview and immersive video and proposes a series of modifications with the scope of improving the coding efficiency. These include specific frame ordering, tile-based encoding, quarter-pel block matching, adjustment of the length of IBC vectors, in-loop filtering, ability to accommodate different QPs, and reference tile border extension. The impact of these tools on the coding efficiency is thoroughly assessed. The experiments demonstrate that the proposed ASCC codec incorporating these tools substantially improves the compression performance in multiview video relative to the standard-compliant SCC. The coding performance proves to be similar to that of multiview HEVC. The experiments also reveal that the proposed ASCC codec reduces bit rate and encoding time compared to the use of standard SCC in the test model for immersive video (TMIV).

In terms of publications, Jaroslaw Samelak is the (co-)author of one book chapter, two international journal papers, of which one in the exquisite *IEEE Trans. on Multimedia* journal, one national journal paper, 8 publications in international conference proceedings among which one remarks top conferences in the field, 14 contributions to MPEG, and 2 other (journal) papers under review.

3. Correctness

The author properly motivates the proposed ideas and carefully analyses the impact on coding performance and execution time of the proposed ideas. The experiments are carried out while carefully respecting the protocols in the scientific literature in the field of multiview and immersive video compression. The proposed methods are thoroughly benchmarked against the state of the art and the results are carefully analysed and interpreted. Overall, I do believe that the thesis gives a proper argumentation of the considered designs, follows a correct methodology and a rigorous mathematical formalism and draws correct conclusions regarding the impact of the proposed methods on compression performance and execution time.

4. Knowledge of the candidate

The candidate presents the context and scope of this dissertation in the introductory chapter which lists also the most important techniques in multiview video coding. Chapter 2 provides a somewhat short but to the point overview of the state of the art in multiview and 3D video coding, screen content

coding and immersive video coding. The methodology followed in order to assess the compression efficiency is detailed in section 3.3. The reference list comprises the most relevant papers in the field (papers that focus on modern machine-learning based solutions are not overviewed, but I do not find that a problem given the focus of the thesis on standard methods for multiview coding). These chapters confirm the general knowledge of the candidate in the discipline of Information and Communication Technology.

5. Other remarks[1]

I am not aware of the fine details of the PhD defence procedure at Poznan University, but I presume that the candidate will have to answer a set of questions during the defence. A detailed set of technical questions and remarks will be provided to the candidate and promoter prior to the PhD defence.

6. Conclusion

Taking into account what I have presented above and the requirements imposed by Article 13 of *the Act of 14 March 2003 of the Polish Parliament on the Academic Degrees and the Academic Title* (with amendments)[2], my evaluation of the dissertation according to the three basic criteria is the following:

A. Does the dissertation present an original solution to a scientific problem? (the selected option is marked with **X**)

[X]	[ ]	[ ]	[ ]	[ ]
Definitely YES	*Rather yes*	*Hard to say*	*Rather no*	*Definitely NO*

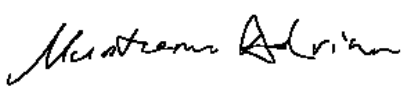
B. After reading the dissertation, would you agree that the candidate has general theoretical knowledge and understanding of the discipline of **Information and Communication Technology**, and particularly the area of **….**?

[X]	[ ]	[ ]	[ ]	[ ]
Definitely YES	*Rather yes*	*Hard to say*	*Rather no*	*Definitely NO*

C. Does the dissertation support the claim that the candidate is able to conduct scientific work?

[X]	[ ]	[ ]	[ ]	[ ]
Definitely YES	*Rather yes*	*Hard to say*	*Rather no*	*Definitely NO*

Moreover, taking into account ... I **recommend to distinguish** the dissertation for its quality[3].



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[1] Optional
[2] http://www.nauka.gov.pl/g2/oryginal/2013_05/b26ba540a5785d48bee41aec63403b2c.pdf
[3] Obviously, this sentence is optional.