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Time Series Classification with 1D-Convolutional Neural Networks

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1. Introduction

The research on Convolutional Neural Network (CNN) was established as an academic field in 1956. Since then, it has repeated the ice ages and booms many times and now reaches the present. Currently, CNN is diverse in medical field, car field, home electronics field and so on. The beginning of these booms is image recognition. Computers have already proven to be superior to ability of human image recognition. Images have a two-dimensional structure. Recently, CNN is used not only for two-dimensional data but also one-dimensional data and three-dimensional data.

In this study, we investigate how to classify one-dimensional time series data with CNN.

2. Proposed method

We carry out time series classification of the surface shape of nine fabrics. We propose to transform time series data into frequency series data with Discrete Fourier Transform (DFT). DFT is often used for frequency analysis of discretized digital signals such as signal processing.

$$\left\{ X(\omega) = \sum x(n) e^{-i\frac{2\pi kn}{N}} \right. \tag{1}$$

Equation (1) shows DFT. $x(n)$ means time function. n means time. k means frequency. $N(= 500)$ means the number of the samples.

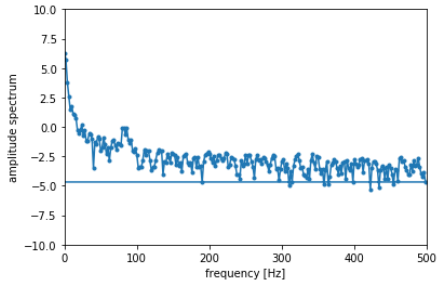

Figure 1: Amplitude spectrum.

In this study, we use amplitude spectrum. Figure 1 shows the spectrum. This spectrum is expressed as $|X(\omega)|$.

We use digital filters. Then we try to increase classification accuracy. In this study, we use three types of digital filters. They are Low-pass filter, High-pass filter and Band-pass filter.

$$\begin{cases} f_1 = \dfrac{2}{f_s} \\ f_2 = \dfrac{60}{f_s} \end{cases} \tag{2}$$

$f_s(= 1\text{kHz})$ means sampling frequency.

3. Simulation result

Figure 2 shows the structure of CNN which we use in this study. It should be noted that the dimension of the input layer is one dimention.

The data which we use is time series data obtained by sensor with surface shape of fabric. The number of the training time series data is 720. The number of the test time series data is 360. So we carry out the 9-value classification with 1D-CNN. Table 1 shows the results of our research. We investigate the average of three times of accuracy. Time series data shows the highest train accuracy. Frequency data shows the highest test accuracy. Low-pass filter and High-pass filter show lower accuracy than the data does not pass through filter.

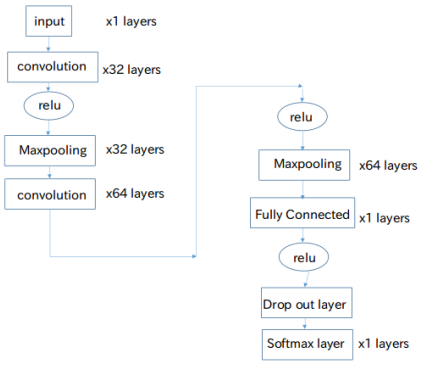

Figure 2: Structure of CNN.

Table 1: Train and test accuracy

	train accuracy(%)	test accuracy(%)
time series	99.0	45.8
frequency	96.7	50.3
Low-pass filter	81.0	40.3
High-pass filter	95.1	37.5
Band-pass filter	98.9	47.2

4. Conclusion

In this study, we carry out 9-value classification by using 1D-CNN. Then, we understand that it is more effective to classify frequency series data than time series data.

However, we cannot show the usefulness of the digital filter. In the future, we will choose optimal cutoff frequency with changing sampling frequency and raise accuracy.