Conclusion on the content of the dissertation

Candidate's full name: Ibraheem Murooj Khalid Ibraheem

Dissertation title: "Improving the Efficiency of Video Transmission in Computer Networks Using Neural Network Coding"

Specialty: 2.3.5. Mathematical and Software Tools of Computing Systems, Complexes and Computer Networks

Scientific degree for which the dissertation is submitted: Candidate of Technical Sciences

Date of defense: 01.10.2025

Assessment of compliance of the dissertation with the requirements of the Regulation on the awarding of academic degree of candidate of science, doctor of science at MIPT (hereinafter referred to as Regulation):

1. Relevance of the dissertation topic

This dissertation addresses the growing challenge of delivering high-quality video over bandwidth-limited networks by enhancing the H.266/VVC compression standard. It integrates deep learning, particularly Residual DCNNs, to improve visual quality without significantly increasing bitrate.

The work builds upon foundational contributions in video coding and perceptual quality assessment by researchers like Sullivan and Taubman. Recent advances in AI-based compression, such as those from Google, underscore the relevance of this direction. By adapting these innovations, the research proposes a solution suited for modern video demands.

Several approaches are designed to be both scalable and efficient and to play a role in shaping the next generation of video transmission

2. Scientific novelty of the results submitted for defense

1. Proposed a new architecture that improves visual quality and reduces compression artifacts in H.266/VVC through in-loop and post-processing enhancement.
2. Integrated genetic algorithms to optimize encoder configurations and intra prediction partitions, accelerating the encoding process without sacrificing output quality.
3. Developed an adaptive distortion management technique that adjusts compression strategies based on scene complexity and content type.
4. Validated that AI-assisted coding approaches can achieve a practical trade-off between bitrate efficiency, visual fidelity, and computational cost.
5. Bridged traditional codec structures with deep learning, creating a hybrid framework that enhances coding performance using data-driven.

3. Theoretical and practical significance of the dissertation work

This dissertation holds both theoretical and practical significance by advancing the integration of deep learning and evolutionary algorithms into modern video compression systems. It introduces an innovative approach using Residual Deep Convolutional Neural Networks (RDCNNs) for in-loop filtering and artifact reduction within the H.266/VVC framework, alongside the application of genetic algorithms for optimizing intra coding decisions. Theoretically, it lays the groundwork for adaptive, content-aware encoding strategies that balance quality and computational efficiency. Practically, the proposed methods achieve notable improvements in encoding speed and bitrate reduction without compromising visual quality, making them highly applicable to real-time, bandwidth-sensitive applications such as video conferencing, surveillance, and high-definition streaming. These contributions address pressing demands for scalable and intelligent video delivery solutions in modern networks.

4. Reliability of the research results

The reliability of the research results is evidenced by consistent improvements across key video coding performance indicators, validating both the proposed model architecture and optimization strategies. The integration of the Residual Deep Convolutional Neural Network (Res-DCNN) within the H.266/VVC framework replaces traditional in-loop filters such as deblocking and SAO, leading to superior perceptual video quality and enhanced rate-distortion performance without increasing the bitrate. Extensive testing across diverse video sequences confirms that the model generalizes well, effectively reducing artifacts and preserving structural details. The dual-branch Unified Res-DCNN model further amplifies these gains, combining the strengths of two learning pathways to simultaneously enhance compression efficiency and visual fidelity.

In addition to perceptual improvements, the use of genetic algorithms for optimizing intra prediction and partitioning decisions contributes to a marked reduction in encoding complexity and computational load. These evolutionary techniques allow for adaptive coding decisions that respond dynamically to the spatial and temporal characteristics of video content. The experiments were carefully designed with consistent hyperparameter tuning, cross-sequence evaluation, and comparisons against established benchmarks. Altogether, the achieved outcomes are reproducible, statistically meaningful, and robust across a wide range of test scenarios—demonstrating the overall credibility and practical applicability of the proposed techniques in next-generation video compression pipelines.

5. Completeness of publication of the main dissertation results in peer-reviewed scientific publications in accordance with the requirements of the regulations and the positive aspects of the study

The main results of the dissertation have been extensively published in peer-reviewed scientific journals and conferences, including five articles indexed in Scopus, one in Web of Science, and two in RSCI, ensuring compliance with academic publication standards. The research findings, covering neural network-based video compression and H.266/VVC optimization, were validated through presentations and discussions at prestigious international conferences and workshops.

6. **Questions and remarks (in accordance with clause 8.5. (third paragraph) of the Regulations on the MIPT Dissertation Council, the applicant answers the questions and comments formulated below during the defense):**

1. Why do modern video compression standards like HEVC and VVC still exhibit perceptual or performance limitations? Could the author specify whether the gaps lie in visual artifacts (e.g., blurring), computational overhead, or suboptimal bitrate control?
2. Standard in-loop filters such as SAO and DBF are referenced. Which particular artifacts (e.g., edge distortion, ringing) persist despite these filters, and how does the proposed method address them?
3. Given the similarity in transform-based architectures, could the proposed RDCNN model be adapted to other emerging codecs like AV1 or EVC?
4. Statements such as "PSNR improved" appear without numeric context. Could the author consistently include quantified performance metrics (e.g., "+1.5 dB PSNR" or "12% bitrate reduction") to strengthen experimental claims and comparisons?

7. **General evaluation of the dissertation:**

This dissertation explores the integration of residual deep convolutional neural networks (RDCNNs) into the video coding pipeline, targeting the enhancement of in-loop filtering and overall coding efficiency. It reflects solid technical depth, notably in bridging classical transform coding with deep learning-based restoration. The use of RDCNN shows promise in addressing persistent issues like edge distortion and blocking artifacts. However, some experimental statements are presented without sufficient numeric backing, which could affect perceived rigor. Furthermore, generalization potential to other codecs (AV1, EVC) is not addressed in depth. Despite these minor gaps, the dissertation contributes a well-motivated and practically relevant improvement to perceptual quality in compressed video and demonstrates alignment with current research in intelligent codec design.

The dissertation complies with the requirements of the passport of the specialty 2.3.5. Mathematical and Software Tools of Computing Systems, Complexes and

Computer Networks, as well as the requirements of the Regulation on the awarding academic degree of candidate of sciences, doctor of sciences at MIPT.

Academic Degree: Doctor of Science, Associate Professor

Place of work: FRC CSC RAS

Position: Head of the Vision Systems Division

Name: Dmitry Petrovich Nikolaev

Date:<<15>> September 2025 Signature____________________

Р.В. РАЗУМЧИК
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