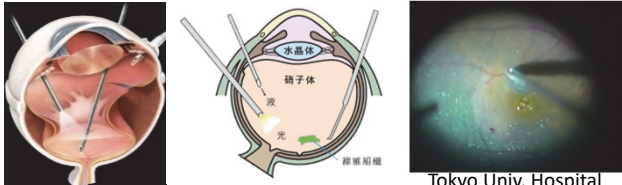


網膜モデル表面の変形分布を非接触計測!!

Background

Eye surgeries requiring skillful surgeons



Cannulation Internal limiting membrane (ILM) peeling Tokyo Univ. Hospital

ILM on retina: Thickness: approximately 3 μm
Retina: fragile tissue and **not regenerative**

Conventional surgical simulators

	Animal model	VR simulator
Image		
Merits	Similarity of structure	Confirmation of surgical process
Demerits	Young's modulus is different.	Impossible to use surgical tool

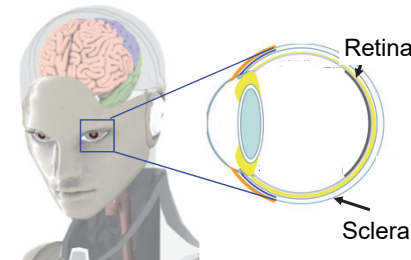
Conventional simulator **doesn't have sensors for evaluating skill.**

Requirement for model for surgical simulator

- Mimicking organs' characteristics
- Deformation sensing**

Concept

Mechanical properties of human eye



Bionic humanoid

Young modulus

Retina: **20 kPa**

Sclera: 1.8-2.9 MPa

Thickness

Retina: **300 μm**

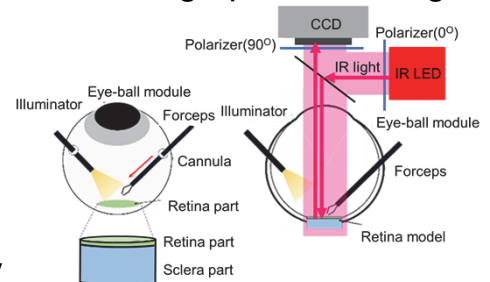
Sclera: 2 mm

Thomas R. Friberg, Experimental Eye Research, 47, 3, pp. 429-436, 1988.

Concept of measurement using optical sensing



Microscope for eye surgery



Deformation distribution of the surface of retinal model is **measured by image processing with digital image correlation.**

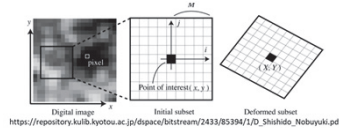
DIC algorithm

- Search a subset centered on the point of interest and a subset of higher correlation coefficient γ

$$\gamma(u, v) = \frac{\sum_{i=0}^m \sum_{j=0}^m (I(x+i+u, y+j+v) - \bar{I}) (I_0(x+i, y+j) - \bar{I}_0)}{\sqrt{\sum_{i=0}^m \sum_{j=0}^m (I(x+i+u, y+j+v) - \bar{I})^2 \sum_{i=0}^m \sum_{j=0}^m (I_0(x+i, y+j) - \bar{I}_0)^2}}$$

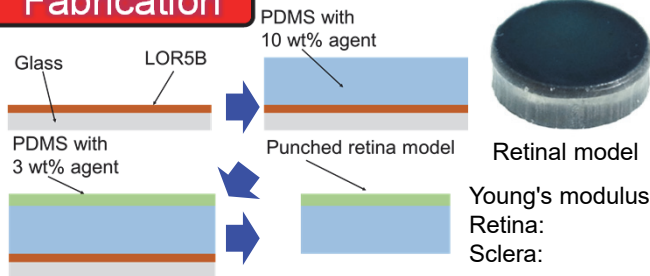
- Determination of u, v that maximizes $\gamma(u, v)$

x, y : Coordinates of focus point before deformation
 X, Y : Coordinates of focus point after deformation
 i, j : Coordinates in subset
 I_0, I : Luminance of digital image before and after deformation
 m : Subset size
 u, v : Displacement of focus point



https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/85394/1/D_Shikido_Nobuyuki.pdf

Fabrication

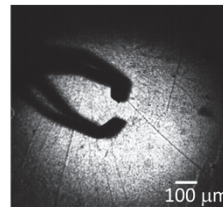
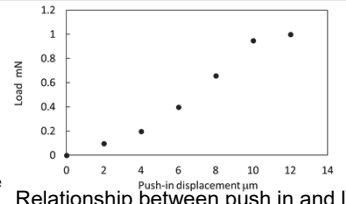
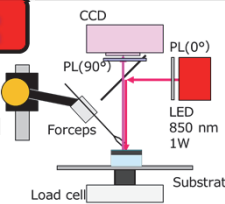


Reference

S. Endo, H. Maruyama, S. Omata, T. Masuda, F. Arai, Bionic Eye - Optical Contact Measurement of Retina Model-, Robomech2018, 1P1-L05, 2018

Experiment

Load cell:
Resolution: 0.01 mN
Stage: 2 mm/step
Light: 850 nm 1W



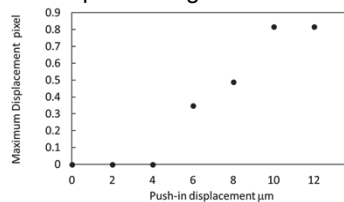
Acquired image



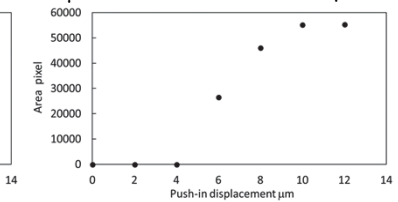
Push in: 0 μm



Push in: 12 μm



Maximum deformation of retinal surface Area of deformation of retinal model



Conclusions

Deformation distribution on retinal model mimicking Young's modulus was measured using DIC method.