**Summary**

This report discussed about Tactile content will be provided via the Internet shortly via tactile displays mounted on computer mouse or mobile phones using lossless data compression techniques, according to this article. Such devices are already being developed commercially, such as Logitech's iFeel Mouse Man, Fuji Xerox's Tangible Mouse, and Kensington's Orbit 3D. Tactile information will be based on stimulation techniques that have been thoroughly researched by a number of researchers. Such content is represented by vibrotactile material-like textures that resemble the surfaces of wood, leather, and other materials. We used lossy compression of texture data to reduce the size of the data in this report. Two compression procedures, quantization, and termination of data within a shifted perceptual threshold curve, were found to be effective. The amplitude spectra of vibrotactile textures could be quantized in 14 steps using the quantization approach. The data size was decreased by around a fourth without any visible quality degradation. The technique for truncating frequency components with amplitudes less than a shifted perceptual threshold curve was also successful. By combining a lossy data compression strategy with Huffman coding, a lossless data compression method, we were able to reduce the data size of vibrotactile material textures to 10-20% of their original size. By reducing the data size of vibrotactile material-like textures without sacrificing quality, lossy compression methods will improve their online delivery.

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# INTRODUCTION

# We look at lossy data compression of tactile textures in this paper. Because textures are spatially distributed across the surfaces of things, they have a huge data size as compared to virtual mechanical switches or iconic tactile stimuli. Rather of basic textures like gratings, we investigate material-like textures with irregular surface patterns. The lowering of communication traffic is a clear benefit of data compression. Furthermore, it has the potential to aid in the discovery of novel features of tactile perception. The development of compression algorithms leads to the examination of human perceptual mechanisms, as seen in the history of data compression for visual and aural information. While it is probable that data compression methods used for sounds or images [2] will be applicable to tactile textures, there have been no previous reports on the use of such methods. As a result, it's impossible to say how much texture can be compressed. Some sound or image compression methods truncate information that is unnecessary to the desired characteristics; as a result, we must determine whether truncations are acceptable for tactile textures. The goal of this research is to see if lossy data compression techniques can be used to compress vibrotactile material-like texture data and if they are suitable in terms of data reduction ratios. Quantization and truncation of subthreshold data are two sorts of fundamental compression algorithms that we use.

## Scope

The current research builds on a prior study [3], in which we investigated the use of lossy data compression algorithms for two different types of vibrotactile textures. We use three types of material-like textures with new experimental participants to preserve the generality of the methods in the current work. Then, to assess the potential compression ratios of vibrotactile material-like texture data, we combine the compression technique with Huffman coding, which is a lossless compression scheme.

# TECHNICAL BACKGROUND

There are two types of data compression algorithms: lossy and lossless. Lossless techniques, such as Huffman coding, leverage the stochastic nature of signals to reduce data size. Data compressed with lossless techniques is decoded into the exact same format as the original data. Lossy methods, on the other hand, rely on human perceptual qualities to transform data into a form that is perceptually like or identical to the original.

## Lossy Data Compression Scheme:

### Quantization and Elimination of Subthreshold Signals

Quantization is a key approach in lossy data compression. The subjective quality is unaffected by minor quantization problems. Various compression algorithms have included quantization. JPEG [2], a compression technique for still images, is one such algorithm. The discrete cosine transformation (DCT) of a picture is computed by JPEG technology to retrieve the intensities of individual spatial frequencies (DCT coefficients). Based on human luminosity characteristics, the derived DCT coefficients are quantized using step sizes that are specific for various frequency ranges. The quantization is subsequently encoded using lossless algorithms such as differential or Huffman encoding.

### Lossy Data Compression in Haptics

A remote master-slave system that provided force or location information to the operators of their haptic systems only when information or changes in information exceeded thresholds or discrimination limens was studied in order to decrease data transfer in haptic systems. Cholewiak et al. [4] published a similar work on the compression of textile stimuli, in which square gratings were divided into main waves and harmonics using Fourier expansion. The effects of harmonics on the perceptual thresholds of gratings were then examined before fine or midcoarse square grating thresholds were proposed.

The study also revealed that when individuals were shown synthetic waves of two sinusoidal waves, they would not notice changes in phase between them. This implies that phase information in vibrotactile texture stimuli can be eliminated in part. When creating high frequency vibrotactile stimuli, phase information is especially unnecessary [5]. However, it is clear that lossy data compression for tactile textures has been used in only a few experiments. This could be since psychophysics rarely addresses the simultaneous manipulation of a large number of physical variables such as vibrotactile amplitudes in many frequency bands.

### Data Compression Algorithms for Vibrotactile Textures

There are two Data Compression Algorithms for Vibrotactile Textures Linear Quantization and log quantization the Vibrotactile texture is explained in 2.2.1 section.

#### Linear Quantization

One of the most often used lossy data compression algorithms is quantization. Between the maximum and minimum Ck, the amplitudes are quantized. Where L is the number of quantization steps, which determines the compression level, the quantized amplitude spectrum Lk is determined. Figure 4 illustrates an example of uncompressed and linearly quantized (L ¼ 4)wood texture amplitude spectra and surface profile. Because each amplitude of the uncompressed texture was written in two bytes, the compressed texture in the figure had a data size that was 12.5 percent of the uncompressed data.

#### Log Quantization

Uniform and nonuniform quantization systems are the two types of quantization schemes. In uniform quantization methods, the step size is constant, whereas in nonuniform quantization schemes, the step size changes. Log pulse-code-modulation, in which the step size fluctuates logarithmically, is an example of a nonuniform method. Low-level signals are finely quantized, resulting in minimal quantization errors. High-level signals, on the other hand, are coarsely quantized. The use of small quantization steps for low amplitudes and coarse quantization steps for large amplitudes is expected to successfully reduce data size while retaining data quality, as long as Weber law is followed. The step sizes were calculated using a log function. The amplitude values of positive and negative amplitudes were quantized individually.

### Vibrotactile Texture Display

Users should be able to actively explore spatially distributed textures by moving their hands around the display. We employed the vibrotactile display illustrated in Figures 1a and 1b, which meets all the criteria. When a participant in the experiment placed his or her finger on the vibrator and moved his or her hand along the X-axis, the vibrator slid along the guide and created displacements along the Y-axis, replicating the texture's surface profile. The contactor had an 11.6 mm diameter and was round. The voltage output to the vibrator had a refresh rate of 3.0 kHz. The stimulator's output force was around 800 N.

### Material-Like Texture

Textures with variable surface height patterns are another type of material. Surface roughness profiles of 11 different materials, such as wood, paper, and cloth, were also measured. The surface profiles were measured using the NH-3SP noncontact surface measurement method (Mitaka Kohki, Mitaka, Japan; nominal resolution of 1 nm). It took 10 mm measurements with a 0:5 m interval on the surface of a randomly selected area of each texture. To verify that the compression methods' effects were universal, various textures were used. Using the tactile display shown above, we played back the 11 measured material textures and choose three that felt noticeably different. This was the situation.

# METHODOLOGY:

## Problem Tree:

### LOSSY DATA COMPRESSION ALGORITHMS

#### Perceptual Characteristics of Vibrotactile Stimuli

The discriminability and detectability features of distinct amplitudes seen in vibrotactile stimuli are exploited by compression methods. The discriminability of supraliminal stimuli determines how they should be handled. When employed for vibratory amplitudes, a typical index for discriminability is the differential threshold, which has a Weber ratio of 10-20% (computed from [34] and [35]). This suggests that amplitudes can be quantized in a crude manner. The detectability of subliminal stimuli indicates how to deal with them. The compression technique reduces amplitudes below the detection threshold since subliminal vibrotactile stimuli do not need to be sent to sers.

#### Data Compression Using Discrete Cosine Transformation

The data compression method is depicted in Figure 3. The textured surface profiles (Fig. 3a) are first converted into amplitude spectra using a discrete cosine transformation (Fig. 3b), and the spectra are then compressed using data compression algorithms (Fig. 3c). Finally, using inverse DCT, the changed or compressed spectra are transformed into a surface profile (Fig. 3d). The produced surface profiles repeated this operation for a virtually limitless material length, despite the fact that we measured material surfaces for 10 mm. The next sections go over each of these steps in depth. The textures' height samples are transformed into amplitude spectrograms as specified in Section 3.2.

# EXPERIMENT AND RESULT:

The perceived dissimilarity between the uncompressed and compressed textures was graded by the subjects. They used a four-point grading scale to assess the dissimilarity. The wood and sandpaper texture data were subjected to three different algorithms. The surface of the fake leather texture data was subjected to linear quantization and truncation of subthreshold stimuli, but not to the log quantization procedure. This was due to the fact that with the wood and sandpaper textures, log quantization performed similarly to linear quantization [3]. As a result, we concentrated on the two ways other than log quantization when it came to the leather texture. With each c, the texture compression levels were set at 5-7 grades.

The standard deviations of the subjects were calculated.The values in the figure were computed by assigning a value of 0, 1, 2, or 3 to “same,” “probably the same,” “probably different,” and “different,” respectively. In general, the dissimilarity score increased (similarity decreased) as the data size of the compressed textures decreased. The changes in the scores were not monotonic. With linear and log quantization, the changes showed a slight plateau at L ¼ 12; 10, and 8. The scores increased exponentially using small quantization step number of L ¼ 4 or 6 with linear and log quantization, respectively. A pairwise t-test was used to test the significance of differences between the uncompressed and compressed texture scores (Table 2). Significant increases were observed in the dissimilarity scores with both linear and log quantization for compression levels of 22.4 percent (L ¼ 12) or less, as shown in the left and middle columns of the table. shows the means and standard deviations of the scores for the threshold-cut wood textures. The dissimilarity between the threshold-cut and uncompressed textures increased monotonically as the textures were compressed further with an increase in b0, which was the size of the threshold curve shift. As shown in the right column of Table 2, textures compressed with a level of 4 dB had dissimilarity scores that were significantly different from the uncompressed texture.

A picture containing text, device, screenshot

Description automatically generated The dissimilarity of the wood textures tended to rise as the compression ratio decreased, following a similar general pattern as the dissimilarity of the wood textures. When L ¼ 14 [1] was used for linear quantization, the scores remained poor. Small quantization steps, on the other hand, improved the scores significantly. The findings of the statistical analysis of the sandpaper texture scores are shown in Table 3. When the compression ratios were 22.4 and 18.8 percent or less, substantial variations between the scores of the uncompressed and compressed textures were noticed using linear quantization, as shown in the left columns. Significant changes in scores were seen when log quantization was used.

Chart, box and whisker chart

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# CONCLUSION:

The applicability of lossy data compression of vibrotactile material like textures, as well as acceptable compression ratios, were investigated. As compression schemes, we concentrated on quantization and truncation of subthreshold signals. We used a vibrotactile display and three different types of material surface roughness patterns to test these technologies. Participants evaluated compressed and uncompressed textures and rated their differences and similarities in a series of psychological exercises. These findings were utilized to determine the ideal compression values that did not degrade perceived quality. Although the effectiveness of lossy data compression of vibrotactile material-like textures was validated in this investigation, the present methods have a problem assuming hand velocity. Since a constant hand motion of 50 mm/s, we estimated the frequency spectra of vibrotactile stimuli. Individuals, though, are initially responsible. This means that the tactile stimuli that users are provided with are determined by their exploring hand speeds. The required sampling rate and compression ratio for texture data, unlike visual or audio signals, is also dependent on individual users or their hand velocities. Users that examine virtual textures at speeds that deviate greatly from the reported average pace may not find the algorithms to be ideal. The issue of user reliance appears to be peculiar to haptic material; it is required to explore and design compression algorithms that are not dependent on hand velocities. For this reason, we discovered that quantization was really successful. The vibrotactile textures' spectral amplitudes were linearly quantized in around 14 steps, reducing the data size to less than 25% of the original data. The truncation of frequency components below a shifted perceptual threshold curve was also found to be useful. Subthreshold amplitudes, on the other hand, should not be automatically deleted, and a shifted curve should be used instead. The degree of shift varied depending on the texture, but it was intended to be between 8 and 4 decibels. Combining these two lossy compression algorithms with Huffman coding can potentially result in significant data size reduction. Further research into this area could help to increase the availability of haptic content on the Internet.

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