Recognition of Surfaces Based on Haptic Information

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1. Introduction

"Real World Haptics" has received considerable attention in recent years. Real world haptics indicates transmitting, recording and reproducing the real environment. In this paper, tactile sensation is focused on because it is important for humans to distinguish surfaces. This paper gets surface data by using multi degrees-of-freedom haptic robot. Then, surface data is analyzed from the position and force point of view. Analysis results show that environment surface can be recognized.

2. Data Recording

This paper used Omega7 haptic robot which is from Force Dimension to record the surface data. This robot has 3DOF active translations. Disturbance observer (DOB) and reaction force observer (RFOB) were applied in the workspace. Fig. 1 shows the Omega7 and Fig. 2 shows the workspace. Position control was conducted to y-axis and force control was conducted to z-axis.

Fig.3 shows the surfaces used in the experiment.. Recorded data were analyzed in a quantitative way in the next section.

Fig. 1 Omega7

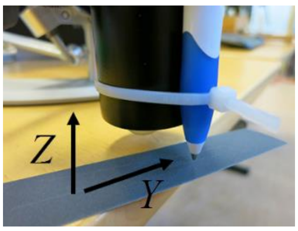

Fig. 2 Workspace

Foamed styrol and sand papers

Fig. 3 Surfaces used in the experiment

3. Data Analyzing

3-1 Position Data

Force control was conducted for z axis, so position data of z indicates roughness. Surface is made up of wave element and roughness element. Zero phase low pass filter is used to extract roughness. ZPLPF is given as

$G_{zp}(z) = \alpha_n z^n + \cdots + \alpha_1 z + \alpha_0 + \alpha_1 z^{-1} + \cdots + \alpha_n z^{-n}$ (1)

Fig. 4 shows the ZPLPF and extracted roughness. From fig.4, only roughness is extracted by ZPLPF.

In this paper, two parameters are used to recognize the surface environment from the position data. Two parameters, arithmetic average roughness R_a and average spacing S_m, are picked up from JIS standard of the roughness (JIS B 0601-2001). Fig. 5 and fig. 6 indicates the concept of R_a and S_m. R_a and S_m are given as

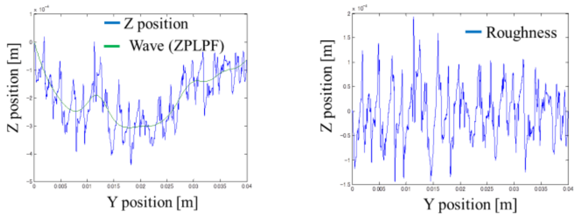

Fig. 4 ZPLPF and roughness

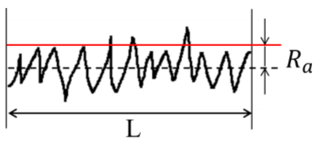

Fig. 5 Concept of R_a

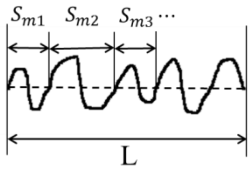

Fig.6 Concept of S_m

$$R_a = \frac{1}{L}\int_0^L |f(x)|dx \quad (2),\quad S_m = \frac{1}{n}\sum_{i=1}^{n} S_{mi}. \quad (3)$$

In fig. 7, R_a and S_m are mapped to recognize the surface in a quantitative way. From fig. 7, the surface recognition is possible.

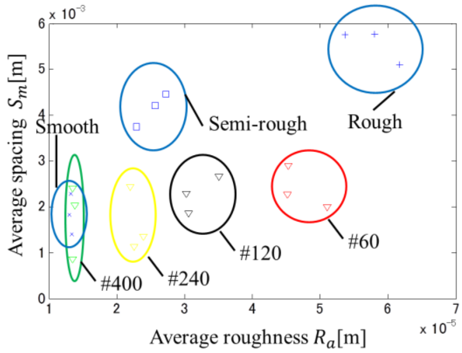

Fig.7 Comparison of surfaces using position data

3-2 Force Data

In fig. 8, average friction force and standard deviation of friction force are mapped to recognize surface. The variance of the mapping is bigger than fig. 7.

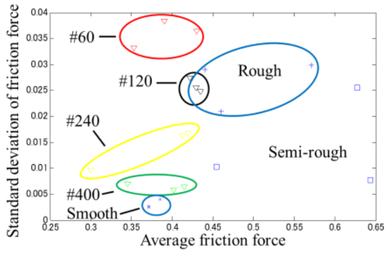

Fig.8 Comparison of surfaces using force data

4. Conclusion

In the sweeping motion, roughness parameters can be calculated from the position data and friction parameters can be calculated from force data. Recognition can be done from the position data.

References

[Nakano (2014)]　T. Nakano.　Recognition of Surfaces Based on Haptic Information.　Master's thesis, TFRT-5957, Dept. Automatic Control, Lund University, 2014.