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Reviewer's opinion
on Ph.D. dissertation authored by
Jarosław Samelak
entitled:
Prediction techniques for compression of multiview video acquired using systems with various camera arrangements

1. Problem and its impact

What is, in your opinion, the most important problem discussed in the dissertation?
The dissertation is devoted to novel techniques to be incorporated into multiview video compression systems. The need for compressing video data is a major challenge in modern multimedia systems. Currently, video data reaches up to 80% of data transmitted over global information networks. This burden to networks is particularly acute in the advent of ubiquitous expansion of virtual reality systems in which the video data is rendered form multiview systems. Thus, the main problem undertaken in the thesis is to develop effective methods for improvement of the inter-view prediction in compression of multiview video.

Is it a scientific one?
Yes, the problem is a scientific one. The study presented by the Author is at the forefront research concentrating on the developing systems for multiview video systems. The Author formulates two dissertation theses proposing novel, original compression techniques to be implemented in multiview video systems. The Author demonstrates the validity of both theses in the dissertation. The methods proposed are assessed through practical experimentation involving the compression of test sequences, followed by a comparison of outcomes against other encoders. Additionally, the adjustment of 3D-HEVC to suit circular camera setups is contrasted with its adaptation to various camera setups, as proposed by the Author of this thesis.

Does it have a practical meaning?
Yes, the undertaken problem has high potential practical meaning. Recently, multiview video has been applied in several advanced multimedia techniques such as: three-dimensional television (3DTV), free-viewpoint television (FTV), virtual reality (VR), augmented reality (AR), and immersive video. The condition for successful widespread development of these techniques is implementation of effective video compression techniques that make possible deployment of these multimedia techniques in systems affordable for the user.

2. Contribution

What is the main, original contribution of the dissertation?

The main and original contributions of the dissertation can be summarized as follows:

- Derivation of an original procedure for rectification of cameras in a circular arrangement, both for the intrinsic and extrinsic camera parameters.
- Proposition of a more efficient version of the 3D-HEVC codec, specifically designed to process circularly rectified 3D videos termed ARC-HEVC). The modifications include the formulas for mapping points between circularly rectified views, enabling the adaptation of Disparity Compensated Prediction and other inter-view prediction tools to work with circular camera arrangements. On average, the proposed codec achieves a 6% reduction in bitrate and more than a 4% decrease in encoding time compared to the standard 3D-HEVC,
- Adaptation of standard-compliant HEVC Screen Content Coding (SCC) for efficient compression of stereoscopic, multiview, and immersive videos; development of the proposed tool reveals significant bitrate reduction for stereoscopic video compression, with approximately 20% lower bitrate for All-Intra and 15% for Random Access, compared to the HEVC Main profile; improved quality of depth maps leads to significantly better synthesized virtual views, which is crucial for immersive video applications. The use of SCC as an internal MIV codec has been independently evaluated and accepted by the MPEG,
- Development of efficient modifications to the High-Efficiency Video Coding Scalable Extension (HEVC SCC) to enhance its compression performance for camera-captured multiview and immersive video. The proposed modifications indicate that SCC can match the efficiency of MV-HEVC while being marginally faster (around 5% faster for 3 views) at the same time.

The Author's main publications reporting the above achievements consist of one book chapter, two IF international journal articles, 8 presentations at international conferences and 14 at international standardization conferences. These are coauthored publications of which in 10 publications Jarosław Samelak is the first author. There are also two manuscripts in the process of publication.

3. Correctness

The Author of the thesis has formulated ambitious theses that he has proved by means of development of novel algorithms and techniques that were verified on experimental data and compared to the recently developed techniques.

Concerning the first thesis, the Author provides experimental findings that compare the compression performance of state-of-the-art techniques with ARC-HEVC for circularly rectified video. Additionally, these results are compared to those obtained using ANY-HEVC,

a non-standard codec co-authored by the Author of this dissertation, designed to accommodate arbitrary camera arrangements.

Regarding the second thesis, the Author introduces the concept of adapting standard-compliant Screen Content Coding (SCC) for compressing frame-compatible multiview video. In this approach, Intra Block Copy is utilized as an inter-view prediction, even though its original purpose was different. The Author works out a procedure for selecting the optimal view alignment and configuring other SCC tools to achieve the best results. The novel approach is applied in three applications: stereoscopic, multiview, and immersive video compression. The Author conducts an experimental evaluation of the proposed methods. The modified proposal is experimentally assessed and compared to state-of-the-art solutions.

It is difficult to find any weaknesses in the thesis. The Author's research methodology is well planned and organised. The order and depth of the presented scientific material is in accordance with the requirements of a doctoral thesis. The thesis contains an introduction to the subject, underlines the importance of the research challenges undertaken, contains sufficient and well-presented theoretical material with novel techniques proposed by the Author. An important part of the thesis is the experimental verification of the proposed algorithms, which after programming implementation have been experimentally verified on the large set of test video sequences. The dissertation contains an appendix that reports experimental results in tabular form, listing the parameters of compression multiview video and indicators of the techniques proposed by the Author, showing their advantages over other previously reported techniques.

The amount of work carried out is underlined by the Author, who states that the software created for the purposes of the thesis totals more than 9000 lines of code written in C+++ and Python.

4. Knowledge of the candidate

The candidate has demonstrated an in-depth knowledge of the topic of the dissertation in the field of multiview video systems, which fits firmly within the discipline of Information and Communication Technology. The first two chapters of the thesis contain a competent presentation of the scope of the thesis and cover the most important topics in the state of the art of video coding. The knowledge of the candidate is confirmed by his participation in numerous conferences gathering groups working on the development of standards in multiview video coding. This participation has been regular during the years 2016–2021.
The list of references is rich, counts more than 100 positions and contains the most recent publications on the topic of the dissertation.

5. Conclusion

Information and Communication Technology

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)[1], 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*

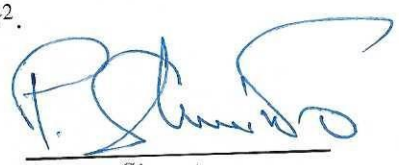
C. Does the dissertation support the claim that the candidate is able to conduct scientific work?

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

Moreover, considering that:

- the proposed modifications to inter-view prediction in 3D HEVC significantly improve compression efficiency, reducing both bitrate and coding time for circularly rectified multiview video compared to state-of-the-art 3D HEVC,
- the Author's proposed algorithms open up novel solutions for the next generation of video coding standards,
- the Author's achievements have been documented in IF journals and presented at international conferences,

I **recommend to distinguish** the dissertation for its quality[2].



Signature

[1] http://www.nauka.gov.pl/g2/oryginal/2013_05/b26ba540a5785d48bee41aec63403b2c.pdf

[2] Obviously, this sentence is optional.