CURVE SMOOTHING FOR PROGRAMMATIC COMPRESSION OF SOUND

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ABSTRACT

Since 1997 Internet traffic had registered a vigorously growth, approximately doubling for each year and it continues to grow close to this rate. Audio Compression has an important role in internet traffic. Programmatic Compression is relatively a new method of data compression. It represents a big interest for researchers, as we can compress any type of data as well. This paper aims to introduce a new method of waveform curve smoothing. By smoothing the waveform curves of sound, we help Genetic Programming System to find a computer program that can approximate the data. After more experiments on smoothed data of speech samples, Genetic Programming System showed good fitness of individuals. This type of smoothing can be applied on any type of waveform signal.

KEYWORDS

Programmatic compression of sound, curve smoothing

1. INTRODUCTION

Programmatic Compression (PC) of data is described in many research papers, and consists in applying Genetic Programming (GP) to find a computer program that gives as output some given set of data. It uses the main characteristic of computer programs to generate data. GP is applied on data to solve Symbolic Regression Problem [1]. If the size of discovered computer program by GP is less then size of data given as target, it is considered a compression. Smoothing method presented in this paper is novel in literature. It uses the main geometrical characteristics of waves. The aim of curve smoothing is to reduce the chaotic-oscillatory characteristic of waveform curve. After transformation of sound waveform into monotone curve, GP is applied on smoothed curve of sound to solve Symbolic Regression Problem. After compression and decompression of small parts of sound, the sound was intelligible with noise. The compression ratio varies between 15% - 20%.

2. PROGRAMMATIC COMPRESSION OF SOUND

GP is a system of automated learning inspired from Darwinian evolutionary theory. The GP system learns and adapts itself to environment. By learning from its environment GP discovers a computer program that fits exactly or approximately with a given set of data. Programmatic compression of sound uses GP to discover a mathematical formula which approximates the sampled sound. Programmatic Compression (PC) is firstly described by Koza [1]. Koza used GP to compress a small bitmap image. The first successful work on PC of sound and its issues is the Banzhaf's and Nordin's work [3].

2.1 Curve Smoothing

For regular data the compression ratio can easily be 10 times or more [3]. In [2],[3] works are reported the difficulties of GP applied on oscillatory-chaotic data. Curve smoothing is applied due to decrease the chaotic-oscillatory characteristics of sound waves. Wave decomposition represents the first step of transformation of waveform curve into a monotone curve. Decomposition uses the alternating rule of convex-negative and concave-positive shapes of waves. Every concave and convex curve is transformed into a monotone curve. After transformation of all waves into monotone curves, they will set together to compose one monotone ascending curve.

2.1.1 Waves Decomposition into Concave and Convex Curves

This technique of identifying convex and concave curves is very simplistic. It uses the main geometrical characteristics of waveform signal. Parts of the sound wave where air pressure is increased are called compressions and parts where pressure is decreased are called rarefactions. Sound wave is an alternation between compression and rarefaction. Compression can be considered as a concave-positive curve, and refraction as convex-negative curve. A concave-positive curve is succeeded by a convex-negative curve, and a convex-negative curve is succeeded by a concave-positive curve. In the figure 1 is presented sinusoidal waveform decomposition and its extreme points.

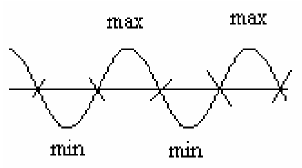

Figure 1. Waves decomposition and extreme points.

The curves are selected by their inflexion points (the point where the curvature changes its sign). After decomposition of waveform signal into two types of curves, concave positive and convex negative curves, we compute their extreme points. Having the curve extreme points, we can proceed to transformation, described in next sections.

2.1.2 Concave Positive Curve Transformation into Monotone Curve

In case the selected curve is concave positive, or it is composed by positive values, the applied transformation formula is:

S’(t) = S(t),   when t<=tMax
S’(t) = max+abs(max-S(t)),   when t>tMax

where **t** is the time of digital signal, **S(t)** is the original signal at time **t**, **max** is the maximum value of curve, **tMax** is the time when curve reaches its maximum value, **S’(t)** is the transformed signal at time t.
The effect of the transformation is presented in figure 2.

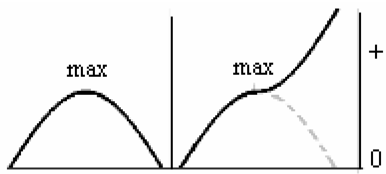

Figure 2.Transformation of concave positive (right image) curve into monotone curve (left image).

2.1.3 Convex Negative Curve Transformation into Monotone Curve

In case the selected curve is convex negative, or it is composed by negative values, the applied transformation formula is:

S’(t) = S(t),   when t>=tMin
S’(t) = min-abs(min-S(t)), when   t<tMin

where, **t** is the time of digital signal, **S(t)** is the original signal at time “t”, **min** is the minimum value of curve, **tMin** is the time where curve reaches its minimum value and **S’(t)** is the transformed signal at time t.
The effect of the transformation is presented in figure 3.

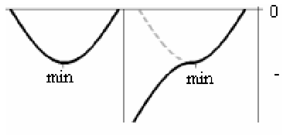

Figure 3. Transformation of convex negative curve into monotone curve.

2.1.4 Entire Waveform Transformation into Monotone Curve

After applying this transformation to waveform the resulting curves are monotone ascending. We described above two cases for applying transformation. All decomposed and transformed concave and convex curves will be set together to compose one monotone ascending curve. To the current curve will be added the distance between first point of current curve and the last point from previous curve. The first curve remains unchanged. The effect of this transformation is presented in figure 4.

Figure 4. Entire waveform transformation into a monotone curve.

3. CONCLUSION

The simulations were done on samples of speech from web page[4]. In comparison with GP applied on oscillations (original data), it shows an increased fitness up to 10 times on smoothed curve. This method have low compression ratio on high frequency sound as extreme points are too many. By storing the extreme points of oscillations, the decompressed sound frequency fits with the original sound frequency. The amplitude is not fitting with original, as this depends on the fitness of the best individual. The decompressed sound is intelligible with noise. In table 2 are shown the compression ratios of "jonyes.wav" sound sample. The chosen part is strictly the speech. Parts with silent are removed.

Table 2. Compression ratio

GP applied on parts number:	Sizes of discovered functions:	Compression ratio:
One part, entire sound sample	150	15 %
6 parts with variable length:	68, 90,50, 53,101,50	19.2 %

The compression ratio is given by formula:

Compression_Ratio(sample) = 100 / (size_of_original_sample/size_of_compressed_sample)

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