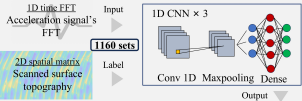


Acceleration signal → Surface reconstruction



1D Spatial FFT

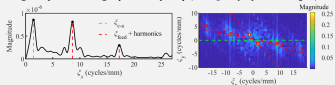
1D Spatial FFT

2D Spatial FFT

① Amplitude A

② Spatial frequency ξ

③ Superposition angle ϕ



$$\text{via } z_i = A_i \cdot \sin(2\pi \cdot \xi_i \cdot (\cos(\phi_i) \cdot (x - \Delta) + \sin(\phi_i) \cdot y))$$

Reconstructed surface

Mark1

Mark2

Mark3

Superposition

Vibration energy based indicator

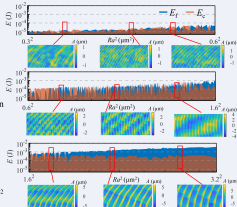
Cutting tool as spring-mass system, elastic energy: $E = 1/2 K x^2$

Surface height z reflects tool tip displacement x :

$$E = \frac{1}{N} \times \frac{1}{2} K \sum_{i=1}^n \sum_{j=1}^m z_{ij}^2$$

Marks are classified as forced vibration or chatter, with energy computed as

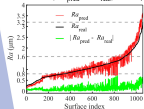
- Total vibration energy E , $r = 0.98$, highly correlated with Ra^2
- Forced vibration energy E_f , $r = 0.95$
- Chatter energy E_c , $r = 0.33$



Reconstruction quality

Quantitative evaluation:

Absolute error $|Ra_{pred} - Ra_{real}| < 0.5 \mu m$



Intuitive comparison of real (scanned) and reconstructed surfaces:

Real Reconstructed Real Reconstructed

