Realizations of Objective Measurement Device of Haptic Softness and Their Expansion to Medical Field

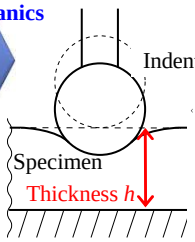
柔らかさ触感の客観データ計測デバイス実用化の達成事例と医療への応用展開

SAKUMA Lab., Tokyo University of Agriculture and Technology, Japan

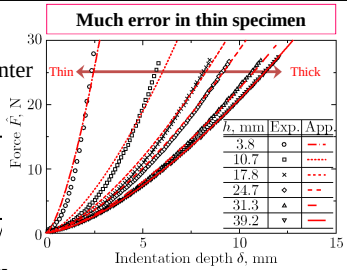
Measurement method of the elasticity (**Young's modulus**) by indentation theory based on palpation

Palpation

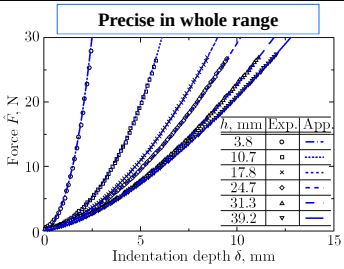
Mechanics

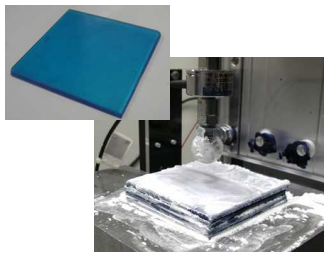


Much error in thin specimen



Precise in whole range





Organization can be evaluated and diagnosed only by touching

Hertz' Contact Theory

$$F = \frac{4}{3}\frac{E}{1-\nu^2}\left(\frac{\phi}{2}\right)^{\frac{1}{2}}\delta^{\frac{3}{2}}$$

Fundamental

$$\hat{F} = \frac{4}{3}\frac{E}{1-\nu^2}\left(\frac{\phi}{2}\right)^{\frac{1}{2}}\{(1+B\delta)\delta\}^{\frac{3}{2}} = \frac{4}{3}\frac{\hat{E}}{1-\nu^2}\left(\frac{\phi}{2}\right)^{\frac{1}{2}}\delta^{\frac{3}{2}}$$

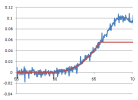
Extended Theory

Young's Modulus E

Elasticity (Young's modulus) is identified only by touching

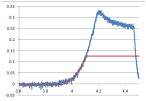
Examples of typical Young's modulus

Egg Yolk



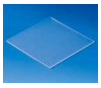
15.6 Pa

Sliced Ham



339 kPa

Silicone rubber



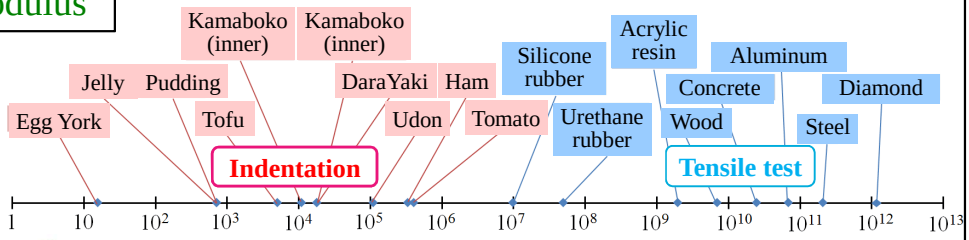
10 MPa

Steel

210 GPa

Diamond

1200 GPa



Typical Young's modulus E, Pa

Realization of Softness Evaluation for Various Substances by Common Index **"Young's modulus"**

Future deployment based on this technology

Developed System For Research
(1)High extendibility
(2)High precision force and displacement sensor

Low invasion for soft substances

Indentation Test

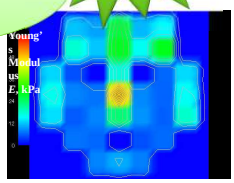
- Young's modulus measurement in consideration of thickness
- Application to measurement of viscoelasticity

Realization

Multi-purpose System by this technology

Diagnosis Devices

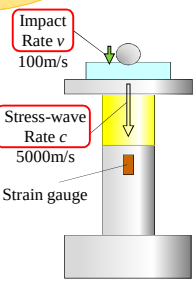
Realization



Medical & Cosmetics

Special Measurement

Realization



Transport Machine, and so on

Application & Development

Realization

Microscopic Devices

Medical Science

Handy Devices

Realization

Medical & Sports

All of softness in your surroundings can be Measured, Standardized and Shared easily, safely and precisely

Promotion of technology development by practical use of data with high objectivity

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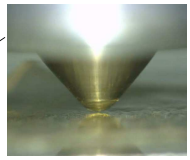
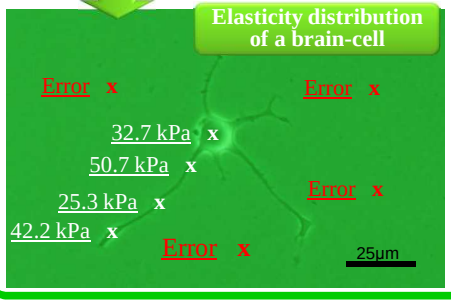
Softness Evaluation at Micron-level



Ball indentor
diamond, r = 500μm

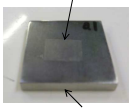
Super-microhardness tester
Shimadzu Corp.: DUH-211S
Resolution: 0.196 μN
Force Range: -1,961 mN

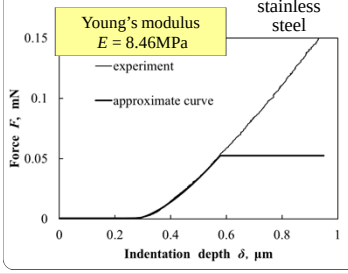
Measurement is possible even if ultra-thin



Measurement at micron level

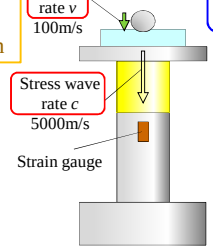
Thickness h = 0.1mm



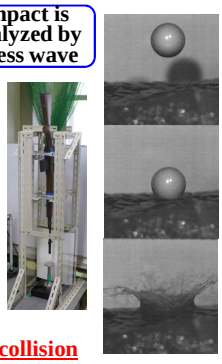


Softness Evaluation at Subsonic-level

Development of equipment using air gun

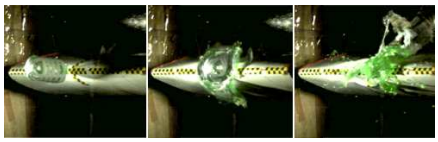


Impact is analyzed by stress wave



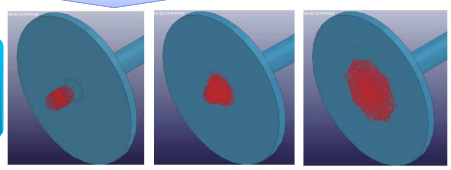
Application to mechanical design of collision

Collision test using airplane



Experimental Result by JAXA, Japan

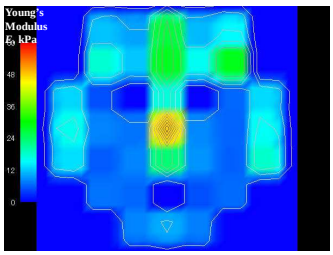
Mechanical analysis of collision by computer simulation



Advancement of design technology of machines

Softness Evaluation of Face Skin

Device under development

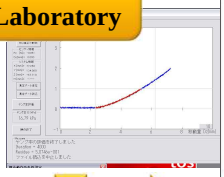


Example of elasticity distribution

Application to dermatology and cosmetics

Development of Handy Device

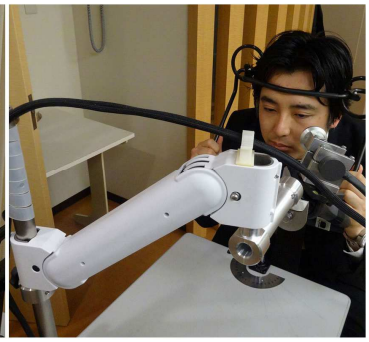
Software by Laboratory



Application to development of handy device

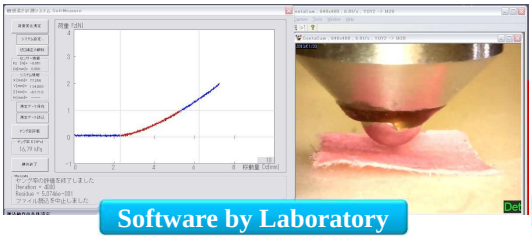
Application to Sports Science

Development of 6-DOF arm for Diagnosis



Application to Medical Science

Development of Desktop Devices



Software by Laboratory

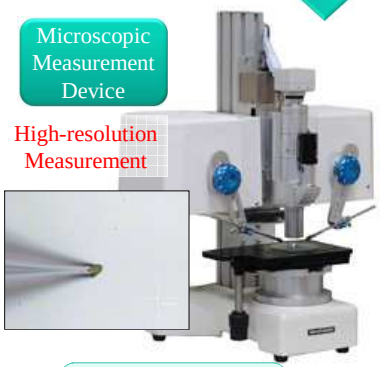
Softness Measurement Robot

Development by using Multi-purpose FA Robot

For various parts and materials

Microscopic Measurement Device

High-resolution Measurement



For various biological cell