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A SEMINAR REPORT
ON

Comparative Study of Different Data Compression Algorithms

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CERTIFICATE

This is to certify that the Seminar report entitled

"Comparative Study of Different Data Compression Algorithms"

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has satisfactorily completed a seminar report under the guidance of Prof. Rajesh B. Ingle towards the partial fulfillment of third year Computer Engineering Semester II, Academic Year 2020-21 of Savitribai Phule Pune University.

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Abstract

Data Compression is regarded as the technique used to minimise data size. That is the method used to encode data in fewer bits in a smaller scale than the real size of the data. Compression is essentially technology which is used to display data without reducing quality but reducing data quantity. Compression technique was developed in order to store and transfer the data effectively. Data compression techniques like loss compression and lossless compression are available. This workshop aims at analysing and comparing these compression algorithms. It also contains multiple compressions of various data types.

Keywords

Data compression, lossy compression, lossless compression, Compression Ratio , Huffman, LZW, RLE, ASRL, JPEG.

1 INTRODUCTION

The Internet is a network where data flows communicate. Nowadays a lot of data is being produced every day because of technological evolution. Billions of people make use of internet and it's a huge thing to handle this growing number of results. Internet not concerned only about data but also about speed. The data flow has to be rapid to meet these requirements. Speed of flow increases with a decrease in data size without reducing accuracy as data is compressed.

Data are approximately 40+ zettabyte (ZB) around globally by 2020, where 1 zettabyte is 2 to power 70 bytes. Store, manipulate and flow data over a large network must be as effective as possible, when this is achieved by compression. Compression means encoding data in smaller pieces from actual dimension. Study on compression of data started in around 1940s. Robert Fano and Claude Shannon also systematically discovered a way to allocate codewords dependent on block probabilities around 1949. The ideal method for that was developed by David Huffman in 1951. Compression methods rely on encoding techniques like Run Length Encoding, Huffman encoding, etc.

Techniques for compression decreases data size, which stored and distributed through a low bandwidth channel. The two types of compression methods are lossless and lossful. Lossless methods of compression do not lead to data or information loss, as the name suggests. The file is compressed by less bit, which means that no information is lost. This can be done using a span of mathematical and computational techniques, including entropy coding, often used to transform the file to be compressed back into its uncompressed original form. Lossless compression techniques are helpful in compression of files where entire info should be preserved, such as executable files.

LZ77 and Huffman coding are often used for lossless encoding systems. The process of lossy compression removes unnecessary bits from a disc, which decreases their size. Since any information is lost when encoding the compressed file cannot be returned to the original file. The decompressed file is a similar proximity to the original file that is recovered with the understanding of the compression application. Loss-based compression techniques have a higher compression rate than loss-free compression techniques so more redundant data are removed. We equate different modern algorithms that are widely used without failure.

2 MOTIVATION

As we are in the digital era, our dependency on internet and electronic devices is increasing exponentially. 500 hours of video were uploaded on YouTube every minute as of may 2019, this is just a fraction of total data. Data compression needed to decrease this size to help in data storage and also in data transmission.

Data compression has became very important part of internet and it has modern techniques, views and optimizations. So, selecting proper compression algorithm is very necessary for the internet.

3 A SURVEY ON PAPERS

3.1 Modern Lossless Compression Techniques: Review, Comparison and Analysis

In this paper, We contrasted and evaluated the efficiency of current lossless compression algorithms. The findings of the simulation indicate that the compressed image that Huffman codes and run-length codes produced is almost the same as the initial image after decompression. The coding algorithm is basic, but the coding ratio is very poor. This coding technique can be used where the consumer does not expect good image resolution and does not pay any attention to the compression ratio. The author concluded that, In the case of selecting algorithms, different algorithms can be used for different data formats

3.2 A STUDY ON VARIOUS DATA COMPRESSION TYPES AND TECHNIQUES

This paper gives an overview of different methods for loss-free compression. Compression is the act of altering or encoding the bits of data to reduce the amount of storage space. It improves the storage of one or more data instances or elements to be reduced. Essentially in cases where compression is required where the reconstruction is similar to original compression algorithms are most needed. Author concluded with overview of Different type of techniques for compression on different types of data such as image, text, audio, etc.

3.3 Research on Image Compression Coding Technology

This paper presents an overview of the many compression methods on the image without loss. Compression is the action through which bits of data are altered or encoded in order to minimise storage space. It enhances the storage of one or more data instances or pieces. Especially if compression is needed if the reconstruction is identical to the original compression techniques. An summary of the image compressing techniques concluded the author.

4 PROBLEM DEFINITION AND SCOPE

4.1 Problem Definition

To study the of Data Compression and the different techniques used to achieve it.

4.2 Scope

We were using the traditional compression algorithms for past years. But as we are stepping towards the future, we are dealing with emerging technologies like machine learning, data science, etc. While colluding with these technologies, we can use these technologies to make these algorithms more efficient.

We will analyze various techniques by performance measures like compression ratios. It will be possible to evaluate the effectiveness of each algorithm and analyze its optimizations using compression ratios.

5 Data Compression Algorithms

5.1 Data Compression:

It is encoding data into smaller bits than it was originally. There are two kind of compression, lossless compression: one where the size of the data is reduced without affecting its quality, and the other lossy compression: where size reduction is only considered irrespective of its quality

5.2 Working Principle of Compression:

It is carried out by a method that employs a way to decide how to reduce the data's size. The algorithm may use a dictionary to convert a string containing bits — or 0s and 1s to a smaller string of 0s and 1s, or the algorithm may insert a reference or pointer to a string containing 0s and 1s that the program has already seen. Text compression will delete all unnecessary characters, insert a single repeat character to signify a string containing repeated characters, and replace a frequently occurring bit string with a smaller bit string. A text file can be compressed to 50

5.3 Data compression types: lossless and lossy compression

Lossless Data Compression:
To enable the exact data to be taken from the compressed data, lossless compression takes help of algorithms for compression. Lossless compression in contrast to lossy compression, which does not allow for the exact reconstruction of the actual data from the compressed one. Where it is necessary that the actual and decompressed data could be similar, or where no determination can be performed if a particular deviation is uncritical, use of lossless compression takes place. When a file is in original state, Lossless compression allows it to get restored in its actual state without losing a single bit of data. When it comes to executable files, text and spreadsheets, where the loss will change the details, lossless compression is common technique. Lossless compressions may be classified based on the format of data to be compressed. Text data, executables data, jpeg data, and mp3 formatted data are the most commonly taken by compression methods. The majority of lossless compressions are of two kinds of algorithms: one which creates a statistical model for the inputs, and another that maps inputs to the bits of strings by this model, with "probable" data producing shorter output than "improbable" one.
Lossless compression algorithms:
1. The Huffman coding 2. Arithmetic coding 3. LZW 4. Run Length Encoding (RLE)

5.4 Entropy coding

In entropy encoding method codes assigned to symbols to fit code lengths to symbol probabilities. In general, entropy encoders compress the data by doing replacement of symbols represented by equal-length codes with symbols represented by codewords whose length to be proportional with probability's negative logarithm. Huffman and arithmetic encodings are two most widely used which are entropy based encoding methods.

5.5 Huffman coding

This coding is a lossless compression method based on entropy. Making use of a variable length code table to encode a source, like character as in file, where the variable-length code has been extracted in a specific way based upon approximate occurrence for every value of the source possible, is referred to as this technique. The Universal Huffman Tree based encoding, it is novel and efficient text compression method that compresses any word level text in a universal manner for corpora across domains. The work's main contribution is the avoidance of code table contact during the decoding. We can compact any text using Universal Huffman Tree without having to produce a new tree for each input, which considerably reduces the size of the code table.

Prefix Codes are input character allocated variable length codes. This is to delegate the codes in a manner where no other code of character is prefixed to the code allocated to one character. Huffman Coding means that the built-in bitstream is uncertainly decoded.

5.6 Huffman Tree Construction Steps

The input consists, array consisting unique characters and their number of appearances, while the output is a Huffman Tree

1. Create leaf nodes for each distinct character and a min heap of all leaf nodes (the Min Heap act as priority queue). To equate two nodes from min heap, value for frequency gets used. At first, the least common character is at position of root.)

2. In min heap, take two nodes having lowest frequency.

3. New internal node created with the frequency same as before as the two nodes. the first extracted node assigns left child, and right children to the second extracted node. This node to be added to a minimum heap.

4. Steps 2 and 3 be repeated unless heap remains with one node. Root node becomes last node in tree, and it completes.

5. Starting on root and working our way up to tree. Maintain auxiliary array. Write 0 to array as you moves towards left child. Write 1 to array while keep moving towards the right one. When leaf node gets encountered, print that array

5.7 Compression Ratio:

Compression ratio for this algorithm is 1.5:1, or about 8 bits/5.32 bits

5.8 Flowchart

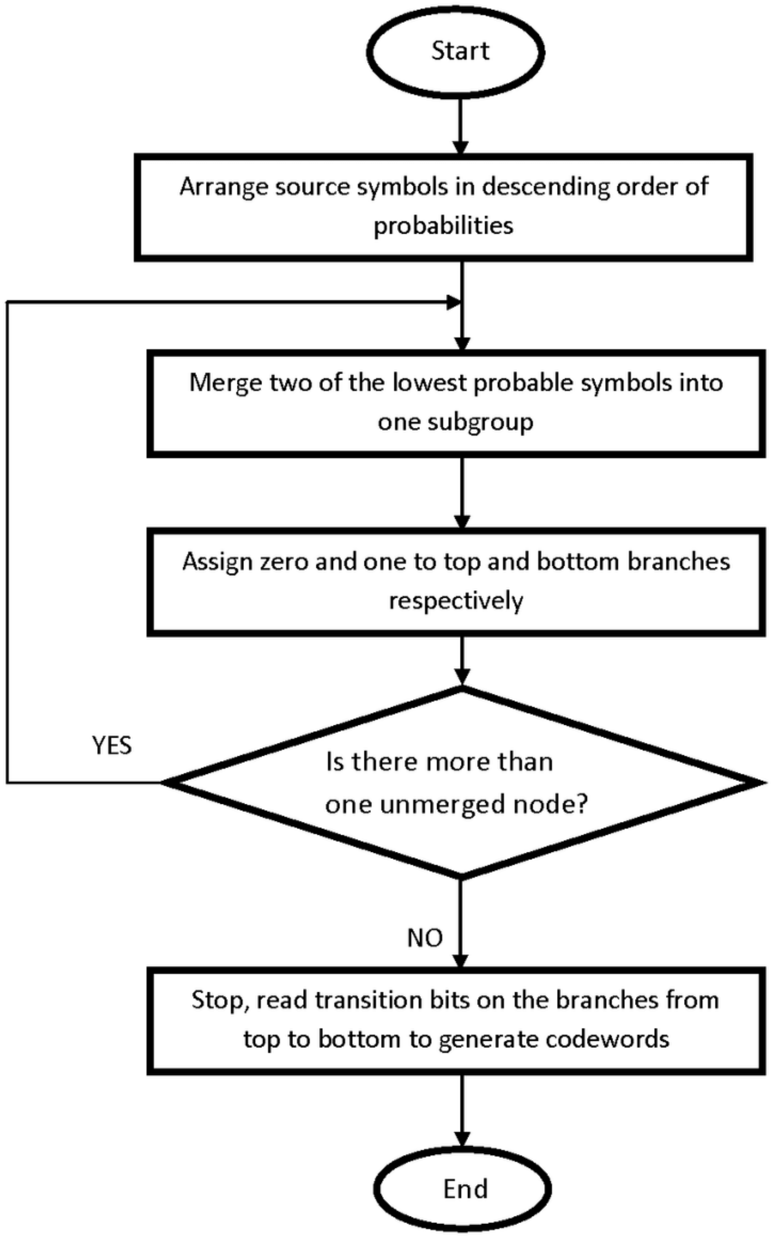

Figure 1: Huffman coding compression flowchart.

5.9 Time Complexity Analysis

The complexity of Huffman coding is O(nlogn) since it uses a min Heap data structure to enforce a priority queue. It takes O(nlogn) time to build a min heap (moving an element from the root to the leaf node requires O(logn) comparisons, which is achieved for n/2 elements in the worst case). Building a min heap takes O(nlogn) time (moving an element from the root to the leaf node requires O(logn) comparisons, and in the worst case, this is achieved for n/2 elements). The algorithmic complexity of the whole operation computes to O(nlogn) since constructing a min heap and sorting it are done in order.If the characters are already sorted according to their frequencies, we can use a linear time algorithm.

5.10 Advantages:

1. binary codes produced can vary in length, this coding method saves a lot of memory space.
2. To encode characters which occur more often in input, it produces short binary codes.
3. There are no prefixes in binary codes that are created.

5.11 Disadvantages:

1. When opposed to lossy methods, lossless methods, like Huffman encoding method, achieves low compression ratio. As result, lossless approaches like Huffman method are only useful for coding text and application data, not digital images.
2. Since Huffman method use two passes, one is for constructing statistical model where on other hand for encoding, is slower operation. As a result, lossless approaches which use Huffman method are much slower than other methods.

3. binary codes are different according time, hence it's difficult to decode tools to tell if encoded data is corrupt or not. This could lead to incorrect encoding and, as result, incorrect performance.

5.12 Applications:

1. All the compression formats using Huffman method are GZIP, PKZIP with BZIP2. 2. For video, like PNG, JPEG, and MP3 Huffmann method is used 3. Huffman method continues to dominate the compression market, as modern range and arithmetic coding schemes have been overlooked because of patent issues.

5.13 Example:

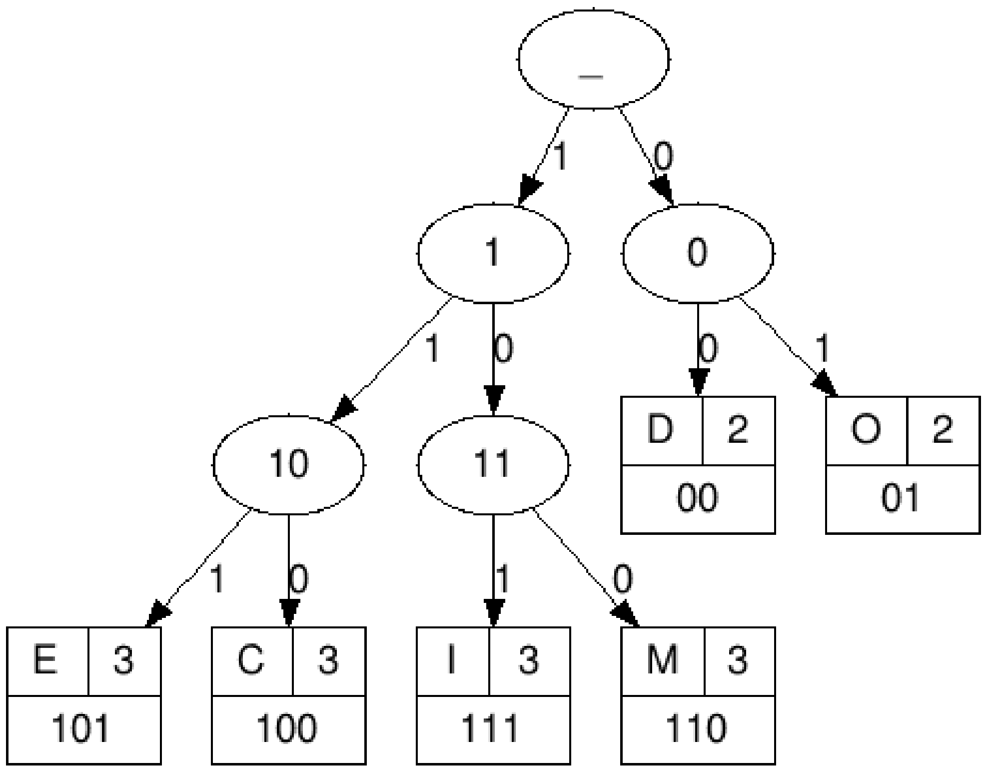

Figure 2: Huffman coding tree creation for example text='DCODEMOI'

6 Arithmetic Coding

The most powerful way to code symbols is by arithmetic coding depending upon their probability. According to information theory, the typical code length is exactly as little as possible. The bit resolution of binary code trees does not cause any deviations. Arithmetical coding has a considerably higher compression rate than the binary Huffman coding tree.

It is more complex, on the other hand, to execute it. A message is coded as a true number between one and zero in the arithmetic coding process. Arithmetic code has a higher compression ratio, in comparison to Huffman coding. Instead of many codewords, a single symbol is created.

The coding of arithmetic is a type of unlost coding. There are few disadvantages of using arithmetic coding. One is that you need to understand the whole codeword so you can decipher the symbols, because if a corrupt bit is sent into the codeword,the whole message can be corrupted. Number of symbols encodable in a codeword is constrained by the precision of the encoding number. Arithmetic coding offers certain patents, so you can pay a little for using those algorithms.

The format of the JPEG data is arithmetic-coded. It's used as an alternative to Huffman coding for final entropy coding. In view for legal limitations above, considering their poorer efficiency, Huffman coding remains normal.

6.1 Arithmetic Coding Algorithm

Arithmetic coding method works in opposing direction, from leave to root.
1. Begin by splitting the range [0, 1] into subrange of every possible symbol that could appear in a message. Make each subinterval's size equal to how often it will be appearing in post.
2. While encoding symbols, you will "zoom" through the current interval and split it in to subintervals the same as you did with new set in stage one.
3. Repeat the operation until the machine's maximum precision has came or all the symbols have been encoded.4. For sending codeword, number is send which is within the most recent interval. Number of symbols getting encoded shall be specified in image format's protocol.

6.2 Time Complexity

Arithmetical coding techniques time complexity is O (nlogn)

6.3 Advantages:

Compression ratio of arithmetic coding, it's higher than Huffman as it uses a single symbol rather than several words

6.4 Disadvantages:

1. To begin symbols decoding, the whole codeword has to be obtained, and the whole message will get corrupt if a damaged bit exists inside the codeword.

2. Number of codable symbols limited to the precise number which could be coded is the precise number.

6.5 Applications:

Length of codeword is similar with ideal value, which will result in greater compression, since the arithmetic code for VLSI testing is used.

6.6 Example:

Symbols	Probability	Probability range
A	0.4	0-0.4
B	0.3	0.4-0.7
C	0.1	0.7-0.8
D	0.1	0.8-0.9
E	0.06	0.9-0.96
F	0.04	0.96-1

Sequence to be encoded: “ACD”

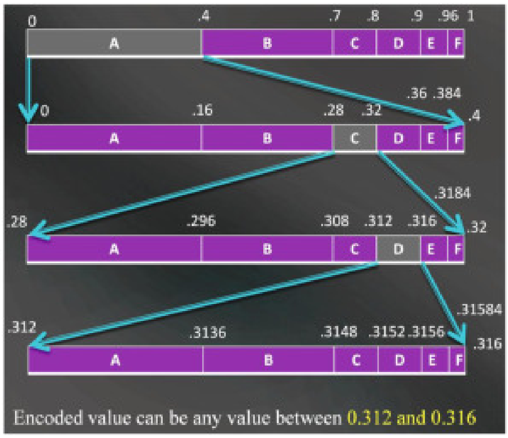

Figure 3: Arithmetic coding for sequence text=’ACD’

7 LZW(Lempel–Ziv–Welch)

7.1 LZW:

A typical compression method is the LZW algorithm. In GIF and to a lesser degree, PDF and TIFF, this algorithm is widely used. The 'compress' order in Unix, among other stuff. It is lossless, which means during the compression process no data is lost. Algorithm has been simple to implement in hardware implementations and has good performance potential. The principle depends on repeated patterns to conserve data space. LZW is the technology most commonly used for general data compression because of its simplicity and versatility.

The way LZW compression functions is to read a number of symbols, arrange the symbols into strings and translate the strings into codes. Compression has achieved, since the protocols have less space than the strings they replace.

7.2 Working:

1. Code table is used for LZW compression, and number of entries in table is commonly set to 4096. From code table, single bytes in input file are often allocated to codes 0-255.

2. Code table includes first 256 entries only as encoding starts, with remaining table becoming void. The codes 256 from 4095 are used to describe byte sequence in compression.

3. LZW detects repetitive sequence manner in data and applies them on to code table to consider as encoding progresses.

4. Codes from compressed file is extracted and translated via code table to determine which character it represents.

7.3 Advantages:

1. The algorithm for LZW compression is incredibly rapid.

2. The whole algorithm can be shown in just a decade without interpreting the incoming text.

3. it is an easy to use algorithm for lossless compression.

4. LZW shines with repeated strings when it comes to data sources. As a result, the compression of English text is incredibly well. At least 50 percent are supposed to be compressed.

5. The LZW algorithm operates much as designed with any fixed stationary source

7.4 Disadvantages:

1. While the algorithm is simple, its implementation is challenging due to the management of the string table.

2. Files with no repetitive data cannot be very well compressed.

3. Text files perform well but not so well for other file formats. 3.

4. Total duration of all strings is calculated, amount storage required is not specified

7.5 Flowchart:

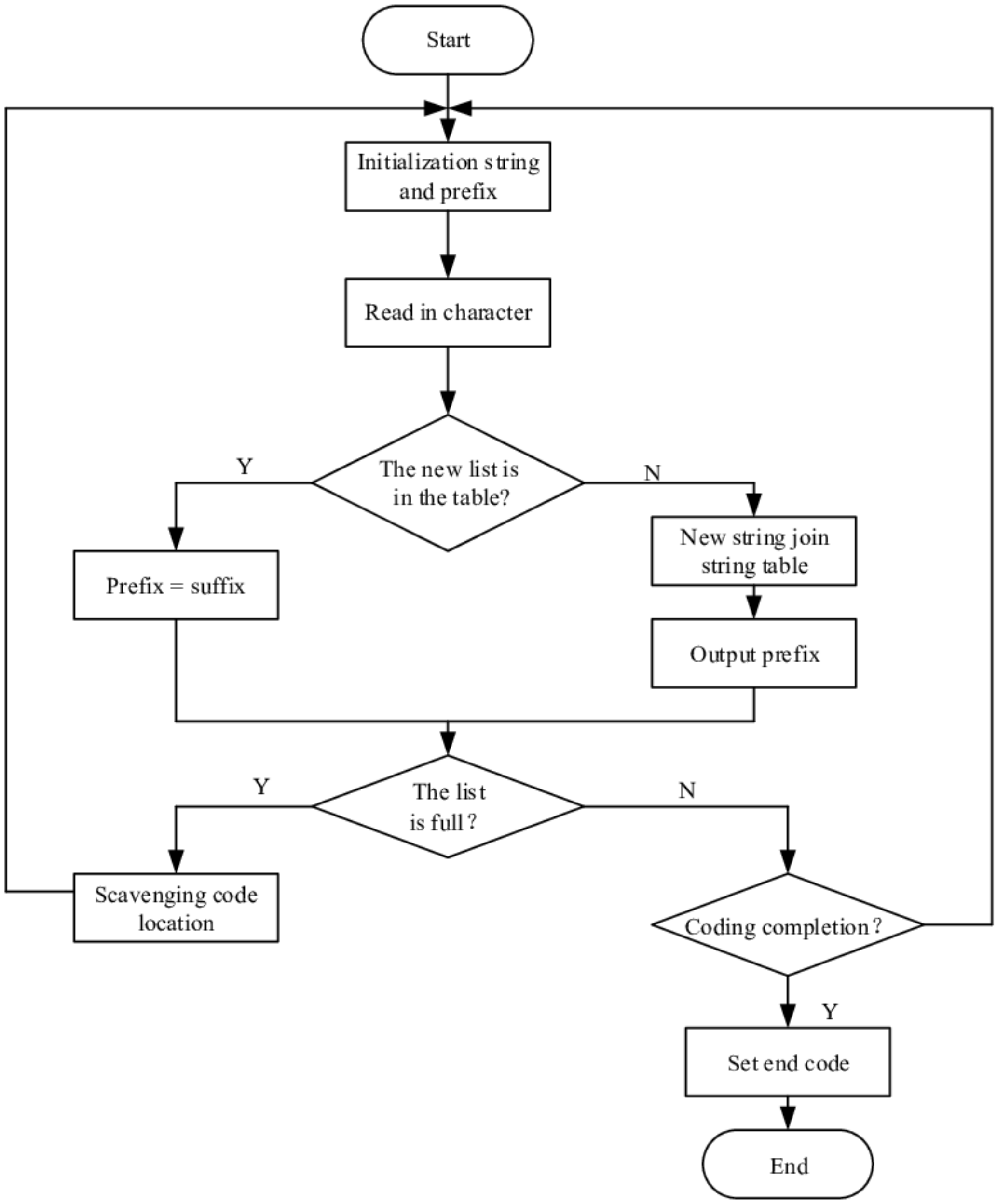

Figure 4: LZW compression Flowchart.

7.6 Application:

A common compression technique is the LZW measurement. The formula is used in GIF and PDF or TIFF on a daily basis.

7.7 Example:

Example 1: Compression using LZW

Example 1: Use the LZW algorithm to compress the string

BABAABAAA

Example 1: LZW Compression Step 1

BABAABAAA P=A C=empty

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA

Example 1: LZW Compression Step 2

BABAABAAA P=B C=empty

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA
65	A	257	AB

Example 1: LZW Compression Step 3

BABAABAAA P=A C=empty

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA
65	A	257	AB
256	BA	258	BAA

Example 1: LZW Compression Step 4

BABAABAAA P=A C=empty

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA
65	A	257	AB
256	BA	258	BAA
257	AB	259	ABA

Example 1: LZW Compression Step 5

BABAABAAA P=A C=A

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA
65	A	257	AB
256	BA	258	BAA
257	AB	259	ABA
65	A	260	AA

Example 1: LZW Compression Step 6

BABAABAAA P=AA C=empty

ENCODER	OUTPUT	STRING	TABLE
output code	representing	codeword	string
66	B	256	BA
65	A	257	AB
256	BA	258	BAA
257	AB	259	ABA
65	A	260	AA
260	AA		

Figure 5: LZW compression Example.

8 Run Length Encoding

8.1 Run Length Encoding:

Run-Length-Encoding is very easy data compression method in which data runs are stored instead of in the initial run as single data and number. This approach works well with data and contains several runs including simple graphics such as icons and illustrations. This approach works well.

A several coloured blocks of similar colour usual it consist of image. For scanning of colour blocks, the same colour value is often maintained by consecutive lines or continuous pixel in same scanning rows. The coding run-length saves the same pixel value with number of pixel values of similar colour instead of saving the same colour blocks one by one in a picture. Color values and count values are simply put to represent several times in a row the same colour pixel values.

If a picture contains several colour blocks of the same colour, run-length coding has a high degree of compression. When the colour value of an image is high, the runtime of the image is low and runtime coding can lead to further redundancy.

8.2 Algorithm:

1. As input, take strings.

2. In the input string count how much times an entity occurs.

3. It is used to encrypt the frequency of the variable.

4. Return strings as an encoding output.

8.3 Advantages:

This algorithm is easy to use and requires less power from the CPU.

8.4 Disadvantage:

RLE compression only benefits files with a lot of redundant data.

8.5 Applications:

Typically RLE is used for 1. PDF files 2. TIFF file

8.6 Flowchart:

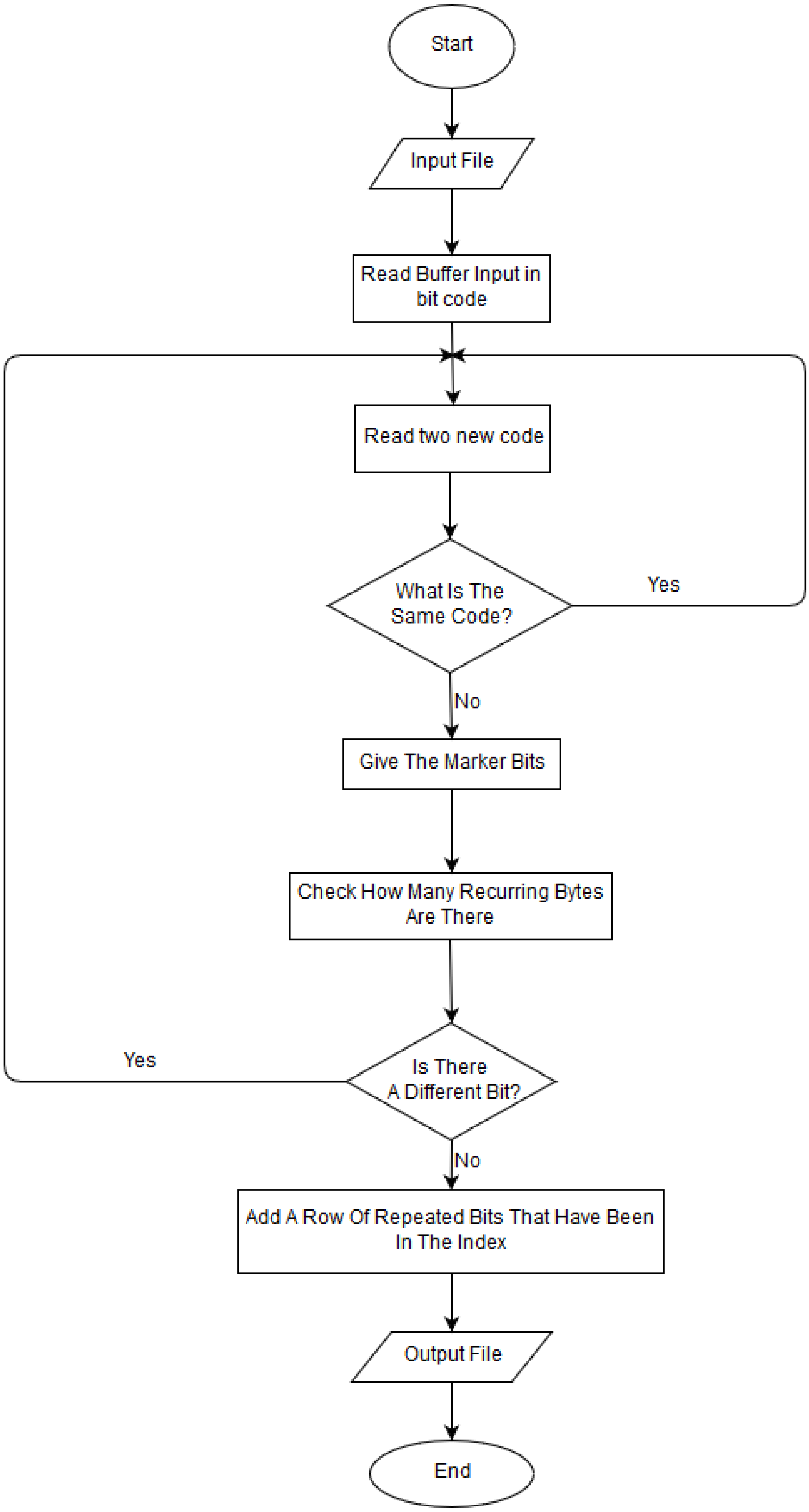

Figure 6: RLE compression Flowchart.

8.7 Example:

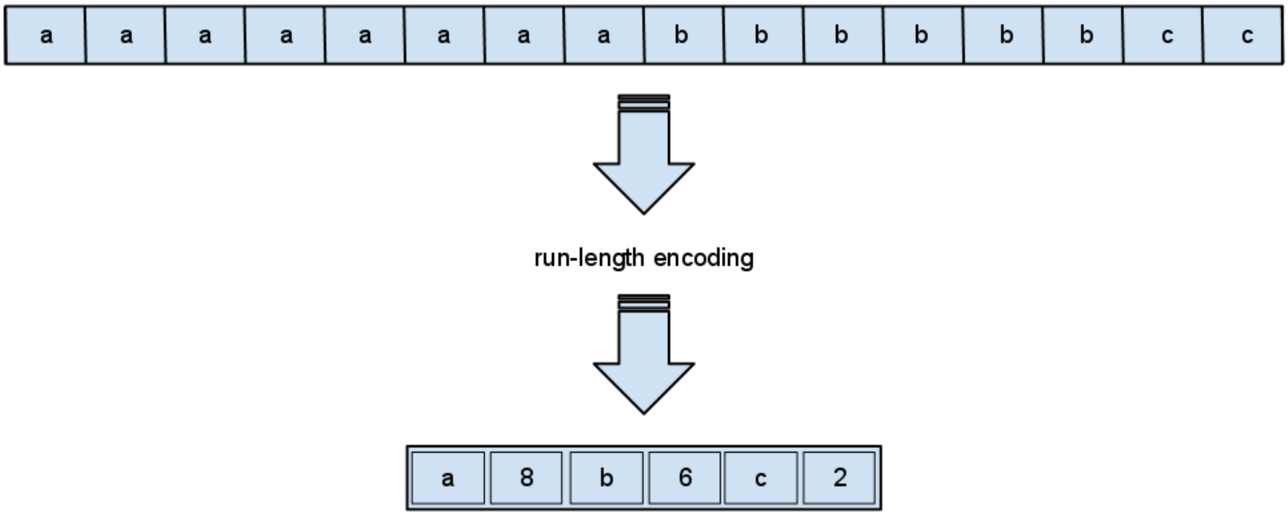

Figure 7: RLE Example.

9 Lossy Compression:

A data loss compression process involves the compression and decompression done on data, which can vary from actual but is ”like enough” to be helpful. Lossy compression on data is used extensively on the Internet, in particular for media and telephony applications. Most data compression formats are losing generation, which results in a persistent lack of continuity as the file is compressed and de-compressed. In comparison to lossless compression on data. Loss compression method are intended for delete outdated or duplicate records, meaning that space is saved instead of data integrity is maintained.

Human experiments usually observe only minor or undetectable losses. Images and audio files that could be trimmed at the edges are compressed using Lossy compression techniques. Images and audio, with the exception of text and processing files, do not require restoration to be similar with the original, particularly if the data lost is minor or undetectable.

Lossy compression permanently removes obsolete, insignificant, or imperceptible bits of data. Lossy compression is useful in graphics, audio, video, and images where loss in few data bits has little to little impact to material representation. Lossy or lossless image encoding can used with graphics

9.1 Image Compression:

The difference between the large amount of data and the bandwidth of visual images on a narrow channel highlights the significance of picture encoding. The redundancy of the image relates to the details between pictures. In order to ensure image exactness, data compression must avoid replication of images. Different compression methods are usually used to process data to eliminate multiple types of repetition

10 Experimental results:

10.1 Huffman compression on Image:

Figure 8: Compressed Image and Decompressed Image

10.2 Run Length Coding compression on Image:

Figure 9: Original Image, binary image, compressed and decoded image

11 Conclusion

The advantages of compression include decreased hardware compression, data delivery and bandwidth and cost savings. Moreover, it takes less than uncompressed time to upload a compressed file and it requires less network bandwidth. An important downside of the data compression is the performance hit by using CPU and storage resources to compress and decompress data. Lossless algorithms of compression do not lead to data loss, as their name suggests. And if the data is compressed without loss, it can recovered through data compressed accurately after a while. Memory documents, spreadsheets, word-processing files, and even different kinds of images and videos data are commonly compressed using Lossless compression. The compression without loss is really useful in the compression of text. The restoration of the original text is crucial, because even small variances lead to phrases with various meaning.

We have learned various algorithms, such as Huffman encoding, RunLength-Encoding, LZW Compression, etc. We also analyzed and worked on these algorithms. We also found that Huffman coding used worldwide norm algorithm and that the correct compression algorithm should be chosen for efficacy according with data formats

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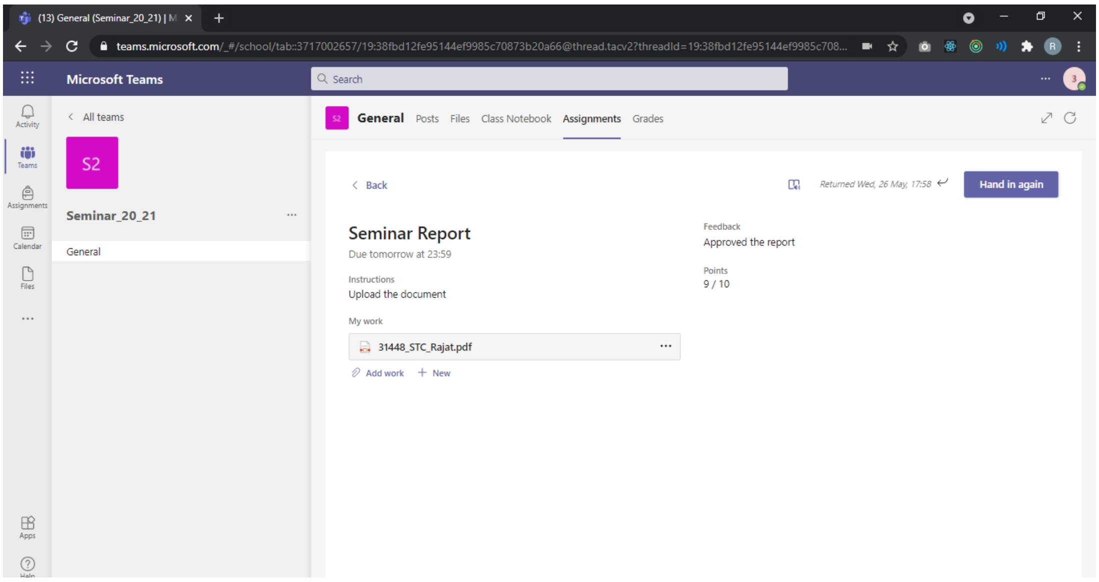
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