Data Management Overview

Data compression and data encoding are related concepts in the field of data processing and transmission. While they both handle the transformation of data, they are primarily concerned with different aspects of data management.

The primary function of compression is to reduce the size of data, in order to minimize the amount of space needed to store the data or the bandwidth required to transmit it. The two approaches to compression are lossless, where redundancies in the data are exploited to reduce the size without losing information, and lossy, where greater reduction is gained by discarding less important data.

The primary function of encoding is to transform the data into another format, in order to ensure compatibility and communicability with different systems. This is often paired with a decoding step to transform the data back into its original form, for proper interpretation of the data by the recipient.

Although they have different functions, compression and encoding are often used in tandem in a variety of applications for more effective data handling.

Industry Trends and Needs

In the software industry, there are several areas where data management is a high priority. For the most part, these are applications that deal with large amounts of data, or data that needs to be transmitted in a timely fashion.

One of the most prominent such areas is in multimedia software. This is any software that presents data to a user in a combination of formats such as text, images, audio, or video. Data encoding is essential in this context to be able to combine the different data forms into a coherent whole. An example of this is a subtitled movie. The audio, video, and text portions of the data need to be formatted in a way that allows a media player to access them, as well as being able to synchronize the playback to combine the separate portions into a single presentation.

Multimedia streaming, in which data is played as it is transmitted through a network, adds additional challenges. With streaming services, it is essential that the transmission of data is able to keep pace with the playback method, and so efficient encoding and compression schemas are used. The encoding used for the data must be able to be quickly and accurately decoded by the recipient as it receives the data, and varying levels of data compression is used to balance the quality of the playback with the bandwidth load.

Similar to streaming, online interactive applications such as video conferencing and online gaming need to use efficient encoding and compression to deliver a quality experience, with minimal latency between participants. Online gaming in particular often needs to handle large assets such as textures and 3D models, with a higher expectation for low latency between participants.

A different area requiring data management is cloud storage. While data encoding is less important in this context, compression has a high priority to reduce service costs and transfer speeds, with a higher emphasis placed on lossless compression to ensure data integrity.

The platforms that these types of software run on is also an important consideration. With mobile devices, resources such as performance, bandwidth, and storage capacity are typically extremely limited compared to desktop computers or servers. These resource limitations make efficient data compression and encoding crucial in order to maintain the experience that users expect, while at the same time limiting the use of cellular data costs and power consumption.

Current Solutions

One technique used in streaming applications is Adaptive Bitrate Streaming. This is a method that a streaming service can use to change the quality of a stream according to the limitations of the end user, such as processing power and bandwidth. ABS encodes and compresses several files to fit a variety of conditions, and streams the highest quality file to the recipient that is still able to play without buffering. Sometimes the adaptation may occur in the middle of a stream, which can present as a visible lowering of quality to the viewer [1].

Current video compression algorithms used in the industry are AVC, HEVC, VP8/9, and AV1. AVC is the most commonly used algorithm, with HEVC being a more modern development following AVC. Both are patented technologies, and require royalties to be paid for use [2]. VP8, VP9, and AV1 are royalty free formats used more commonly on modern web browsers, with AV1 being the most recent [3].

General data compression is typically done using a compression algorithm known as DEFLATE, which combines the compression strategies of Huffman coding and LZ77 compression [4]. Most modern compression formats, such as ZIP, gzip, or Zlib, use DEFLATE as the implementation [5]. Another alternative is Zstandard, developed by Meta as a competitor to DEFLATE [6].

Critical Analysis

For video compression, used mainly in streaming applications, there are several considerations when comparing the different algorithms. AVC, being the most common, is nearly guaranteed to be compatible with any recipient, at the cost of a lower compression efficiency. The more modern replacement, HEVC, has higher efficiency compression, and is better able to handle larger video formats such as 4K or 8K than AVC, at the cost of needing higher processing power for the encoding and decoding. On the latest generation of mobile devices, this may not be a concern, but earlier generation devices may struggle with the newer format. Additionally, these formats require royalties to be paid by the media provider to use them, which can impact the cost to consumers.

The open and royalty free alternative in AV1, and to a lesser extent VP8 and VP9, offers a lower cost for use, and in some cases better compression efficiency than AVC or HEVC. However, the processing power to encode and decode these codecs may put them out of reach of older generations of mobile devices, and the ability to use the format would cost development time to support.

For general data compression, DEFLATE offers reasonable efficiency and guaranteed compatibility with any given system. The new competitor, Zstandard, could potentially offer similar compression rates with much faster compression and decompression speeds, but the currently low adoption makes this option less attractive for cross compatibility.

Proposal: Neural Compression

New advances in AI and machine learning offer new possibilities in data compression. Neural networks have the potential to reach much higher levels of lossless compression for video and data storage by identifying and discarding unimportant features and data, resulting in much lower file size and faster streaming. Future devices would need the processing power capable of decoding and decompressing the new AI created formats, but in the end would offer higher quality for lower cost than current systems [7].

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