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

Mateusz Lorkiewicz

entitled:

Block partitioning in video encoding with the use of artificial neural network

1. Problem and its impact

Importance. Video compression is of paramount importance in numerous applications, including media broadcasting, immersive media, video on demand, healthcare, entertainment, to name a few. In his dissertation, the author addresses the computational complexity of block partitioning methods used in video compression standards and proposes several original contributions in this field. I find this work to be important, (i) from scientific perspective, as it demonstrates that block partitioning can be learned using artificial neural networks (ANNs), and also (ii) from practical perspective, as it demonstrates that controlling the compression efficiency versus complexity trade-off is feasible with the proposed designs.

Scientific contributions. The author carefully addresses the performance-complexity trade-off in block partitioning and proposes original methods based on artificial neural networks that enable control of this trade-off. The scientific contributions brought by the candidate are important, as demonstrated by the numerous scientific publications, comprising an IEEE journal publication (impact factor 3.6), international conferences and contributions to MPEG.

Practical relevance. The research in this PhD thesis focuses on learning the block partitioning performed by video compression standards based on ANNs. The proposed methods enable an efficient encoder control, being highly relevant in practical applications. The results demonstrate that the proposed methods optimize the performance-complexity trade-off of block partitioning and outperform the state of the art. It is important to remark that the candidate has promoted the results of his work in numerous contributions to the MPEG standardization activities, which demonstrates the practical and industrial relevance of his PhD work.

2. Contribution

Thesis structure and contributions: The candidate presents the context and scope of this dissertation in the introductory chapter. Chapter 2 provides a thorough overview of the encoding backbone which is HEVC and a substantial state of the art overview of partitioning methods categorised into ANN- and non- ANN-based approaches. Chapter 3 outlines the research methodology, presenting the impact of video encoder modifications, the chosen test sequences, and the proposed encoding time versus compression efficiency metrics. Chapter 4 introduces the proposed partitioning algorithms, defines and specifies the ANN training procedures as well as the implementation in HEVC. Chapters 5 and 6 present

the Basic and Extended partitioning approaches respectively, including detailed ANN architectures and evaluation results. Chapter 7 focuses on decision algorithms, defining both hard-decisive and soft-decisive variants and evaluating their performance. It also introduces a method to control encoding time versus compression efficiency trade-off using a single parameter. Chapter 8 compares the best partitioning algorithms with state-of-the-art solutions. Chapter 9 explores experimental improvements of the Basic and Extended approaches, discusses ANN enhancements, and examines contextuality in HEVC encoding. Finally, Chapter 10 provides the dissertation summary and outlines directions for future research.

The thesis is essentially centered on two major research statements (or "theses" as the author names them). The first is that an ANN can be used to drive an encoder control algorithm and significantly reduce the computational complexity of the video encoder as compared to HEVC reference model encoder. This research statement is validated by practical design of ANN-based block partitioning. Two algorithms are proposed that demonstrate significant encoding time reduction at minimal penalty in rate. The second research statement is that equipping an ANN with a soft decision mechanism enables controlling the complexity vs performance trade-off using a single parameter. The proof of this statement is constructive. The author proposes soft variants of his algorithms and demonstrates improved performance compare to the state of the art while offering the ability to control the performance-complexity trade-off using a simple parameter. The author also proposes two metrics to quantify numerically and compare two partitioning algorithms.

In terms of publications, Mateusz Lorkiewicz is the (co-)author of one IEEE journal paper as first author, two national and three international conference publications, and 34 contributions to MPEG standardisation activities. I find of particular importance the proven ability of the candidate to contribute to the MPEG standardisation activities where the research group to which he belongs is very active.

3. Correctness

I find the PhD thesis to be well written and "stuffed" with a lot of content. The author provides strong arguments for the proposed ideas and conducts a detailed analysis of their effects on coding efficiency and execution time. The experimental setup adheres to established protocols in the video compression literature, ensuring scientific rigor. New metrics to quantify the encoding time versus compression efficiency trade-off are proposed. Comprehensive benchmarking against state-of-the-art methods is presented, with results carefully examined and clearly interpreted. Overall, the thesis demonstrates sound argumentation, a robust methodology expressed with accurate and detailed mathematical formalism, and well-founded conclusions on the impact of the proposed methods on compression efficiency and encoding time.

4. Knowledge of the candidate

The topics addressed in this PhD thesis are scientifically very challenging. The thesis is well structured, well-presented, scientifically solid, and it is pleasant to write. The research methodology is correct, well elaborated and presented. The experimental results are presented in detail and the results are properly interpreted .

Overall, the obtained results and publications demonstrate the general knowledge of the candidate in the discipline of Information and Communication Technology.

5. Other remarks[1]

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 the originality of this work and its practical relevance, the through experimentation, the obtained results that favour the proposed methods relative to the state of the art, as well as the scientific publications, I **recommend to distinguish** the dissertation for its quality[3].

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Signature

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