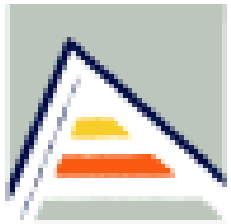

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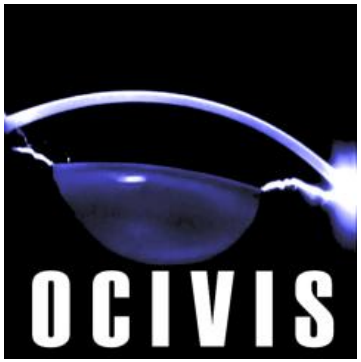

Look-up table of quadrics applied to corneal topography

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INTRODUCTION

CLASSIC INSTRUMENTS:

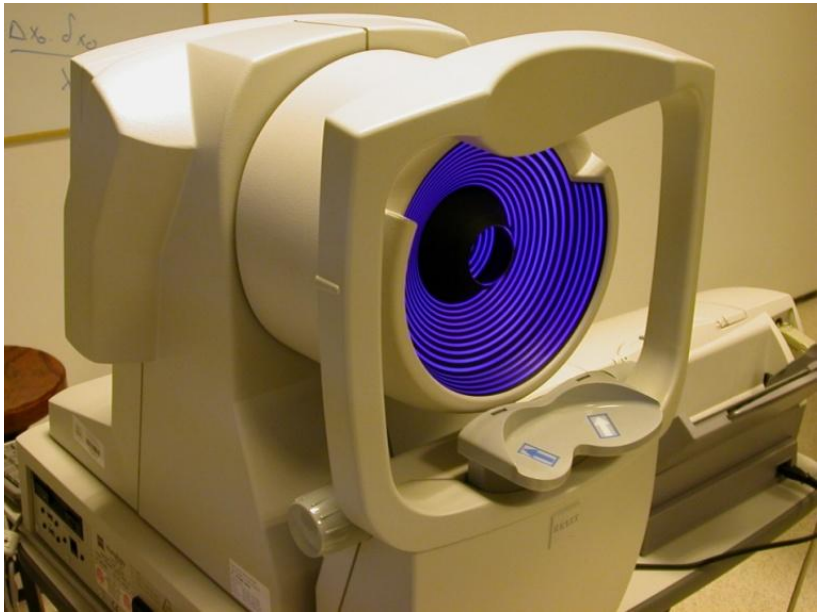
·Topography maps→Placido rings

MODERN INSTRUMENTS:

·Normal/Pathological shapes

·Contact lens fitting

·Refractive surgery



INTRODUCTION

ADVANTAGE

·Videokeratometers→ useful information about corneal topography and tear film

DISADVANTAGES

·Not control of camera and processing algorithms

·**HIDDEN** information

·Cartesian to polar coordinates → extrapolating corneal data

PURPOSE

- New look-up table method to convert acquired corneal data from reflected Placido rings to curvature radii

    * Full control algorithm and information
    * No extrapolation

WHAT WE DO?

- TO CALIBRATE A TOPOGRAPHER HEAD

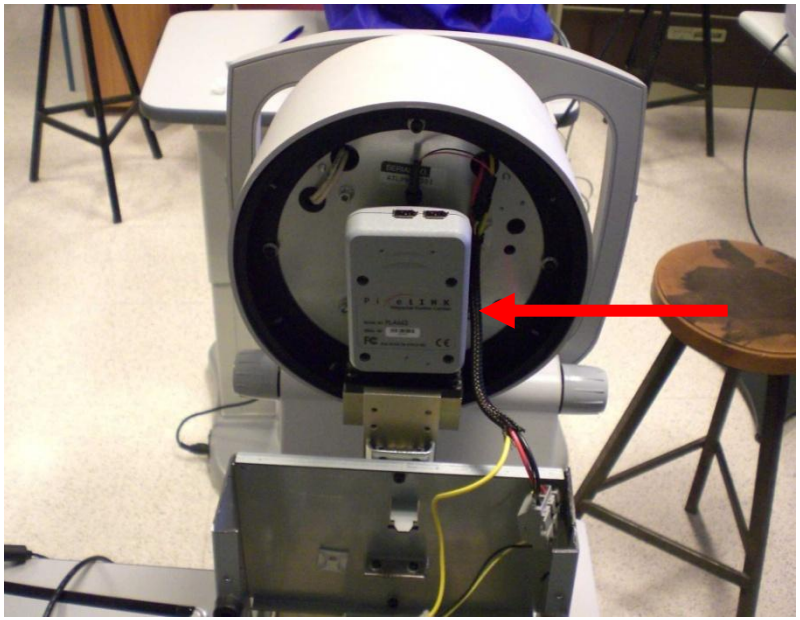
- PROCESSING ALGORITHM
  - RINGS EXTRACTION
  - RINGS LABELLING
    - ELLIPTICAL SCANNING ALGORITHM

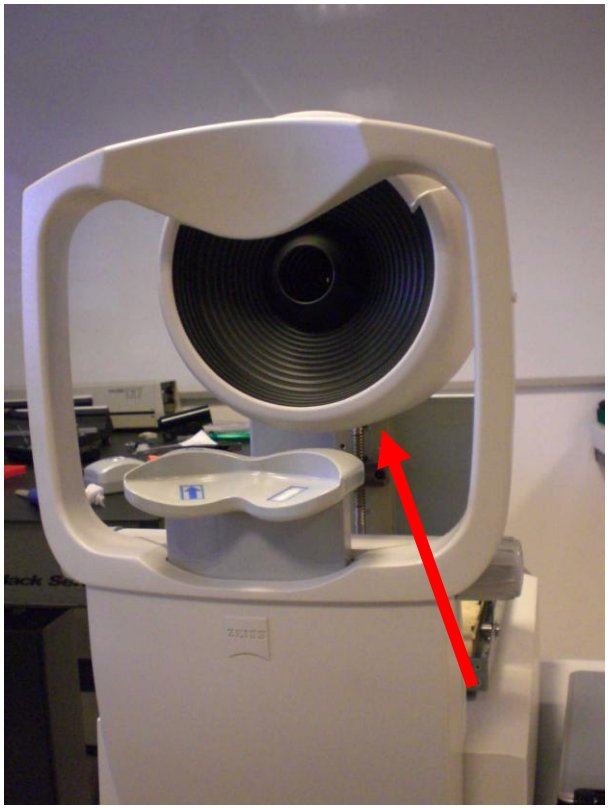
EXPERIMENTAL SETUP

·Corneal topographer → Humphrey Atlas 995 of Zeiss Meditec, 22 rings and IR light

·Video Camera→ CMOS color camera PL-A662 FireWire PixeLINK with 1Mpx

·CCD→ back of the head





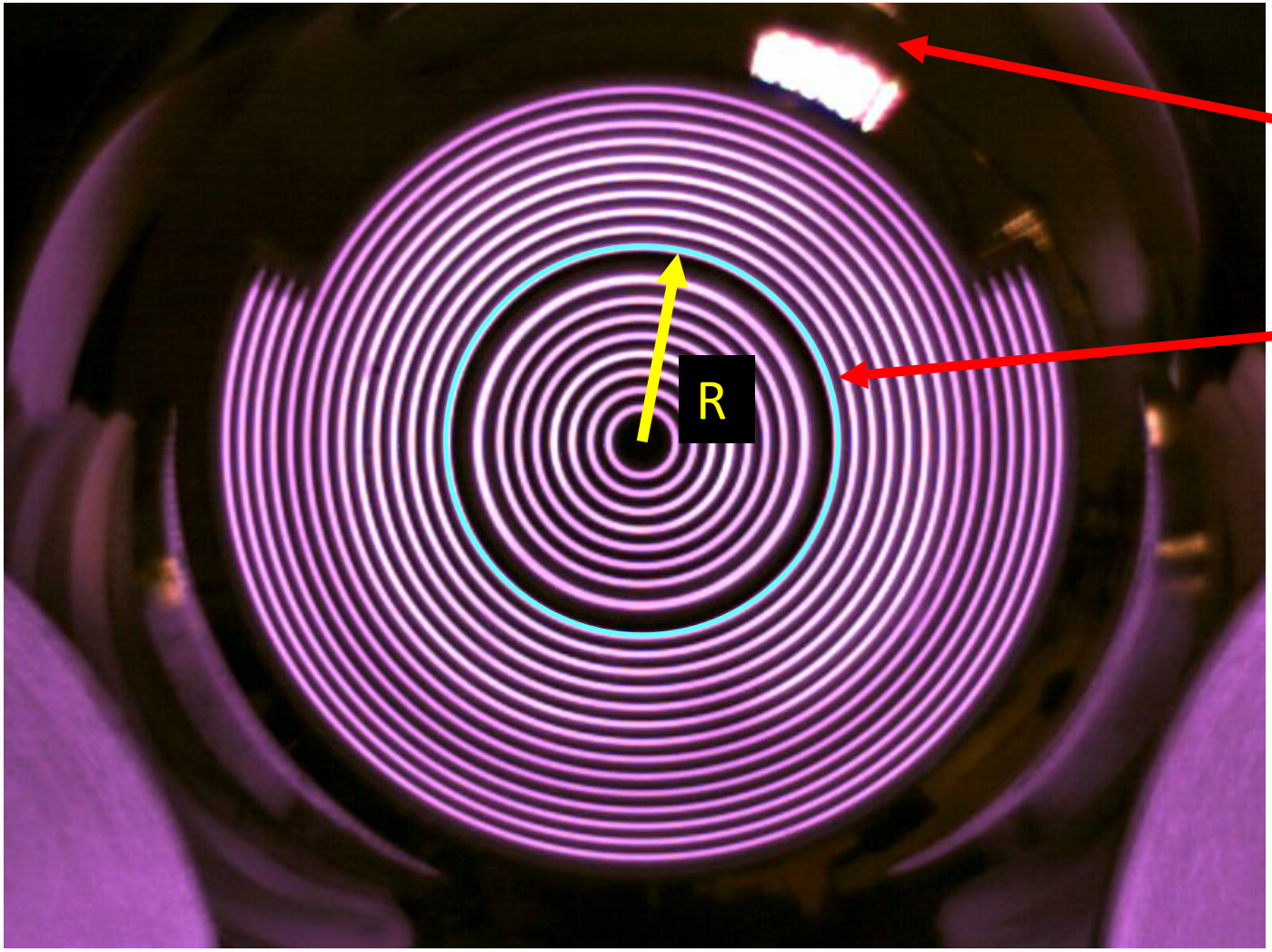
CALIBRATION PROCESS

- Corneal reflection of Placido ring→keratometric principle as

$$R = \frac{hC}{2z}$$

- 16 steel spheres

- Spheres in front of topographer → reflected Placido rings on each one



Sphere C=8 mm

Ring nº 9
R(px)

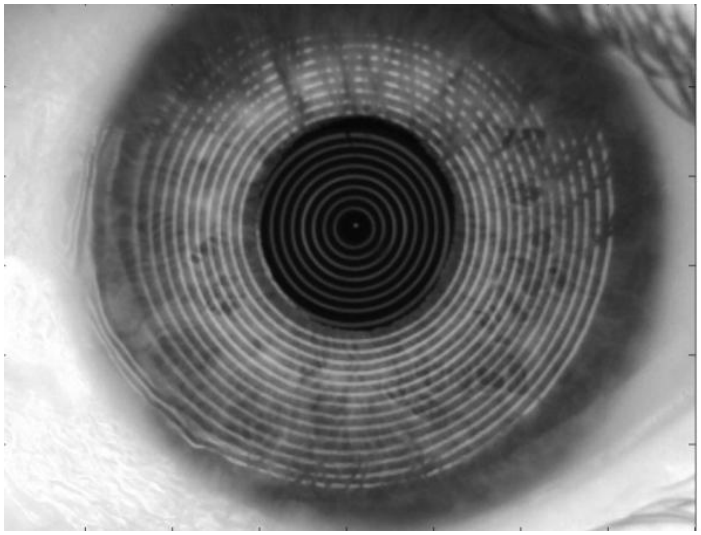
$$R = \frac{hC}{2z}$$

RING EXTRACTION

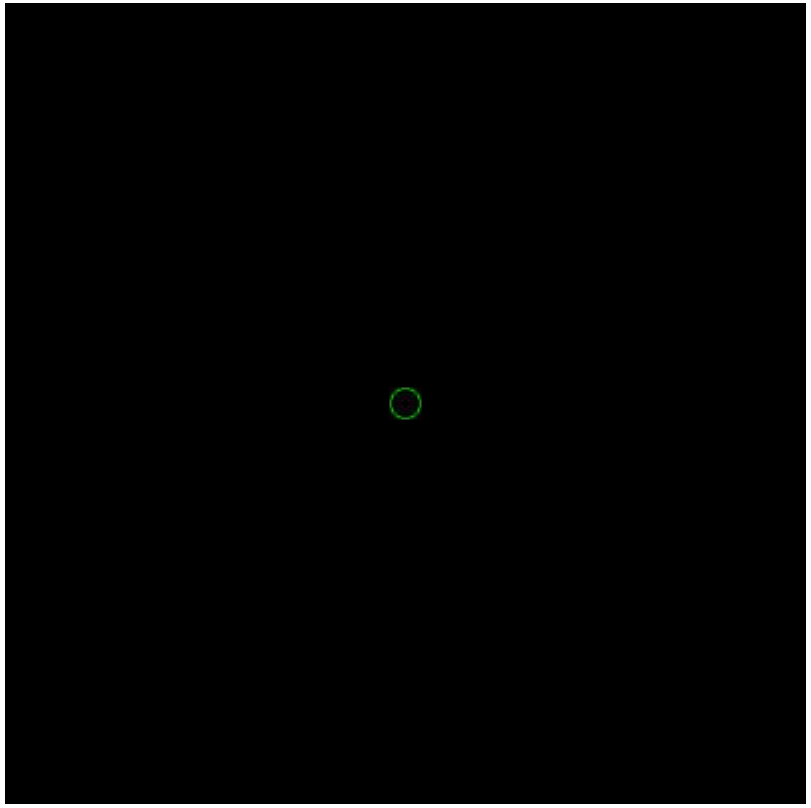
- **Placido rings**→ eyes surface
- **Open top-hat** : detect wave crest $OTH_{FB}=(F - F \circ B)$
- **Close top-hat** : detect wave hollow $CTH_{FB}=(F \cdot B - F)$

To Improve Contrast

(Open Top-Hat) – (Close Top-Hat)



RINGS LABELLING
Elliptical scanning algorithm



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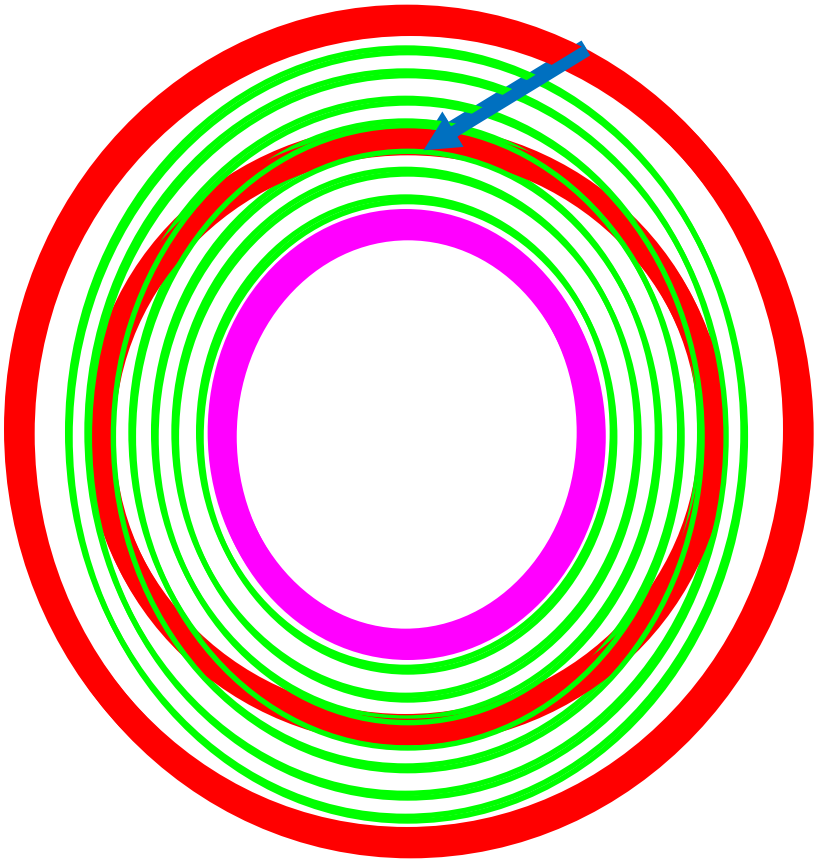

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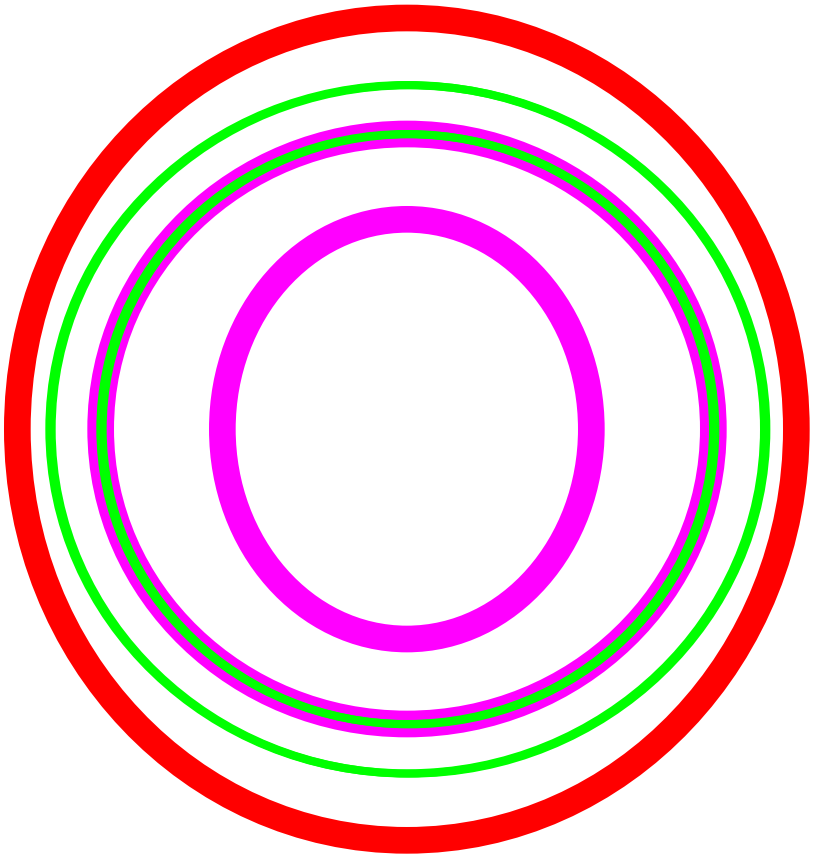


CALIBRATION EQUATIONS

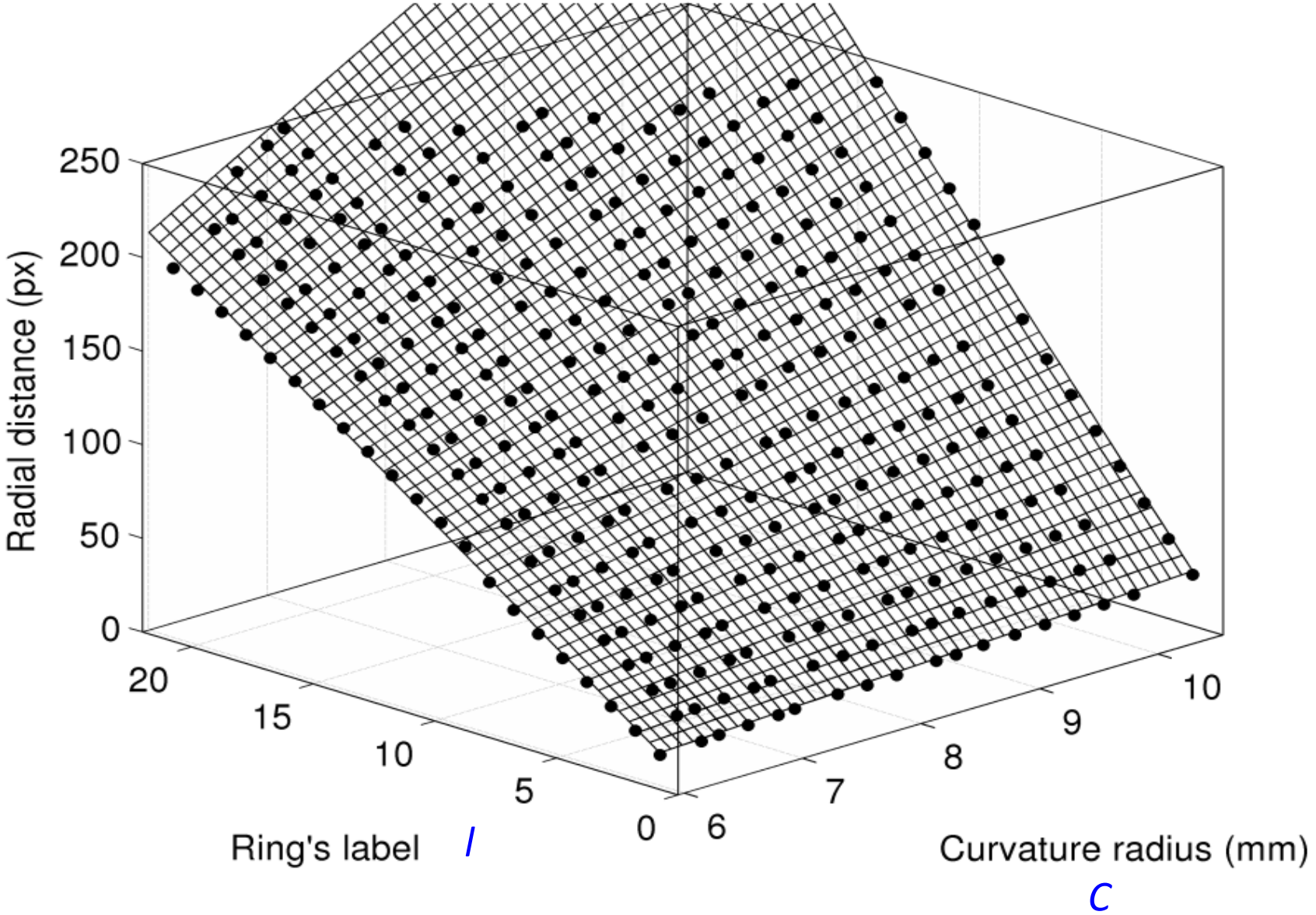
- Curvature surface

$$R = \frac{hC}{2z} \qquad \frac{h}{2z} = al + b$$

R=(*al*+*b*)C

- 3 variables
  - * Independent variable *l* (ring's label) and curvature radius *C*
  - * Radial distance R from fitting to a circle
  - * Coefficients (a) and (b) → least square fitting

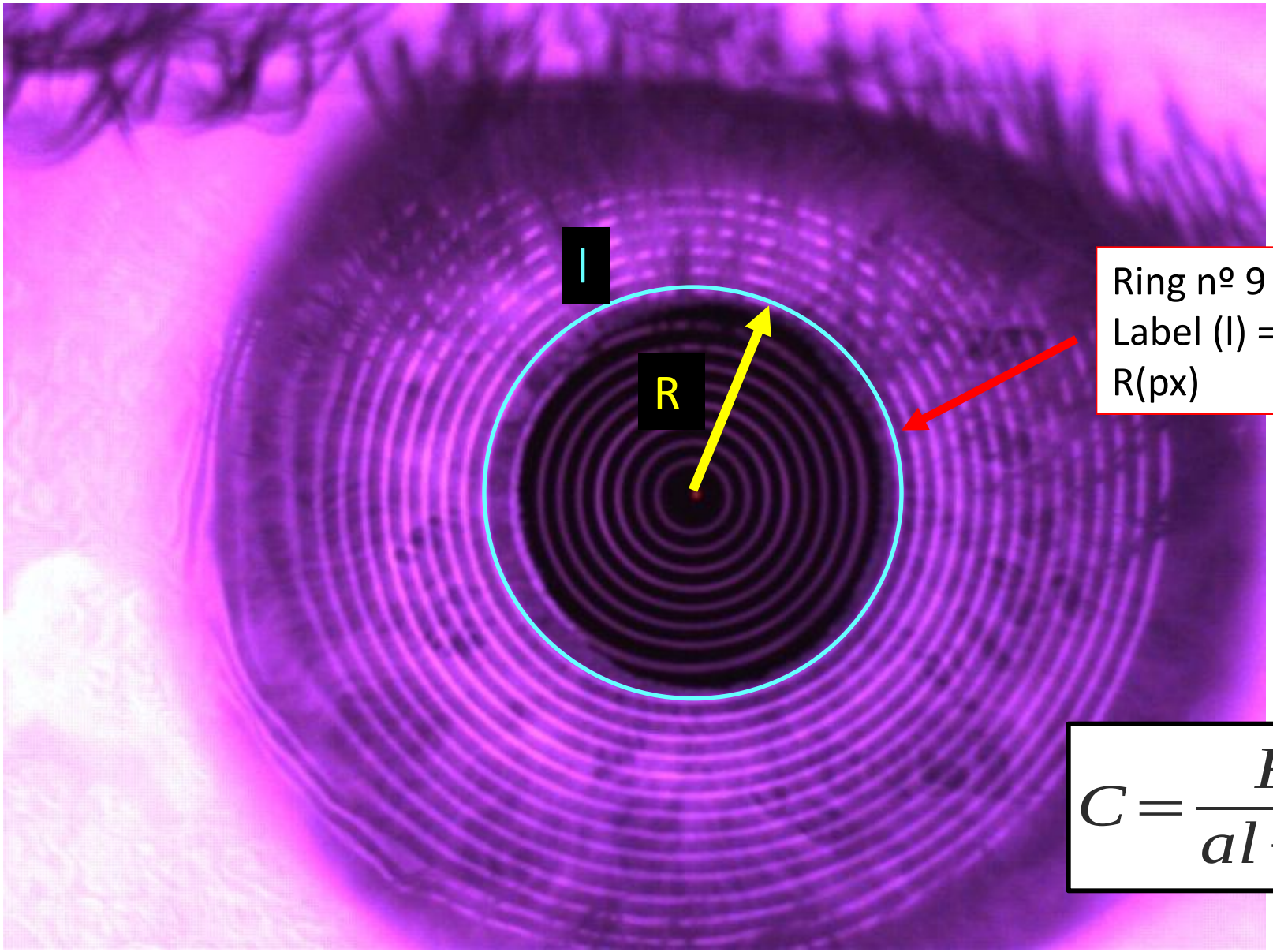
CALIBRATION EQUATIONS



R

I

C


I
R
Ring nº 9
Label (I) =9
R(px)
$C = \frac{R}{al + b};$

CALIBRATION EQUATIONS

- Curvature radius C(x,y), no C(R)

$$C=\frac{R}{al+b};\qquad \boxed{C(x,y)=\frac{R(x,y)}{(al+b)}}\qquad \boxed{(x,y)\in Ring_l}$$

$$R=\frac{hC}{2z};\qquad R^2=x^2+y^2;\qquad R=m_l C+n_l$$

- Quadric equation:

$$\boxed{x_l^2+y_l^2=m_l^2C^2+2m_l n_l C+n_l^2}$$

$$\boxed{v_l D_l v_l^T+E_l v_l^T+F_l=0}\qquad \boxed{V_l=\{x_l,y_l,c\}}$$

- Calibration equation for each ring

$$C(x,y)=(d_l x+e_l y+h_l+G_l(x,y))/2$$

with:

$$G_l(x,y)=((d_l x+e_l y+h_l)^2+4(a_l x^2+c_l xy+f_l x+b_l y^2+g_l y+k_l))^{(1/2)}$$

- C and (x_l,y_l) coordinates of data for each l ring →least –squares fitting.

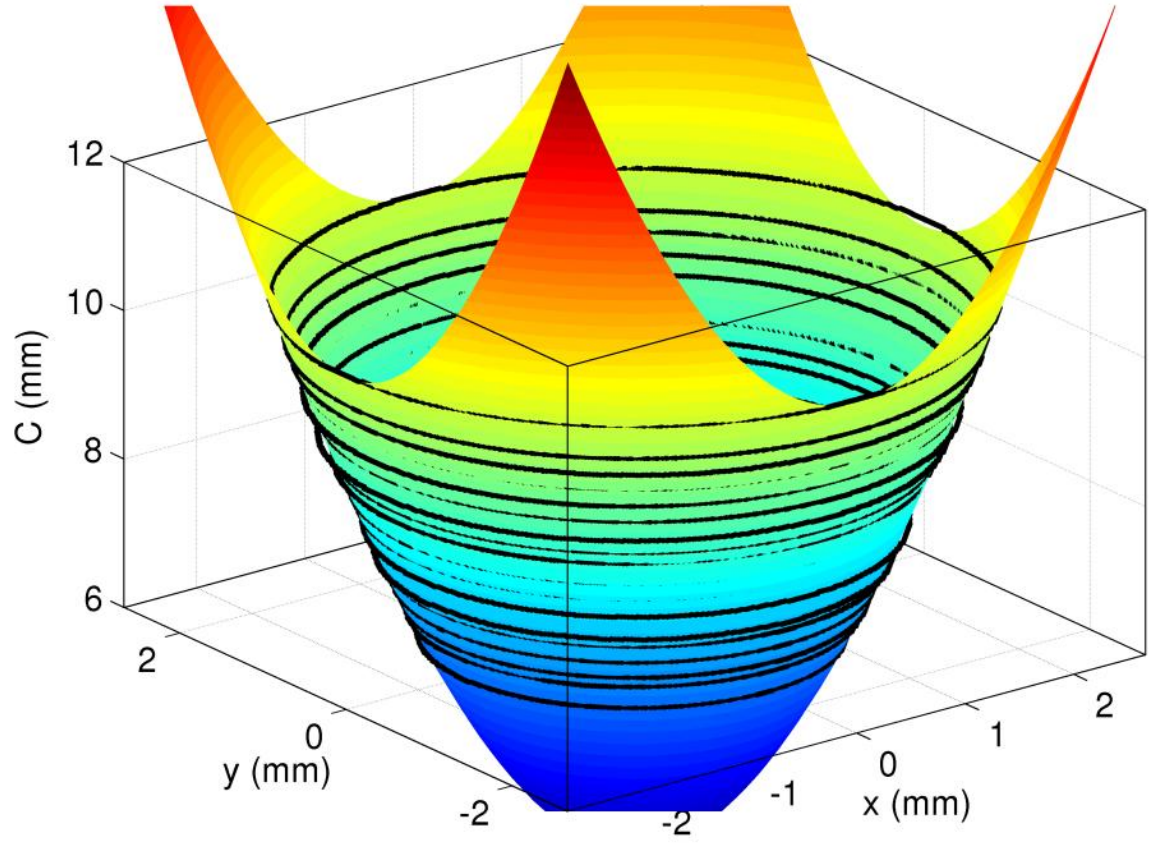
LOOK-UP TABLE OF QUADRICS

- Results for the fitting of ring 16

a_{16}	40.78(38.99,42.57)	f_{16}	3.01(2.67,3.34)
b_{16}	40.88(39.09,42.68)	g_{16}	1.10(0.07,1.41)
c_{16}	-0.08(-0.13,-0.04)	h_{16}	-26.16(-28.04,-24.29)
d_{16}	-0.35(-0.39,-0.31)	k_{16}	92.43(85.47,99.38)
e_{16}	-0.11(-0.14,-0.07)		

Parameters and confidence bounds of 95%

Data and surface resulting from the fitting



CONCLUSIONS

- The technique avoids extrapolating corneal data
- It overcomes the difficulty with the lack of symmetry of projected rings
- It provides a better description of the corneal morphology

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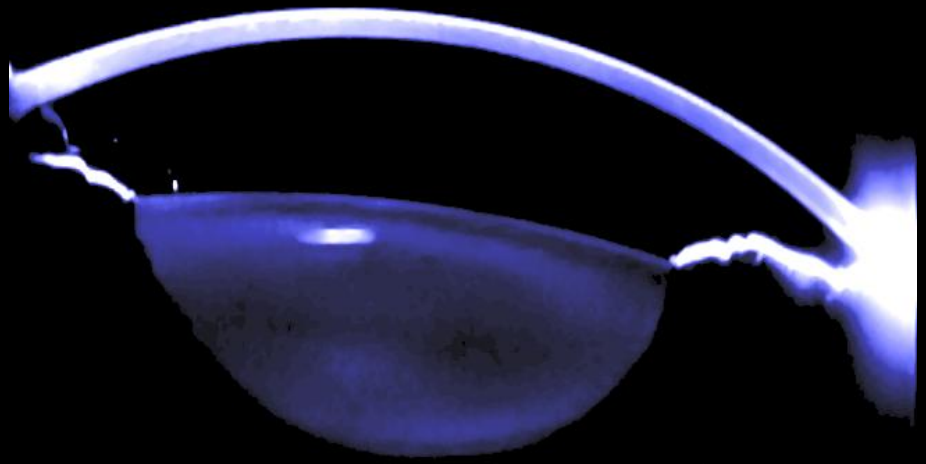

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http://web.ua.es/es/ocivis/