PERCEIVED EMOTION INDUCED BY A SURFACE WITH RANDOM ROUGHNESS

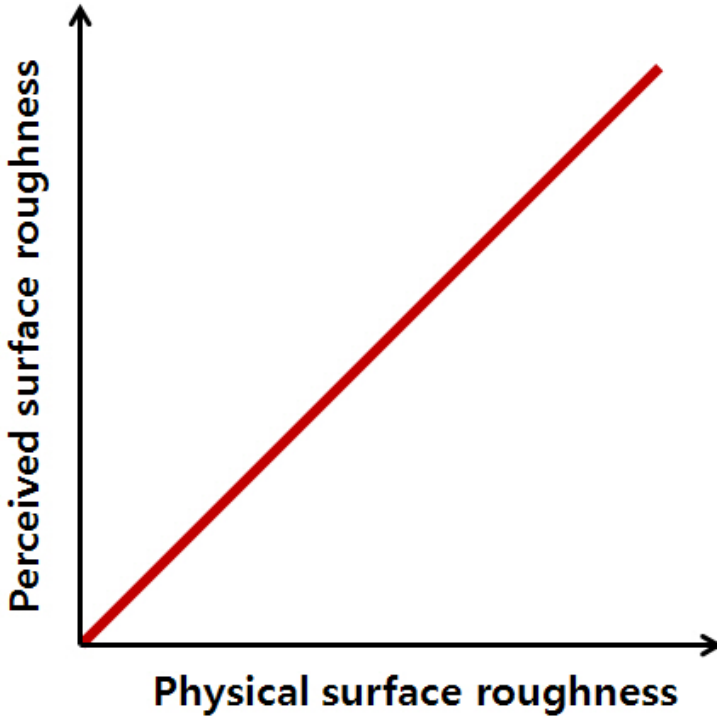
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Physical vs. Perceived Roughness

- Physical Roughness

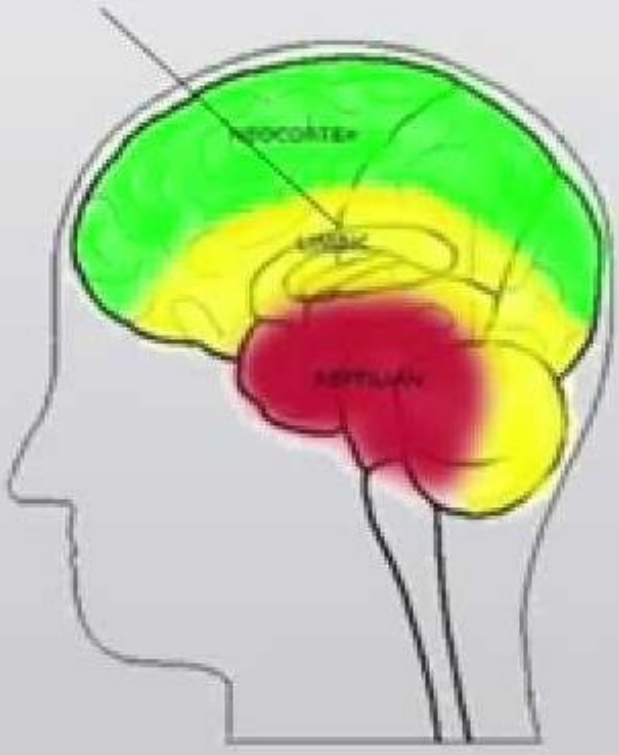
  ≠ Perceived Roughness



Daniel Kanehman's two systems

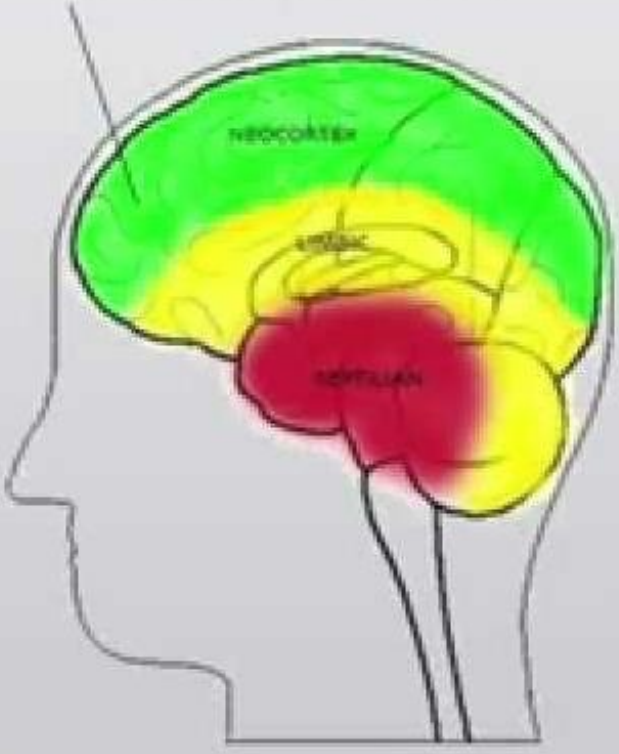
"FIRST REACTIONS"

System 1 ≈ fast, automatic, impulsive, associative, **emotional**, and unconscious processing ≈ limbic.



"THINKING"

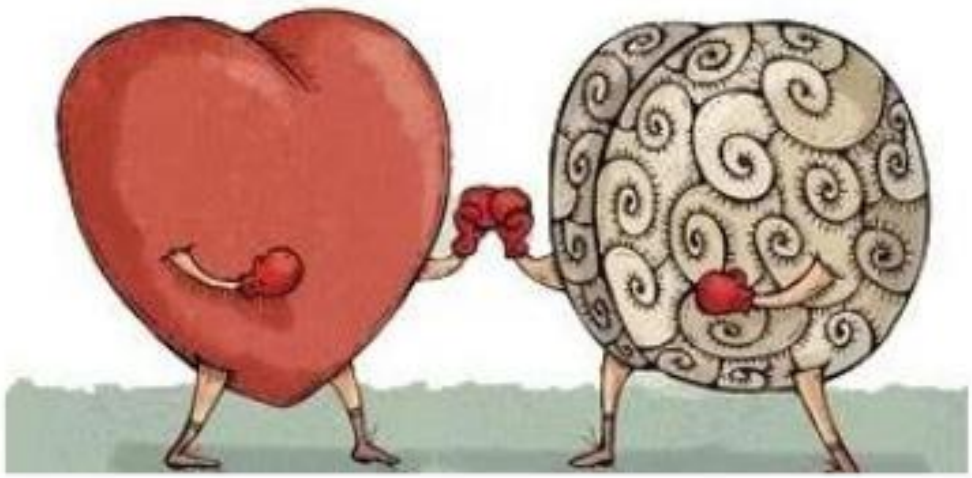
System 2 ≈ slower, conscious, reflective, deliberative, analytical, rational, logical processing ≈ neocortex.



Why emotion is important?

95%

System 1
(Non-rational brain)



5%

System 2
(Rational brain)

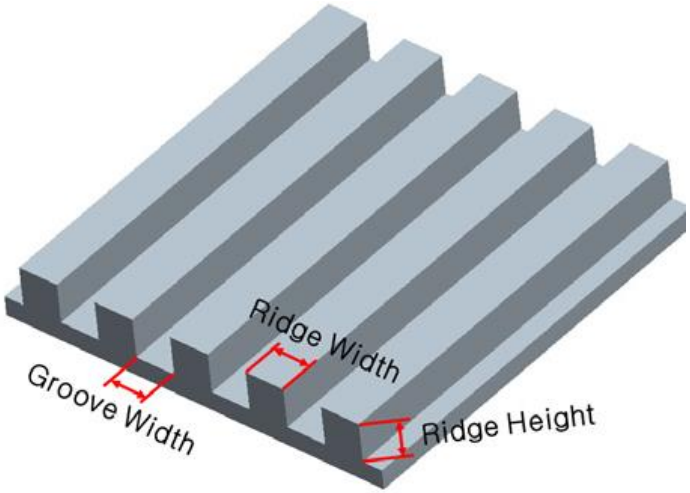
Kansei (感性) Engineering:

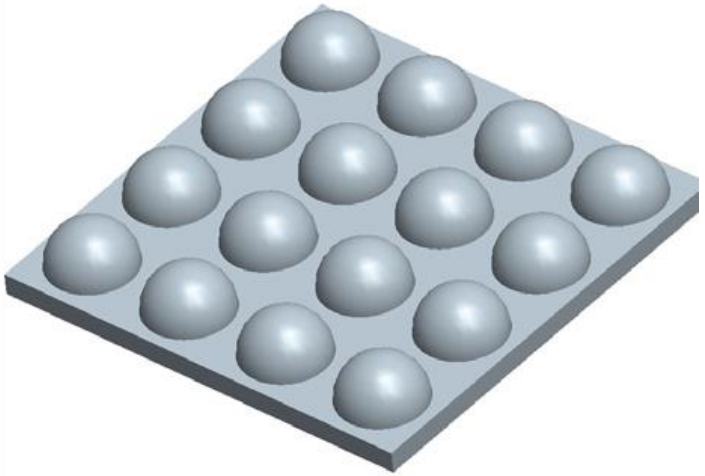
- Relating emotional descriptors with design variables to help designing emotionally appealing products
- Kansei : the customers' feeling for a **product**
- Established by Nagamachi, Japan in 1989
- Similar approaches observed in the area of advertising sector

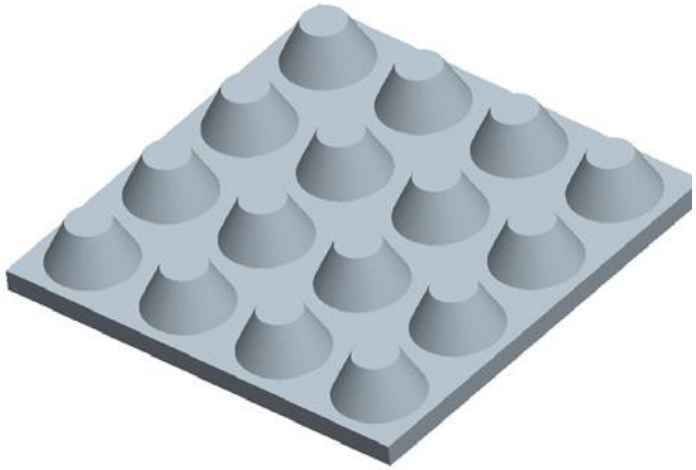
Procedures

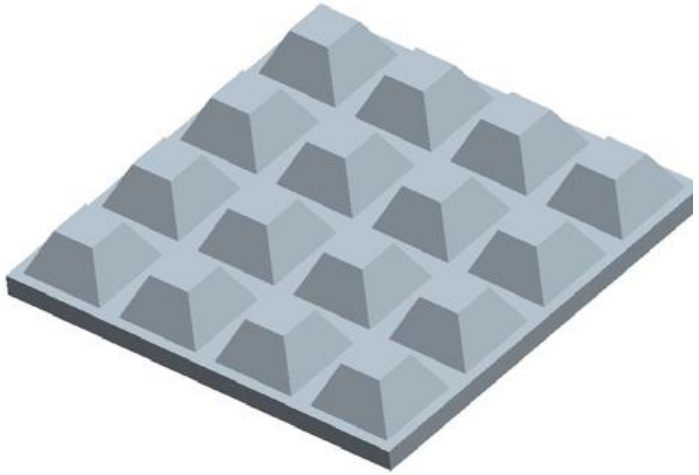
- Collecting emotional descriptors
  - from literature, experiment, pre-developed descriptors
- Relating preferred emotions with design alternatives
  - by experiment; consumers evaluate product with the collected emotional descriptors
- Dimensional analysis of identified emotions
  - factor analysis of identified emotions
- Build a predictive model explaining customer emotion/satisfaction according to design variables
  - by relating emotional factors with design variables

Surface with regular pattern



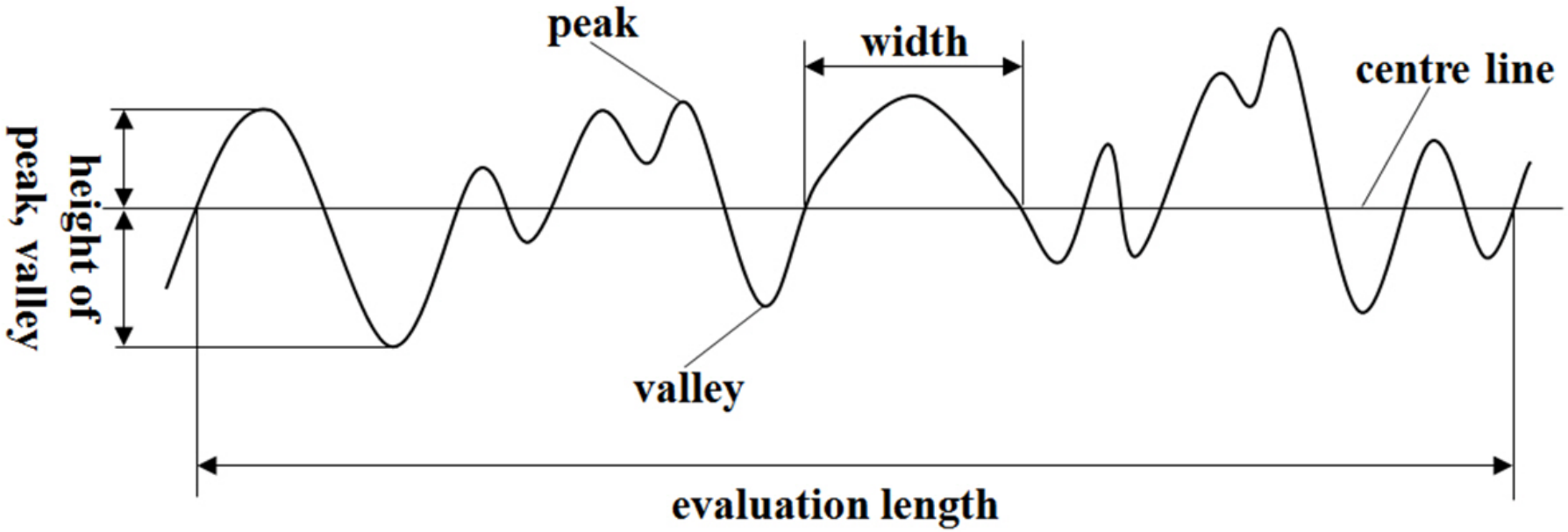






Natural surface

- What defines naturality?

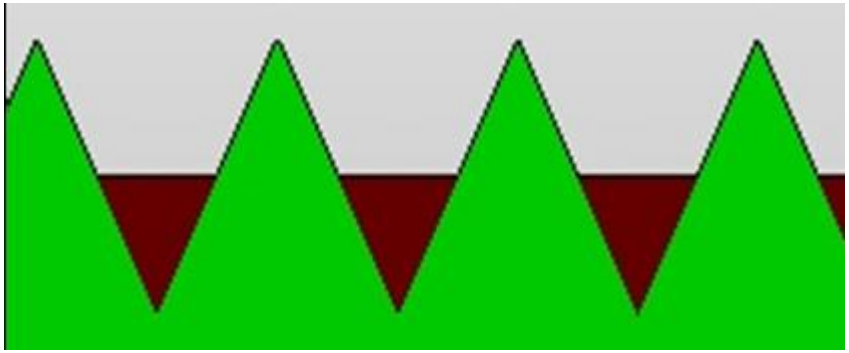


Methods

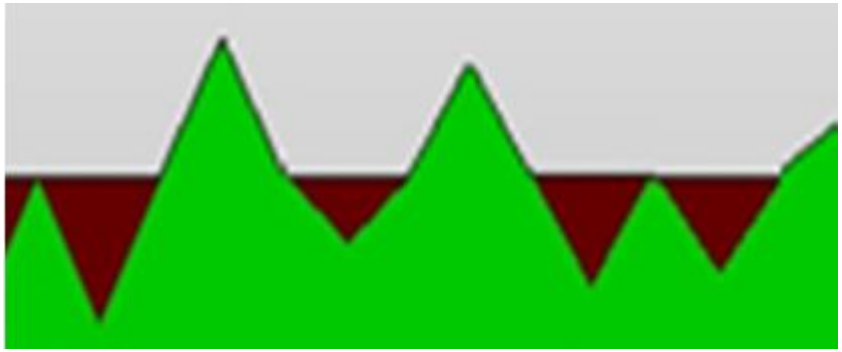
- Fabrication of specimens
- Measurement of physical characteristics
- Measurement of perceived roughness
- Relating perceived roughness with physical characteristics

Fabrication of sample surface

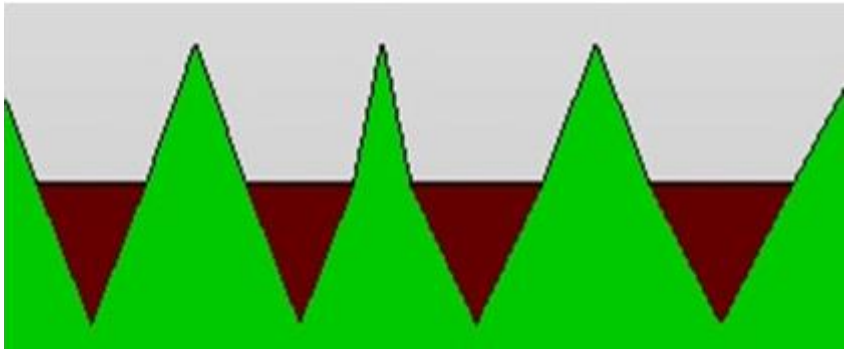
- Sample surface fabrication by 3D printing methods



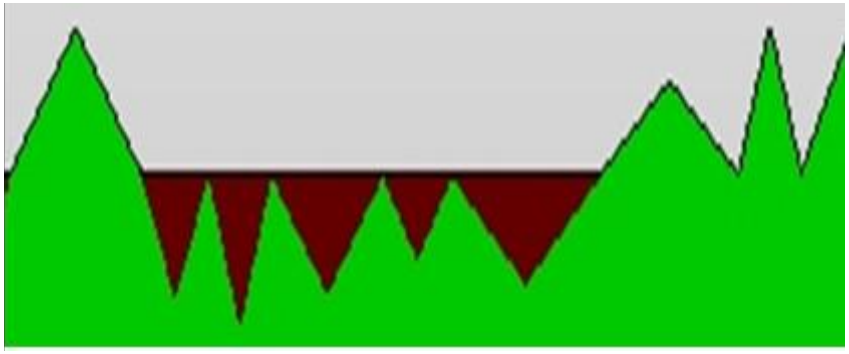
Set I



Set II



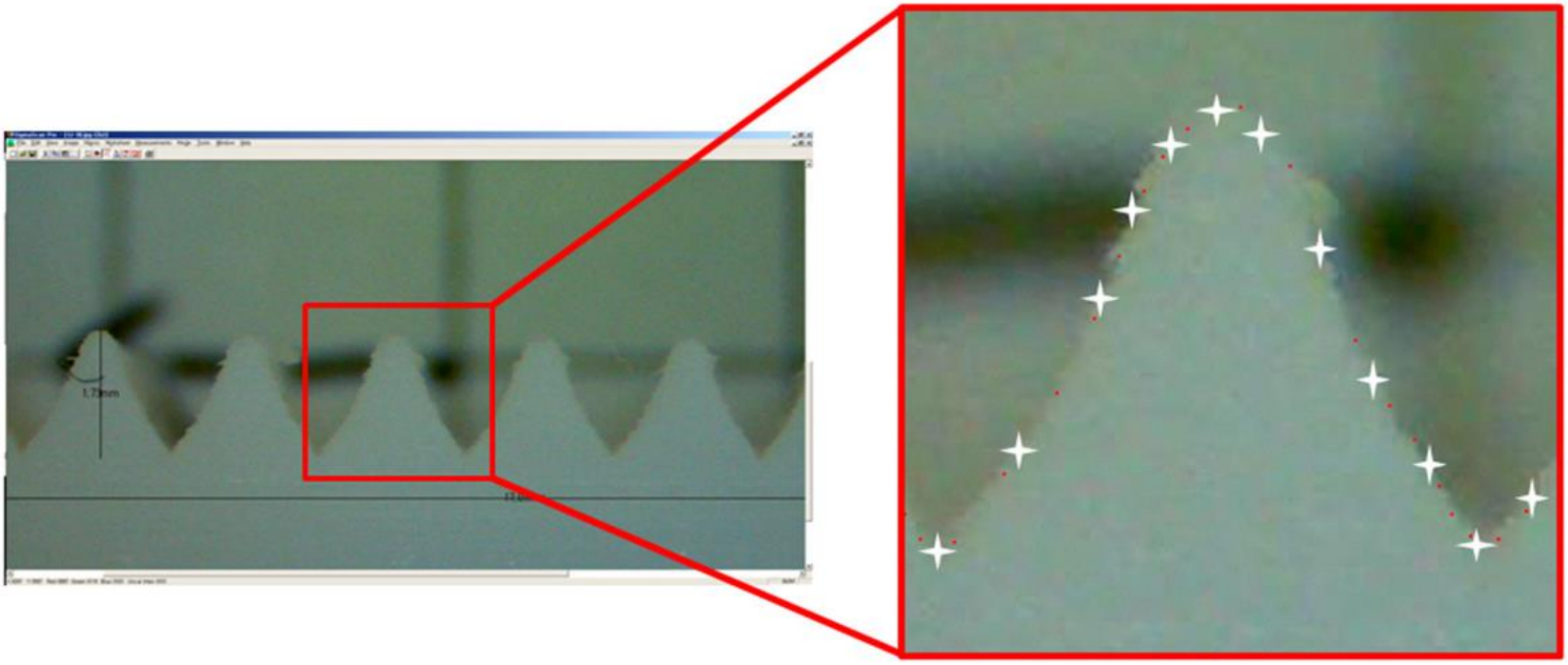
Set III



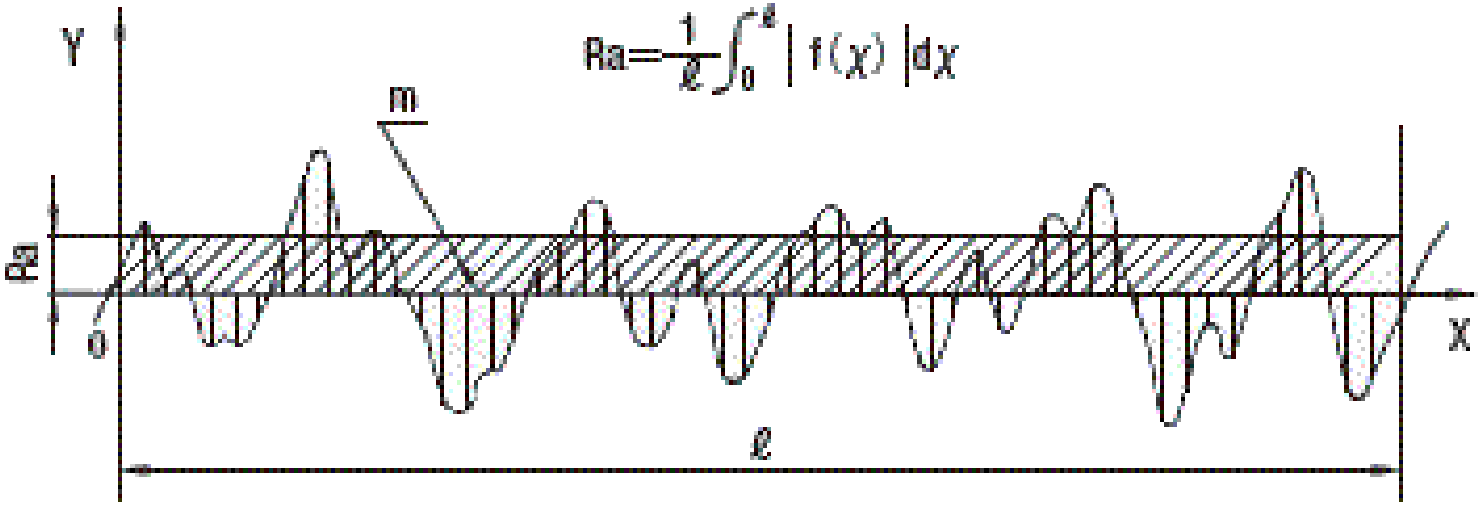
Set IV

Physical Roughness Measurement

- Measuring the roughness by machine vision

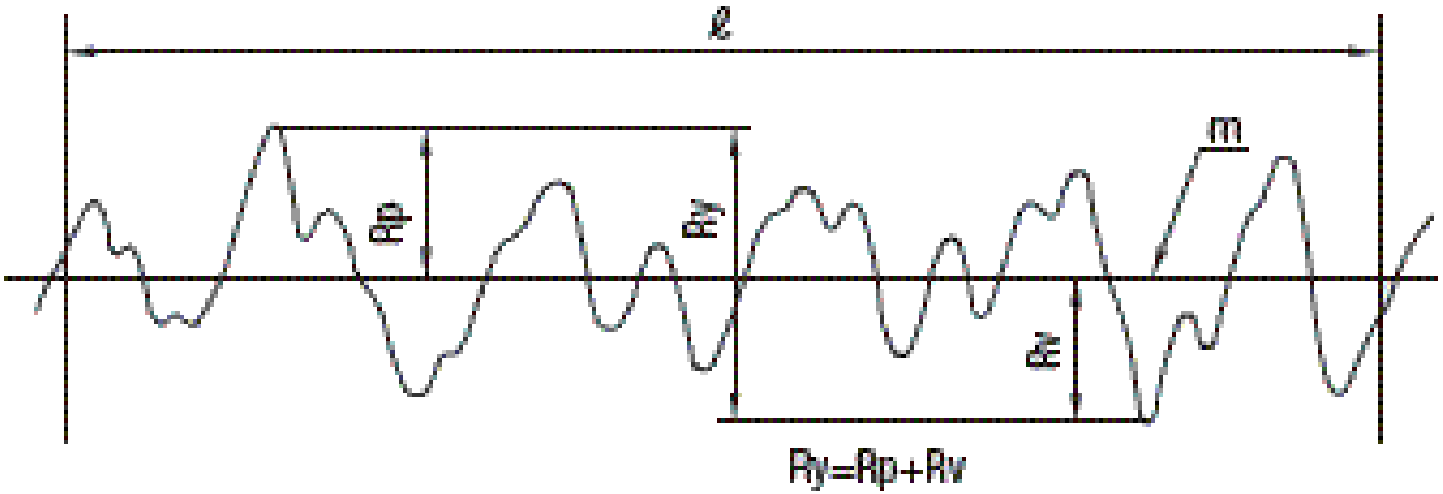


Arithmetical average roughness (Ra)



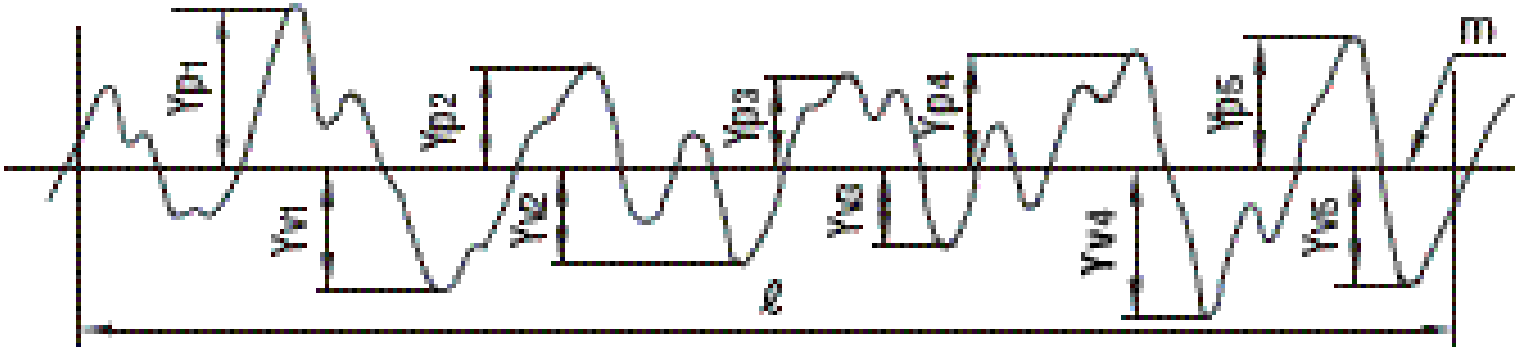
- A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. This portion is presented in a new graph with the X axis extending in the same direction as the average line and the Y axis representing the magnitude. When the roughness curve is represented by y=f (X), Ra is the value in microns (μm) found from the formula above.

Maximum height (Ry)



- A portion stretching over a reference length in the direction in which the average line extends is cut out from the roughness curve. The gap between the peak line and valley line in this portion is measured in the direction of the magnitude axis, and this value is indicated in microns (μm).

Ten-spot average roughness (Rz)

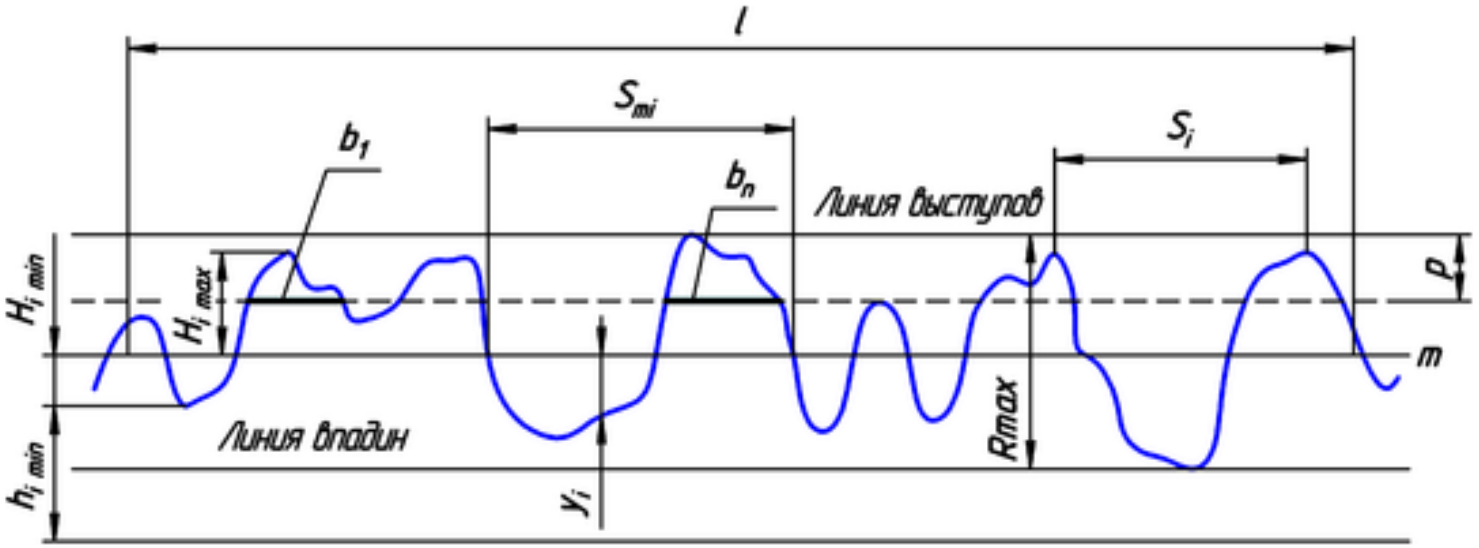


$$Rz = \frac{|Yp_1 + Yp_2 + Yp_3 + Yp_4 + Yp_5| + |Yv_1 + Yv_2 + Yv_3 + Yv_4 + Yv_5|}{5}$$

Yp_1、Yp_2、Yp_3、Yp_4、Yp_5 : Heights of the of top five peaks within the sampled portion of reference length ℓ

Yv_1、Yv_2、Yv_3、Yv_4、Yv_5 : Heights of the five lowest valleys within the sampled portion of reference length ℓ

Spacing measurements

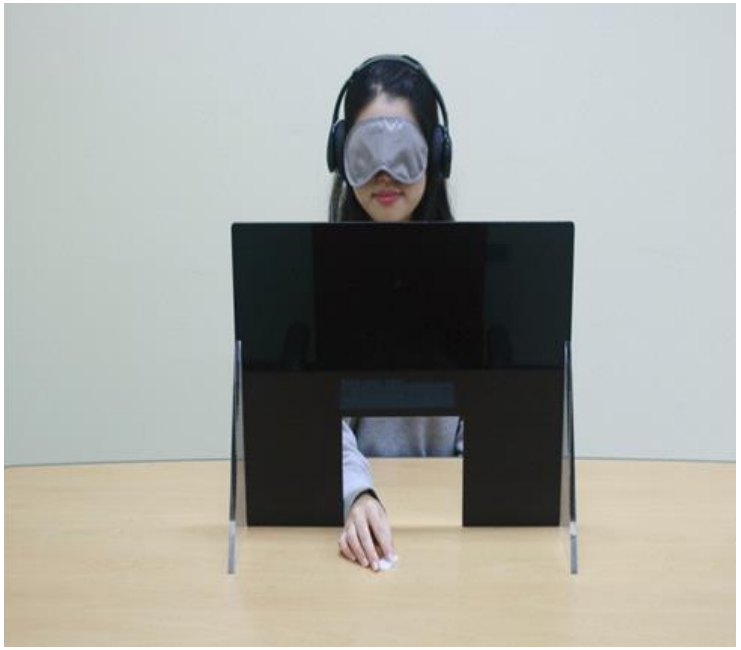


- Sm, mean spacing of profile irregularities
- S, mean spacing of local peaks of the profile

Perceived Roughness: Experiment

- 20 university students (16 male; 4 female) described perceived emotions after blindly touching the test specimens





Emotional evaluation

- 16 adjectives representing emotions retrieved by literature review

No	Adjectives
1	warm
2	cold
3	slippery
4	sticky
5	smooth
6	rough
7	hard
8	soft

No	Adjectives
9	uneven
10	flat
11	coarse
12	fine
13	dimply
14	grainy
15	sparse
16	slick

Physical vs. Perceived Roughness

	Set I	Set II	Set III	Set IV
Ra	0.761	0.897	0.868	0.956
Ry	0.710	**0.923**	**0.829**	**0.970**
Rz	0.718	0.888	0.838	0.872
Sm	**0.806**	0.316	0.521	0.442
S	**0.806**	0.033	0.553	0.286

Implications

- Surfaces with same height in its roughness:
  - Sm and S showed high correlation (> 0.7) with perceived roughness
  - Thus, Sm and S represents best the perceived roughness for regular surface.

- Surfaces with random height and width:
  - Ra, **Ry**, and Rz showed high correlation (> 0.8) with perceived roughness.
  - Thus, **Ry** represents best the perceived roughness for irregular surfaces.

Dimensional Analysis

Set I: regular pattern

		Component		
		1	2	3
E13	Dimply	.852	-.084	.035
E11	Coarse	.850	-.102	.082
E14	Grainy	.836	-.252	.081
E9	Uneven	.828	-.300	-.038
E6	Rough	.795	-.389	-.065
E15	Sparse	.794	-.090	-.057
E7	Hard	.628	-.041	-.273
E12	Fine	-.179	.853	-.004
E5	Smooth	-.194	.852	-.079
E16	Slick	-.108	.852	-.084
E3	Slippery	-.177	.782	-.082
E10	Flat	-.149	.767	.003
E8	Soft	-.110	.591	.111
E4	Sticky	.108	.053	.851
E1	Warm	-.270	.080	.497
E2	Cold	.022	-.164	.245

Set IV: irregular pattern

		Component		
		1	2	3
E5	Smooth	.861	-.258	.010
E12	Fine	.851	-.235	-.016
E3	Slippery	.841	-.249	.036
E16	Slick	.825	-.199	.005
E8	Soft	.804	-.253	.041
E10	Flat	.792	-.276	.032
E13	Dimply	-.310	.826	.021
E14	Grainy	-.312	.823	.031
E9	Uneven	-.361	.806	-.012
E11	Coarse	-.202	.779	.035
E15	Sparse	-.244	.766	.003
E7	Hard	.053	.578	-.408
E6	Rough	-.258	.539	.005
E4	Sticky	-.005	.049	.764
E2	Cold	-.065	.117	.590
E1	Warm	.185	-.218	.488

Factor 1: rough/coarse

Factor 2: smooth/slick

Factor 3: sticky

Stepwise Regression

- Relating emotional factors with physical variables

Factors	Set I: regular pattern	Set IV: random pattern
F1:	1st: Sm 2nd: Ra	1st: Ry 2nd: S
F2:	1st: Sm 2nd: Ra	1st: Ry 2nd: Rz 3rd : Sm
F3:	1st: Ra	1st: Ry

Implications

- For regular surface, emotional factors can be explained by Sm and Ra.
- For irregular surface, emotional factors can be explained mostly by Ry.
- Same emotional factors could be explained by different physical characteristics depending upon its shape.

Questions?