Information and Coding

Lab work nº 2

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Acronyms

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Chapter 1

Introduction

The main goal of this project is to explore data compression techniques by implementing custom codecs for audio, image, and video data. Compression is a key aspect of information and coding, enabling efficient storage and transmission of data. Each codec leverages specific properties of the data type to reduce size while maintaining integrity in lossless cases or balancing quality and compression in lossy scenarios. Our implementation focuses on creating efficient tools for bit-level manipulation and predictive encoding. This includes developing BitStream class for handling binary file operations, implementing Golomb coding for integer data compression, and applying predictive coding to audio and image files.

- **Context of the Project:** Efficient compression of multimedia data is crucial in applications like streaming, storage, and transmission.
- **General Objectives:** Explore techniques to minimize data size while maintaining acceptable quality.
- **Approach:** A combination of theoretical study and practical implementation of coding techniques, leveraging programming tools and libraries.

Chapter 2

Methodology

The project methodology focuses on implementing and testing custom codecs for different types of data: audio, image, and video. Each step involves using specific tools and algorithms tailored to the characteristics of the data that's being compressed. Below is a summary of the methods used for each type of data:

2.1 Implemented Methods and Classes

- **BitStream Class:** The BitStream class was developed as a fundamental tool to handle bit-level operations with efficiency and precision. It allows our main program to read and write bits from/to binary files and this class also groups bits into bytes during writing ensuring correct bit order during reading. This class serves as the "backbone" for subsequent coding techniques.
- **Golomb Coding:** This class implements the Golomb coding algorithm for efficient integer encoding. It is proper for encoding residuals in predictive coding tasks due to its adaptability and ability to optimize compression based on a parameter m. The class supports encoding and decoding, with configurable methods for handling negative values.
- **Predictive Coding:** Predictive models were implemented to reduce redundancy in audio, image, and video data. The codec predicts the next value based on prior data, storing only the residuals (differences between predicted and actual values).
  - For audio: Temporal and inter-channel prediction were applied for mono and stereo data.
  - For images: Pixel values were predicted using linear and non-linear predictors (JPEG and JPEG-LS predictors).

  - For video: Temporal prediction with motion compensation was used for inter-frame coding.

2.2 Tools Used

- **Programming Language:** C++.
- **Libraries:** Additional libraries for data handling, compression, and evaluation.

Chapter 3

Performance Metrics

3.1 Processing Time

Análise do tempo de codificação e decodificação.

3.2 Compression Ratios

Comparação dos rácios de compressão obtidos.

3.3 Error Metrics

Cálculo e análise de MSE e PSNR para codecs com perdas.

Chapter 4

Comparative Analysis

4.1 Comparison with Industry Standards

Comparação dos resultados com codecs padrão como JPEG, MP3 e H.264.

4.2 Efficiency and Quality Discussion

Discussão sobre diferenças de eficiência e qualidade.

Chapter 5

Limitations and Improvements

5.1 Limitations

Identificação das limitações dos métodos implementados.

5.2 Suggested Improvements

Sugestões de melhorias possíveis.

Chapter 6

Conclusion

Resumo dos principais resultados e análise geral do projeto.