Quantifying the Influence of Uncertainty in Profilometric Data on Contact Pressure

STUDENT PROJECT

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Outline

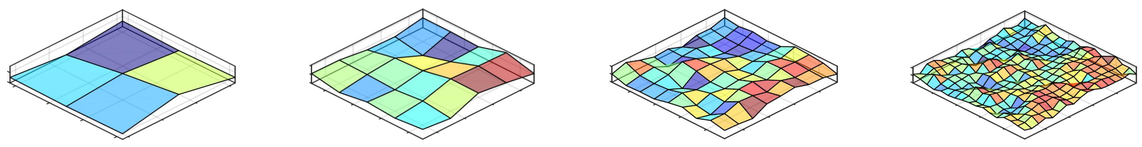
Motivation

Research on contact between rough surfaces has become an important topic in industrial applications. As it is very expensive to measure rough surfaces, it is easier to use numeric algorithms, e.g. the Random Midpoint Displacement, to create virtual rough surfaces based on randomly generated numbers. Since these simulated surfaces enable the creation of large numbers of rough surfaces in a short time, this concept brings many advantages in research.

The influence that using randomly generated rough surfaces has on the results of further research will be analyzed. Therefore, the extend of uncertainty in calculated contact pressure for randomly generated rough surfaces is determined using a Monte-Carlo simulation. Furthermore, the influence of a variation of the fineness of the surfaces will be examined.

Random Midpoint Displacement

The Random Midpoint Displacement (RMD) is a method to randomly create self-affine rough surfaces by using a recursive algorithm. In every iteration, it divides a flat square into smaller squares and changes the height of their midpoints by adding random numbers to the mean height-displacements of their corners. Then, the midpoints of the edges of the squares are varied in their heights by adding a random number on the mean height-displacement of the surrounding corners.



Rough surface created by Random Midpoint Displacement after 1, 2, 3 and 4 iterations

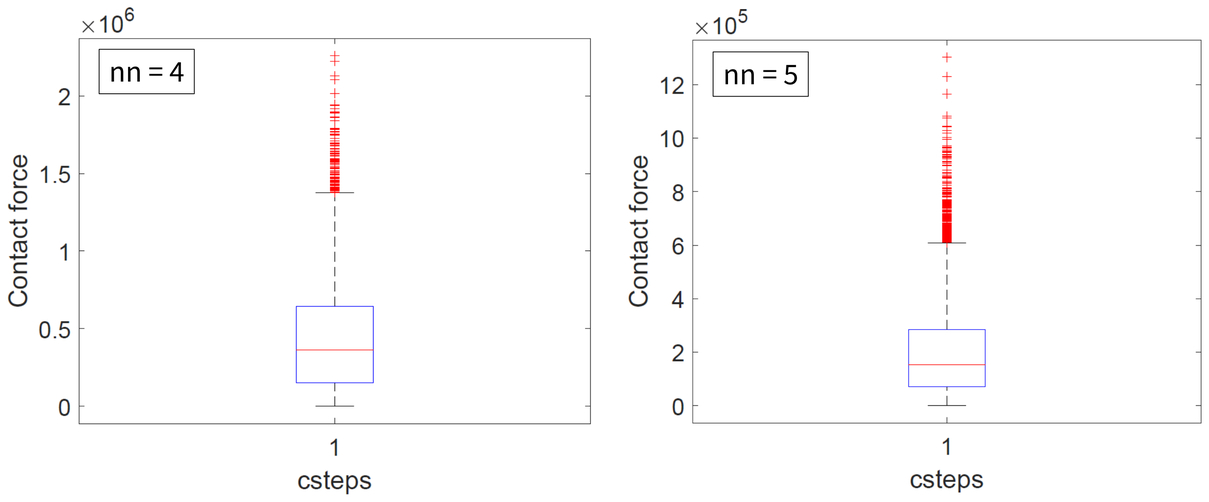
Influence on Contact Force

The influence of uncertainty in profilometric data on the contact force between two rough surfaces is determined. This is done using a Monte-Carlo simulation of 10.000 iterations to estimate the mean and the variance of the contact force.

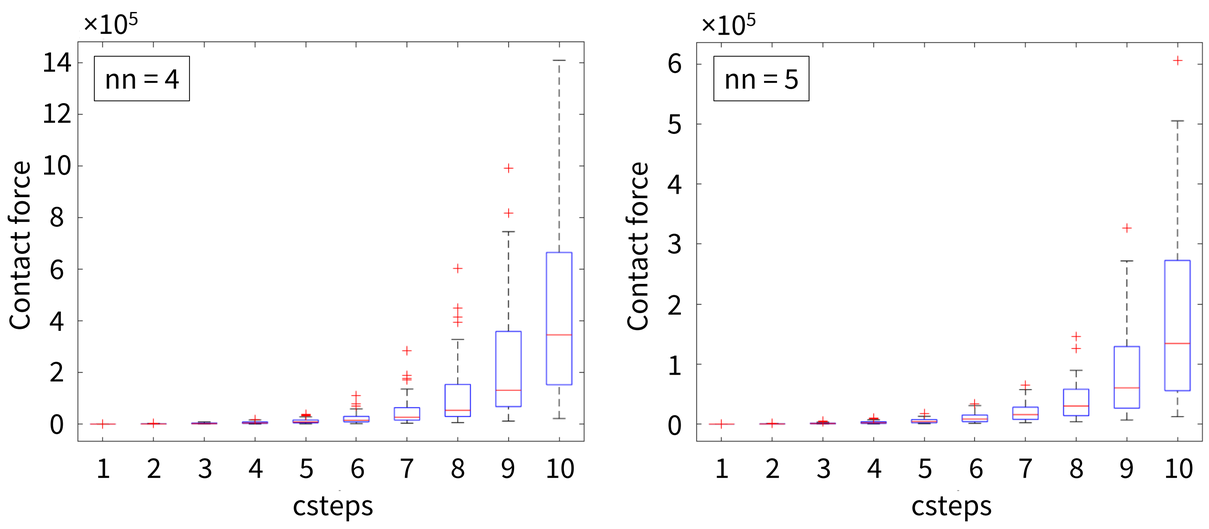
Results and Visual Representation

	Mean	Variance	Standard deviation
nn = 4	4,3637765E+05	1,1778933E+11	3,4320450E+05
nn = 5	2,0111503E+05	2,9100562E+10	1,7058887E+05

- Mean decreases with growing fineness (nn: number of iterations in RMD) of the surface
- Very big variance for every fineness



- Boxplots show an asymmetric distribution around the mean
- Large number of outliers with higher contact force



- Contact force grows with increased displacement of the rough surface

Conclusion

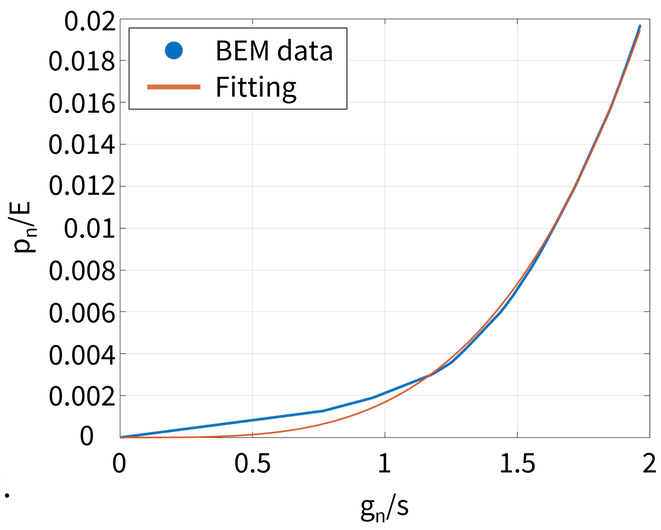
- Small changes in topology have a big influence on the contact force
- Uncertain results for a small number of iterations
- Influence of uncertainty grows with displacement
- The dimension of the contact forces gets smaller with increasing fineness

Influence on Fitted Function

MATLAB is utilized to fit a function to the results concerning the change of the contact pressure with increasing displacement.

The function is set to be of the form $c(1) \cdot x^{c(2)}$ to describe the contact pressure based on the displacement.

To examine the influence of uncertainty on this function and therefore on its coefficients, another Monte-Carlo simulation is conducted.

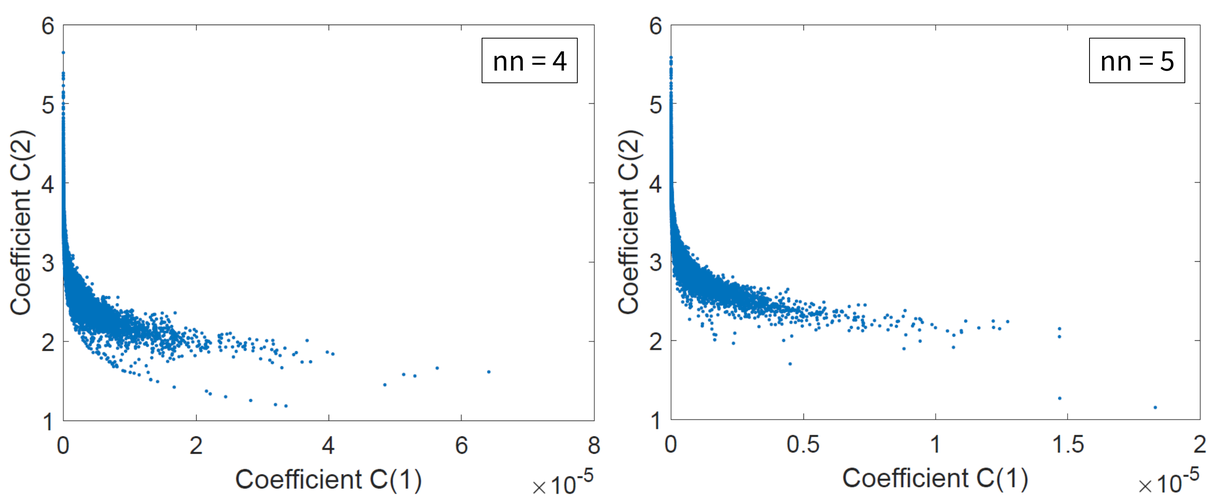


Results and Visual Representation

nn = 4	Mean	Variance	Covariance	Pearson's correlation coefficient
c(1)	2,2702414E-06	1,5510817E-11	-1,2679141E-06	-6,2150769E-01
c(2)	2,8686909E+00	2,6831932E-01		

nn = 5	Mean	Variance	Covariance	Pearson's correlation coefficient
c(1)	6,1428673E-07	1,2176418E-12	-3,4011400E-07	-6,2198716E-01
c(2)	3,2178179E+00	2,4556510E-01		

- Coefficient c(1) is smaller than c(2) leading to the small covariance
- The variance of c(1) is, relative to its mean, significantly smaller than the variance of c(2)



- The distribution of points resembles a function $x^{-b}, b > 0$
  → Legitimate result, knowing the fitted function is $c(1) \cdot x^{c(2)}$
- Variation of fineness has a big impact on c(1), but a minor one on c(2)

Conclusion

- Different influence of uncertainty on coefficients
- c(2) hardly influenced compared to c(1), few dependance on fineness
- Heavy influence of uncertainty on c(1), seen in big variance
  → Nonlinear correlation between displacement and contact pressure