Compression of Human Movement Data

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Introduction

There exists numerous applications for human movement information including virtual reality, wearable electronics, physical therapy and human performance. The utilization of biomechanical understanding to any human movement application depends on the efficient processing and representation of the kinematic data. Yet techniques for dealing with this class of multimedia information has received little attention compared with the mature fields of image, audio, and text. In order to enable the applications listed above, efficient and standard techniques for processing and representing kinematic data are needed. This work addresses the second of those needs, the representation of kinematic data. Representation is more important than processing as processing cannot happen without representation, and consensus is required for useful representation while processing techniques can be customized.

We apply an array of compression techniques borrowed from other fields of multimedia networks as well as several novel approaches to compress six-axis IMU data of various human movements and body segments. The authors hypothesise that the most efficient representation format will utilize a mechanical understanding of the relationship between rotation and orientation ie, cross-correlation between accelerometer and gyroscope information.

Methods

In order to meaningfully and repeatable demonstrate the performance of a compression algorithm, a public kinetic signal corpus must be selected. For this study, the Human Gait Database (HuGaDB) is used. HuGaDb is a public dataset of six-axis IMU signals collected from six different body segments of 18 healthy subjects performing 12 different movement activities[TO Cite]. This database was selected because it allowed the comparison of compression techniques across body segment, subject, and activity in addition to sensor modality. The data collected from three random subjects was designated as training data, and only data from the remaining 15 subjects was used in our results.

Eight lossless compression techniques are selected and compared in this study. The first six are taken from the field of audio compression. The last two are novel approaches. Why audio? Why Lossless?

Comma separated value (CSV) is selected as the baseline size when computing compression ratio (CR). CR is computed by dividing the size of the CSV file by the size of the compressed file. In addition to CSV, two other traditional techniques are included for further conext: ZIP compression, and efficient binary representation.

All compression techniques are implemented as FIR filters using 16.16 fixed point computation. This guarantees stability and reversible operations. Source code is released for public use at http:www.github.com/dchiasson/humaco.
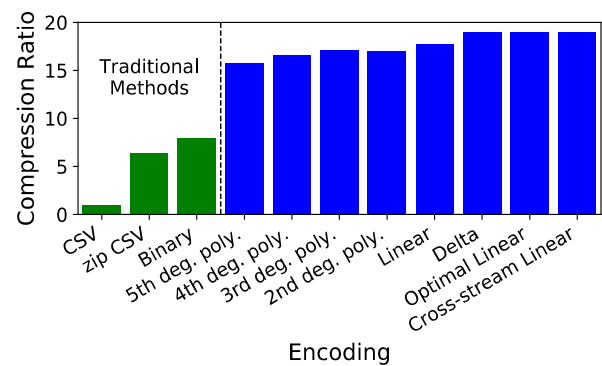

Figure 1: Compression ratios relative to CSV representation. Higher is better.

Results and Discussion

All tested compression techniques far outperformed traditional representation methods in size efficiency. Delta encoding proved to be the best performing polynomial regression technique (CR=19.016), with each additional degree performing worse. This supports previous work which found higher degree polynomial predictors suffer from poor white noise attenuation [Tanskanen].

The optimal per-stream FIR filter (CR=…) proved to be similar performance to delta encoding. Investigation of the coefficients showed that the per-stream FIR had learned an approximation of Delta encoding for accelerometer data and ….

Cross-stream FIR (CR=…) outperformed all other methods thus supporting our hypothesis. However, the performance improvements were minor and came at the cost of over an order of magnitude increase in computation compared to delta encoding.

Significance

Using these techniques, kinematic data can be represented at almost one-twentieth the size of the current de-facto standard. This enables a range of applications which may have real-time data streaming, wireless communications, or limited storage space.

Acknowledgments

Do I have any acknowledgements?

References

Reference citations can be brief, but must include the bare minimum amount of information to locate the reference.