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Real time interpolation of haptic information using case base

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Abstract: This paper has described a real time interpolation technology for haptic information using case base. To share haptic data in multiple points, we must send complete haptic data. However, in the transmission line, packet loss and noise are occurred sometimes. In this situation, users don't sense correct force. We developed new interpolation method for haptic sense data without conventional mathematical approach. We can interpolate haptic information lag and loss using case-based approach. In our method, the system selects a suitable case and reconfigures it to fit the error.

Keywords: haptic, interpolation, case base, haptic interface.

I. INTRODUCTION

Recently, image data and sound data can transport efficiently by reason of development of transmission technology as QoS[1]. But, transmission technology of haptic data still has many problems. One of problem is that packet loss and noise are occurred sometimes in the transmission line. Even if image and sound data has a few noises, we can understand. But, in case of haptic data, the noise struck us as incongruous.

Linear interpolation method and Lagrange interpolation method are general mathematical interpolation method[2],[3]. They are effective method in linear situation. In other case, the method cannot interpolate correctly.

We propose that a real time interpolation technology for haptic information using case base. The purpose of our system is to provide the high quality haptic information transfer system which interpolates packet loss and noise on the data.

II. Interpolate system for haptic information

In this study, we use PHANToM Omni (Sensable Technologies) as a haptic interface device. Our system can interpolate the data for haptic data of the PHANToM.

1. The outline of interpolation method

The Fig.1 shows the outline of a multimedia communication environment. Each terminal has a haptic device. The sender sends haptic data to the receiver. The image and sound data can be transferred by Qos Technology. This target area of this research, haptic data communication environment, is shown in the broken line circle area of the figure 1. The system interpolates packet loss or noise for the haptic data and controls the receiver haptic device according to interpolated data.

At first, the system has gathered haptic data for haptic cases, and constructed the haptic case base. Next, the system compares them and the element of the case base, and checks error of them. After this process, the system controls the PHANToM force according to the interpolation.

We assume that the first 3 points of the input data are correct.

2. Composition of case base

The each case in the case base is represented in the text format. A set of data consists of the three dimensional position(X,Y,Z). An each line of the text file represents these positions.

We prepared the following case data for evaluation of our method. To evaluate the interpolation, the case data are generated by the linear function or quadratic function. These data are in the target virtual space. The case data are fragments of the haptic data, so the start positions and the finish positions of each data are not same.

3. Case Search

The system searches similar cases from the case base to repair the original data. To decide the similarity of cases, the system measures the distance between the input haptic data and case by each coordinate(X,Y,Z). The system memorizes these distances into the local memory array for each coordinate(X,Y,Z). The system

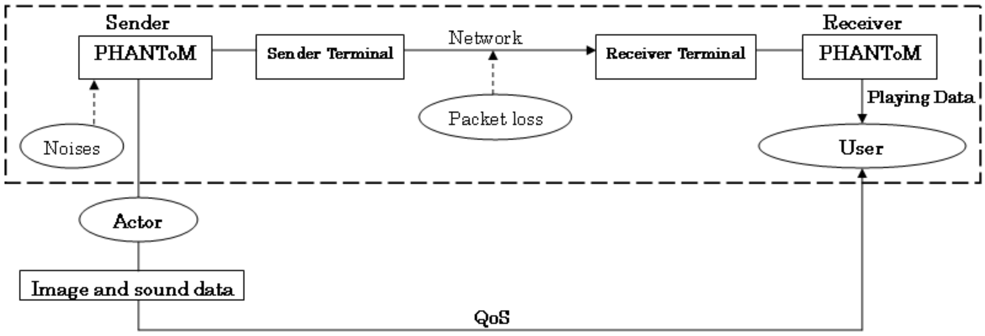

Fig.1 The outline of a multimedia communication

calculated the same distance data for each case when the case base was build. After the system compares cases and the input haptic data, it selects the cases which distances are same more than 3. This selection criteria is based on the assume that the first 3 points of the input data are correct.

4. Offset cancellation

The system uses the translation of axes for offset cancellation. For example, if the offset of the X-axis is 2.0, all x position values of the input data are increased 2.0 points from original data of the similar case. This means that the x values are translated to the position which is shifted positively by adding 2.0. Even if cases are translated, relative distances between cases and the haptic data are not changed. This translation makes no effect for the motion of the stylus of the haptic device. The system doesn't treat the offset cancellation as data error, so it doesn't repair the following complex process.

But it is possible that the haptic data include both offset and errors. In this case, the system memorizes the offset and the similar case. When the system decides that the data include errors, it translates offset cancellation and repairs the errors. As a result, the system can repair data which include both offset and error, and control the haptic device according to the repair data.

5. Haptic data Interpolation

The system selects the similar case and compares the input haptic data and the case. If there are some different points, the system repairs the original data according to the case. We assume that the case is correct. If there are errors in the haptic data, the system repairs or interpolates them. After all interpolation process were finished, the system controls the haptic device using the interpolated data.

In this study, there are two error types which are data alteration and data loss. Therefore, the system must solve these errors. We explain the detail of our repair method and interpolation.

At first, the alteration error is treated as follows.

① The system checks errors and finds alteration error.
② It searches the difference between the similar case and the input data.
③ It replaces the alteration of the input data referring to the case.

The Fig.2 shows the alteration correction process. The system compares the series of the input data at upper part of the Fig.2 with the case at lower part of the Fig.2. In the Fig.2, the third position of the case is "C", but same position of the input data is "X". The system copies "C" of the case to the third position of the input data. After all interpolation methods were finished, the system replays the input data to control the haptic device.

Next, the loss error is treated as follows.

① The system checks errors and finds data loss.
② It searches the difference between the similar case and the input data.
③ It interpolates for the position of data loss.

The Fig.3 shows the interpolation process for data loss. If the data order of the case is "A,B,C,D", and the data order of the input data is "A,B,D", the system finds the data loss for "C". In the second step, the system refers the correspondence position of the case. In the third step, it inserts the data "C" between the data "B" and the data "D" of the input data.

If the control data of the haptic device is increased by this method, the system controls the device according to increased data. If the last positioning data for the haptic device is lacked, the system interpolates the last position into the input data instead of the data loss. There are some differences between the input haptic data and the case. The first data or the last data of these two data are always not same.

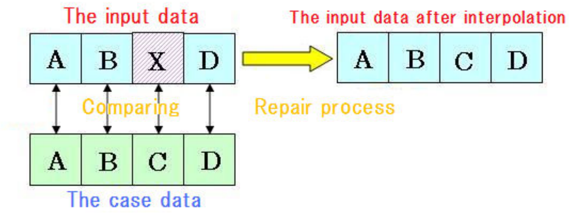

Fig.2. The alteration correction process

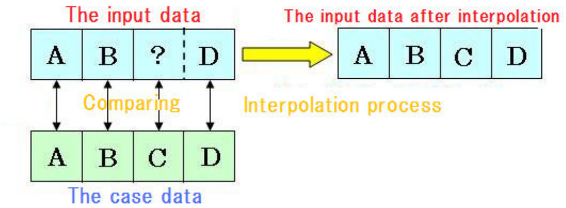

Fig.3. The interpolation process

6. Haptic device control according to the interpolated data

After the interpolation process is finished, the system sends the haptic data into the haptic device. The control process for the haptic device is shown as follows.

① The system calculates distance between the current position of the haptic device's stylus and the next destination of it, and multiplies its distance and a spring constant K to make haptic force. The system calculates them for each three axes, and gives this force to the haptic device.

② The system controls the device to move it to the next destination.

③ It repeats the process ① and ② until the device arrives at the next position.

④ If the device arrives at the next position, it reads the next destination from the input data, and sets up the next position.

⑤ It repeats the process between process ① and process ④ until the device arrives at final position.

III. EXPERIMENTATION

To evaluate the system, we assume that there are alterations and data losses of the haptic data in the linear function and the quadratic function. We made three examples for each functions. There are two kinds of the input data that include alteration and data loss. We also prepared the third type data that include these two errors and offset shifted error. We evaluated the interpolation functions for each data. Some evaluation examples include several errors. The offset errors are given *independent on each axis.

We also measured the execution time for all interpolation process to evaluate real-time performance.

IV. THE EXPERIMENTAL RESULT AND CONSIDERATION

We report the experimental results of the test input data in the linear function and the quadratic function.

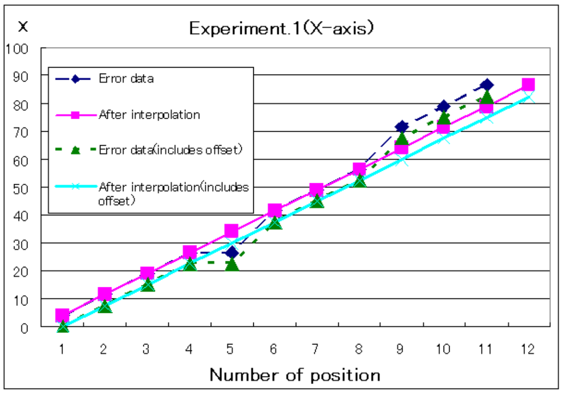

Fig.4. X-axis

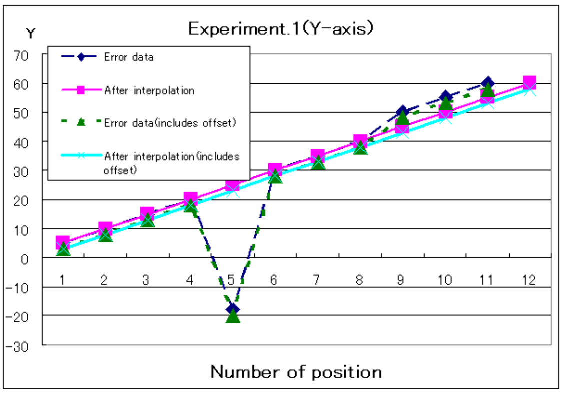

Fig.5. Y-axis

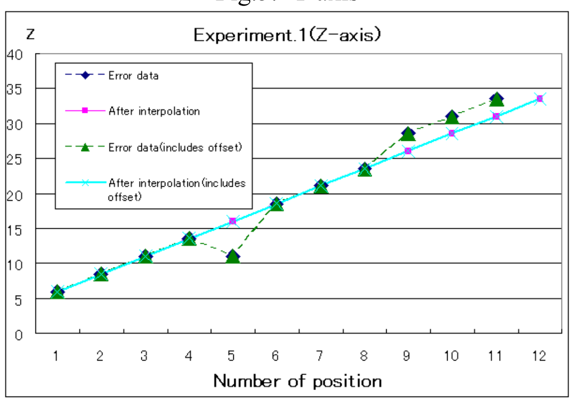

Fig.6. Z-axis

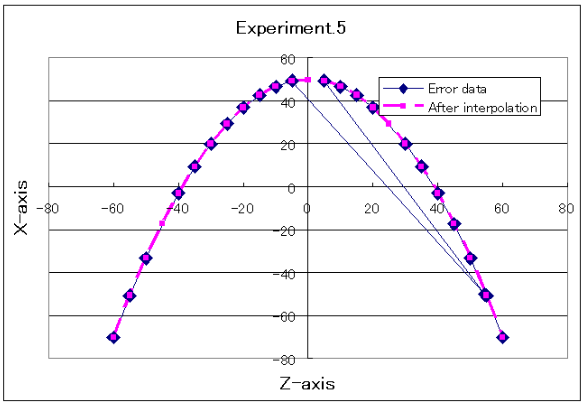

Fig.7. The quadratic function

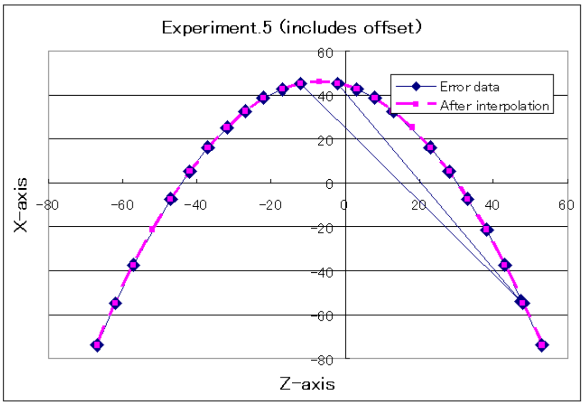

Fig.8. The quadratic function includes offset

The Fig.4, the Fig.5 and the Fig.6 show the experimental interpolation results of each axis for the input data in the linear function. They show the linear line correctly that system executed interpolation process or repairing process. We also confirmed the translation function for offsets of X-axis and Y-axis. The value of offset X-axis is -4.0 and the value of offset Y-axis is -2.0.

The Fig.7 and the Fig.8 are the experimental results in case of the quadratic function. They show the relation between Z-axis and X-axis. The value of Y-axis is fixed at 20. In this case, the offset of X-axis is -4.0 and the offset of Z-axis is -7.0.

In the experiment-1, there are errors that the alteration error is at fifth position, and the data loss error is excited between the eighth and the ninth position. In the experiment of the data in the linear function, each data is at regular interval which is equal to the interval between positions. The system can check the error to find an irregular interval. If there is no offset in the input haptic data, the system executes the translation process only. The Fig.6 shows non offset case. The offset of Z-axis is 0.0 .

In the experiment-5, it is difficult to calculate position simply like the experiment-1 because the distance between positions isn't always constant. In this study, the system can execute this process correctly under the condition that first 3 points of the input data are correct. In the Fig.7 and the Fig.8, we confirmed that the system executes all processes correctly.

We measured the execution time required for the repairing and the interpolation process. As a result, the execution time is measured less than 1 m seconds. The human don't feel a delay less than 1 m seconds, because there is 1 m seconds delay that is from touching an object to sense it in the human neurons[4].

V. CONCLUSION

The purpose of this study is interpolation of error haptic data at network communication. We evaluated out interpolate method to apply the data in the linear and quadratic functions for these experiments. But we don't study more complex cases, for example, as the cubic function. In this study, the system can execute this process correctly under the condition that first 3 points of the input data are correct. But if the 3 points are not correct, the system can't treat the data. Therefore, the issues are to improve our method that combines the fragment of the case data to new cases to suit the exception case. In the next development, we will try to transmit the haptic data using the communication system like Skype, and we will improve our method for this communication.

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