

# Data Compression project

## 1. Introduction

Data compression plays a critical role in modern computing, enabling efficient storage, faster data transmission, and optimized performance across a wide range of applications. This project aims to design and develop a comprehensive **Data Compression Application** that provides both **lossless** and **lossy** compression options through an intuitive **Graphical User Interface (GUI)**. All implemented techniques are developed **from scratch**, ensuring a deeper understanding of the underlying algorithms.

## 2. Project Overview

The application allows users to choose between **Lossless Compression** and **Lossy Compression** modes. After selecting a compression type, the user can upload appropriate input data (text or image) and the system will apply the selected compression algorithm. The program includes built-in modules for multiple compression methods, performance measurement, and decompression (where applicable).

## 3. Lossless Compression Module

The **Lossless Compression** module enables users to compress and decompress files without any loss of information. Upon selecting *Lossless* mode, the user can choose from the following techniques:

### Implemented Lossless Techniques (from scratch)

#### 1. Run-Length Encoding (RLE)

Compresses repeated sequences by representing consecutive identical symbols with a count-value pair.

#### 2. Huffman Coding

Generates optimal prefix-free binary codes based on symbol frequencies.

#### 3. Golomb Coding

Uses parameterized coding optimized for geometric distributions.

#### 4. LZW Coding (Lempel–Ziv–Welch)

Dictionary-based algorithm that replaces repeated patterns with dictionary indices.

#### User Workflow for Lossless Compression

1. Open GUI → Select **Lossless Compression**
2. Choose the desired technique (RLE, Huffman, Golomb, LZW)
3. Upload a file (text)
4. Program compresses the file using the selected technique
5. User can optionally **decompress** the file to verify correctness

## 4. Lossy Compression Module

The **Lossy Compression** module focuses on image compression using **Quantization**, a key process in many multimedia compression standards.

#### Quantization Process

- The user uploads an image (JPEG, PNG, etc.)
- The image is transformed.
- The quantized image is reconstructed and displayed

#### User Workflow for Lossy Compression

1. Open GUI → Select **Lossy Compression**
2. Upload an image file
3. Program applies quantization techniques
4. Display the compressed (quantized) image