Reproducibility Report for "Hypothesis Tests with Functional Data for Surface Quality Change Detection in Surface Finishing Processes"

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1   Computer and software environment

Software used: MATLAB® (R2020b)

Hardware and Operating System: Any operating system capable of installing MATLAB software (Windows/ MacOS/Ubuntu etc.).

2   Reproducing the results in the main paper and the supplemental online material

For the explanation of the input data, please refer to Section 3.

Table 1: Reproducing the results in the main paper

To reproduce	Input data file	Code file	Output
Figure 6	Section4_2_data	Figure6_code.m	The two boxplots in Figure 6a and 6b
Figure 7	Section4_2_data	Figure7_code.m	Three png figure files of Figure 7a, 7b, 7c, respectively
Figure 8	Section4_3_data	Figure8_code.m	The two boxplots in Figure 8a and 8b
Figure 9	Section4_3_data	Figure9_code.m	Three png figure files of Figure 9
Figure 10	Section4_3_data	Figure10_code.m	Five png figure files of Figure 10a, 10b, 10c, respectively
Figure 11	Section4_4_data	Figure11_code.m	One png figure file of Figure 11a, 11b, 11c
Table 1	Section4_2_data	Table1_code.m	Table 1
Table 2	Section4_3_data	Table2_code.m	Table 2
Table 3	Section4_4_data	Table3_code.m	Table 3
Table 4	Section4_4_data	Table4_code.m	Table 4
Table 5*	Section4_5_data	Table5_code.m	Columns 6-8 of Table 5

* Columns 1-5 are sourced from Jin et al. (2020). Column 9 is derived by following the hypothesis test based decision rule.

Table 2: Reproducing the results in the supplementary online material

To reproduce	Input data file	Code file	Output
Figure 1	Simulation data generated in code	FigureS1_code.m	Figure 1
Table 1	Simulation data generated in code	TableS1_code.m	Table 1

3 Explanations of the data files

Section4_2_data folder contains the ball polishing experiment described in Section 4.2. The surface roughness data of the nine polishing stages is stored in this folder. For each stage, the ball surface is divided into three shells and three locations are sampled on each shell. In total, there are 81 ($9 \times 3 \times 3$) .csv files, each named with the experiment batch name (i.e., Sele0017), the process type (i.e., polish), the process stage (i.e., a number from 1 to 9), the shell number, (i.e., S1 to S3), the location number (i.e., L1 to L3). The phrase "Height" in the file name means the surface pixel height being measured. For example, "Sele0017_polish1_S1_L1_Height.csv" is the data file that contains the pixel heights of Shell 1, Location 1, at Polishing stage 1 of the Sele0017 experiment batch. Each file contains $786,432$ pixel heights, measured in nanometer.

One .mat file, named "allSaValues.mat", records the Sa value of each sample location returned by the microscopic device. We verified that the Sa values are the same as what one would obtain, had one applied Equation (2) in the paper to the original pixel height values on a corresponding stage and location.

Section4_3_data folder contains the data of the lapping experiment described in Section 4.3. In this experiment, different numbers of locations are sampled at different stages. Table 3 below summarizes the number of locations sampled for each of the processing stages listed in Figure 8 in the paper. There are 55 locations in total. "BC_nan_retain.mat", which contains a $55 \times 307,200$ matrix, includes the pixel heights of the 55 locations and $307,200$ pixel heights per location. "Sa.mat" contains 55 Sa values, one for each location. Again, we verified that the values in "Sa.mat" are the same as what one would obtain, had one applied Equation (2) to the pixel heights stored in "BC_nan_retain.mat". The "BC_nan_retain.mat" has some missing pixel heights in each location. The "start_index.mat" contains the index of the first non-missing pixel height for each location. The value in "start_index.mat" forms a 55×1 vector.

Table 3: Number of inspection locations for each stage

Stage	# of locations
Coat	2
TT	4
Lap 1	1
Lap 2	1
Lap 3	1
Lap 4	1
Lap 5	3
Lap 6	6
Lap 7	9
Lap 8	9
Lap 9	9
Lap 10	9

Section4_4_data folder contains the surface roughness data of the lapping experiment used for the sensitivity analysis in Section 4.4. This experiment includes five lapping stages. The surface is divided into three shells and each shell has five sampling locations. In total, there are 75 ($5 \times 3 \times 5$) csv files, each of which stores $786,432$ pixel heights. The naming convention for the roughness data is the same as the one for Section4_2_data. "Sele0022" specifies the experiment batch name for this experiment.

Section4_5_data folder contains 26 csv files, one for each stage and there are a total of 26 stages. Each of the files stores the surface pixel heights corresponding to 32 locations sampled per stage.

Table 4 summaries the data files and their names in each data folder.

Table 4: Data files and names

Data folder name	Number of files	File names
Section4_2_data	81 csv files and 1 mat file	Sele0017_Polish[1..9]_S[1..3]_L[1..3]_Height.csv allSaValues.mat
Section4_3_data	3 mat files	BC_nan_retain.mat Sa.mat start_index.mat
Section4_4_data	75 csv files	Sele0022_Polish[1..5]_S[1..3]_L[1..5]_Height.csv
Section4_5_data	26 csv files	matrix_stage[0..25].csv

References

Jin, S., A. Iquebal, S. Bukkapatnam, A. Gaynor, and Y. Ding (2020). A Gaussian process model-guided surface polishing process in additive manufacturing. *Journal of Manufacturing Science and Engineering 142*(1), 011003 1–12.