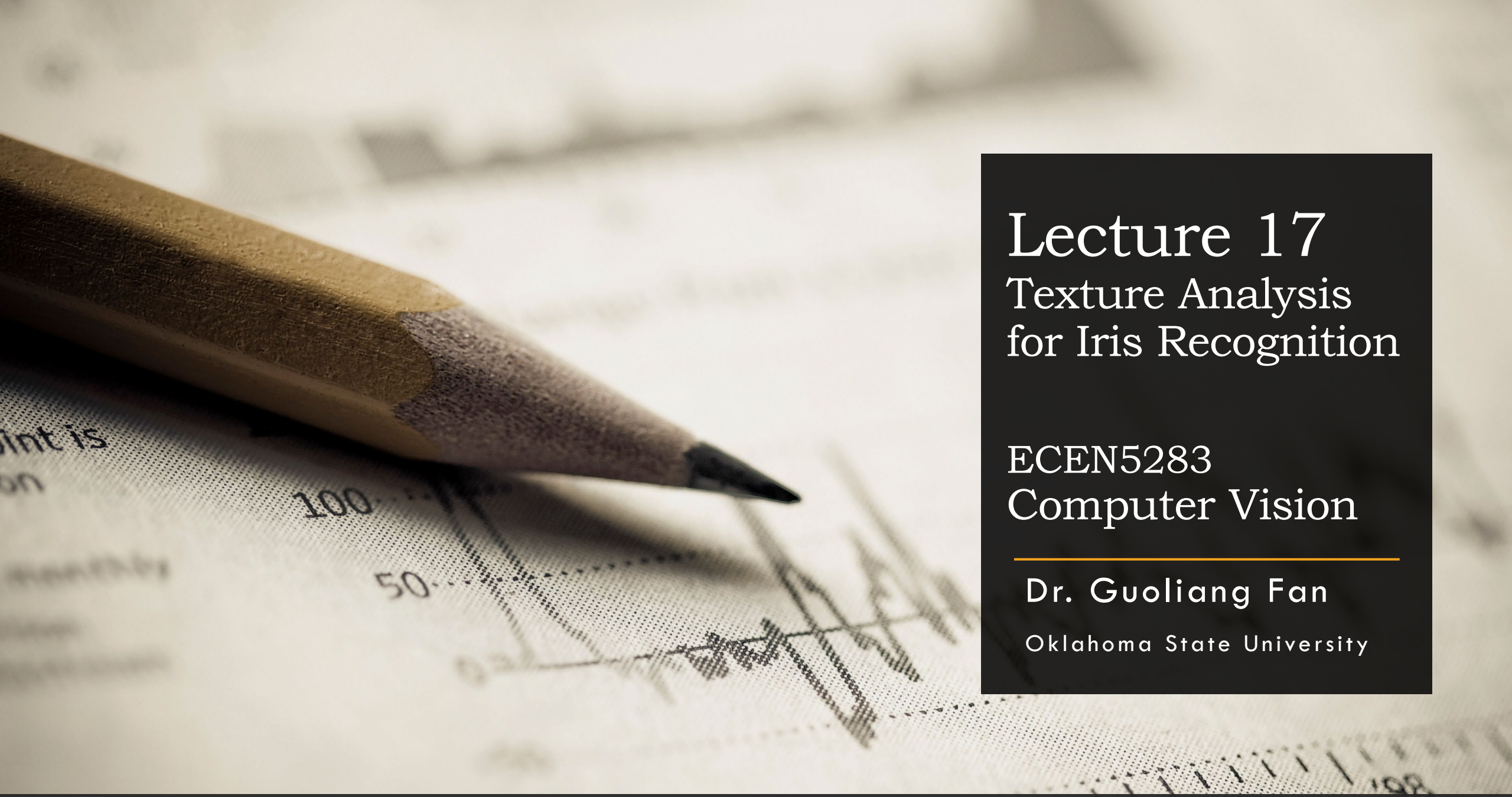

Lecture 17
Texture Analysis for Iris Recognition

ECEN5283
Computer Vision

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Oklahoma State University

Goals

To review the Gabor filter bank for texture analysis.

To showcase a real application of Gabor-based texture analysis, i.e., iris recognition.

Fourier Basis vs. Gabor Filters

The Fourier basis has not spatial selectivity but provides the best frequency selectivity.

No spatial resolution/
Perfect frequency resolution

$$f(x, y|u_0, v_0) = \exp^{j2\pi(u_0 x + v_0 y)} \quad \text{(Fourier basis)} \quad \rightarrow F(u, v) = \delta(u_0, v_0)$$

Gabor filters can achieve ***localized frequency characterization*** by multiplying the Fourier basis elements with Gaussians.

$$g(x, y|u_0, v_0) = \exp^{j2\pi(u_0 x + v_0 y)} \exp^{-\left\{\frac{x^2+y^2}{2\sigma^2}\right\}} \quad \text{(Gabor basis)}$$

Some spatial resolution/
some frequency resolution

Uncertainty principle: spatial resolution and frequency resolution cannot be enhanced at the same time.

$$\rightarrow G(u, v) \propto \exp^{-\left\{\frac{2\pi^2[(u-u_o)^2+(v-v_0)^2]}{1/\sigma^2}\right\}}$$

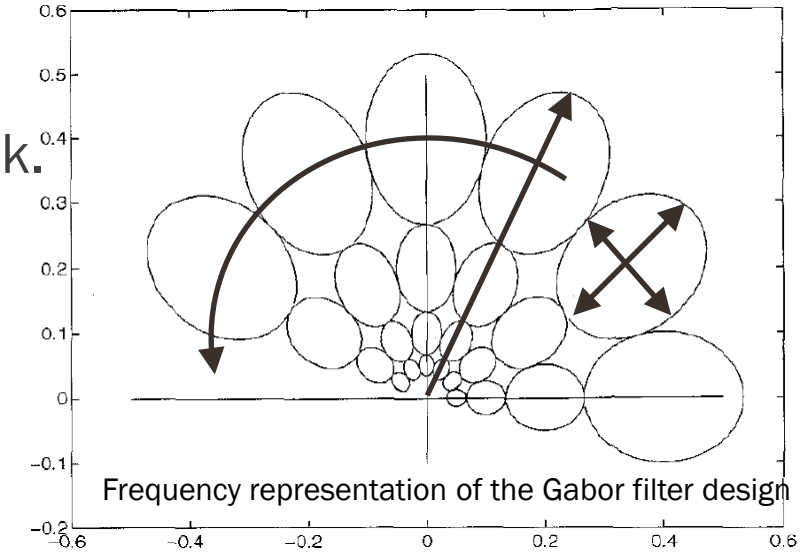
Gabor Filter Bank Design Review

Four main factors to be considered

- The number of free parameters should be small.
- The whole spectrum should be covered
- The overlap between neighboring channels should be minimized.
- The characteristics of visual perception should be considered.

There are some parameters to determine a Gabor filter bank.

- Scales and orientations
- Scaling factor between successive filters.
- The std of the Gaussian in each scale and orientation



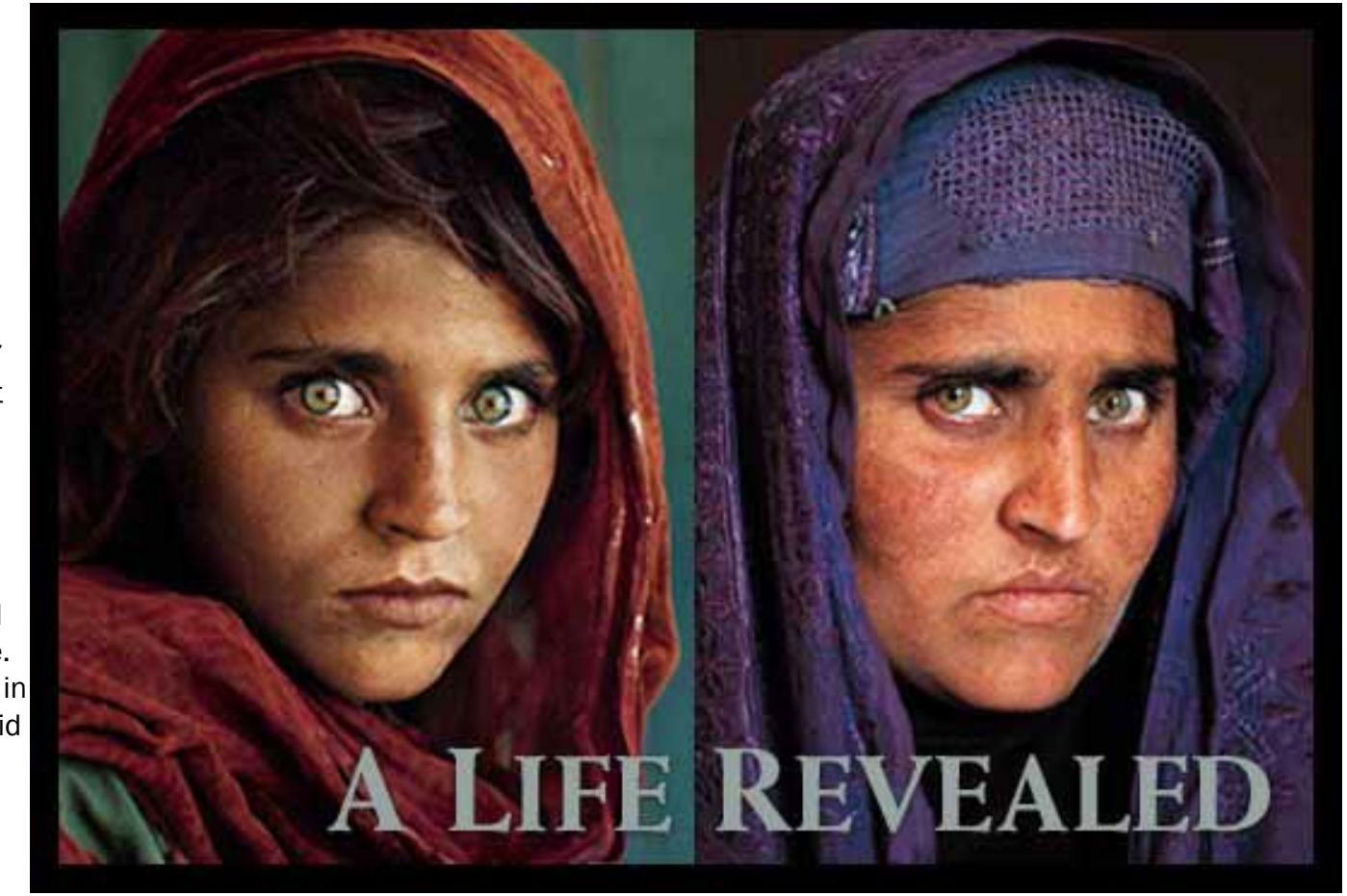
Frequency representation of the Gabor filter design

S. Manjunath and W.Y. Ma, "Texture features for browsing and retrieval of image data", IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI), vol.18, no.8, pp.837-42, Aug 1996.

Iris Recognition: How the Afghan girl was Identified by her iris patterns?

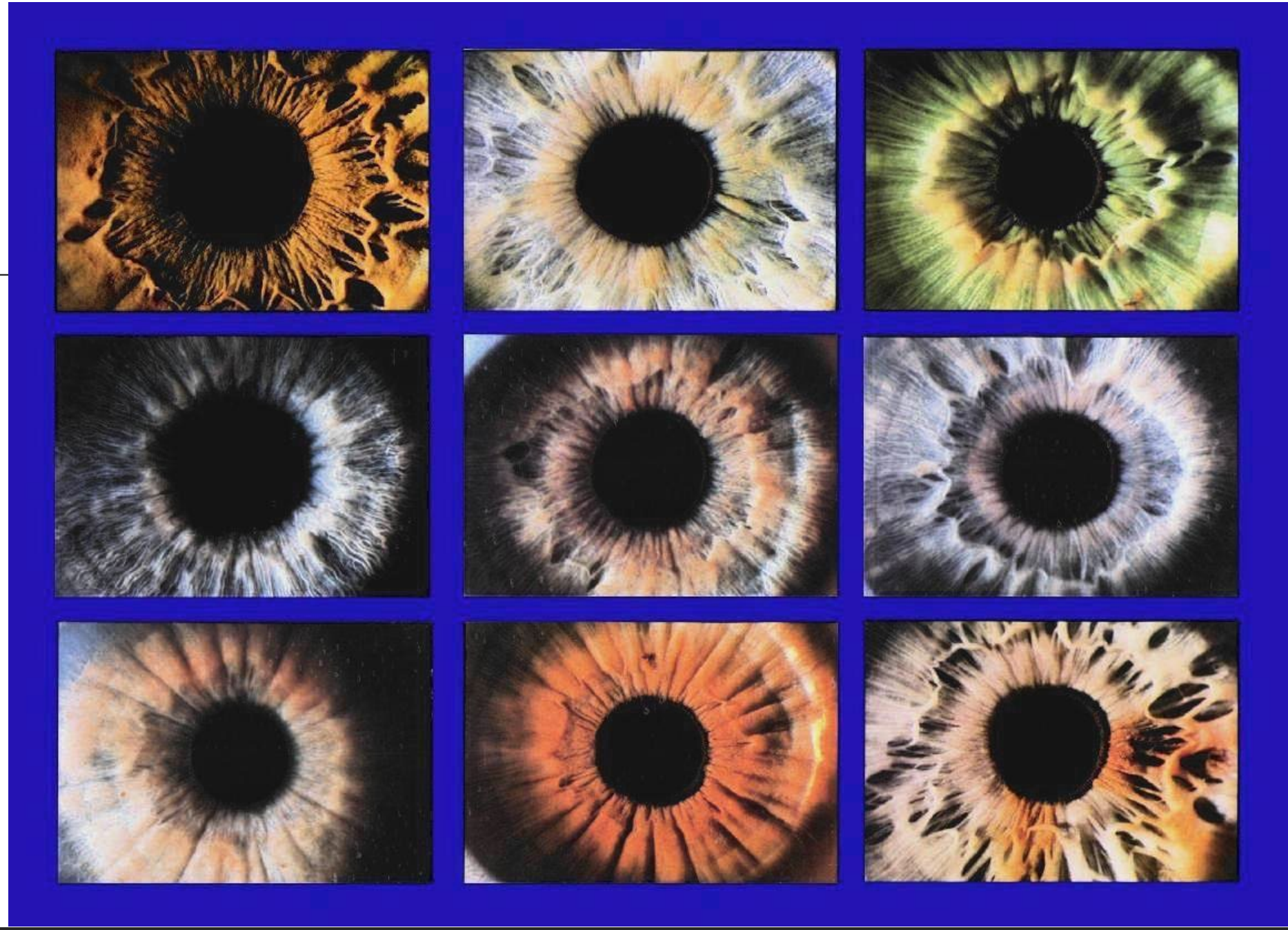
Portrait of a Survivor
Photograph by Steve McCurry

The young Afghan refugee who stared from the cover of *National Geographic* in June 1985 was an enigma for 17 years. What was her name? Had she survived? This past January photographer Steve McCurry joined a crew from National Geographic Television & Film to methodically search for her. They showed her photograph around the refugee camp in Pakistan where McCurry had encountered her as a schoolgirl in December 1984. Finally, after some false leads, a man who had also lived in the camp as a child recognized her. Yes, she was alive. She had left the camp many years before and was living in the mountainous Tora Bora region of Afghanistan. He said he could find her, and three days later he and a friend brought her back to the camp. There, the remarkable story of this woman, Sharbat Gula, began to be told.

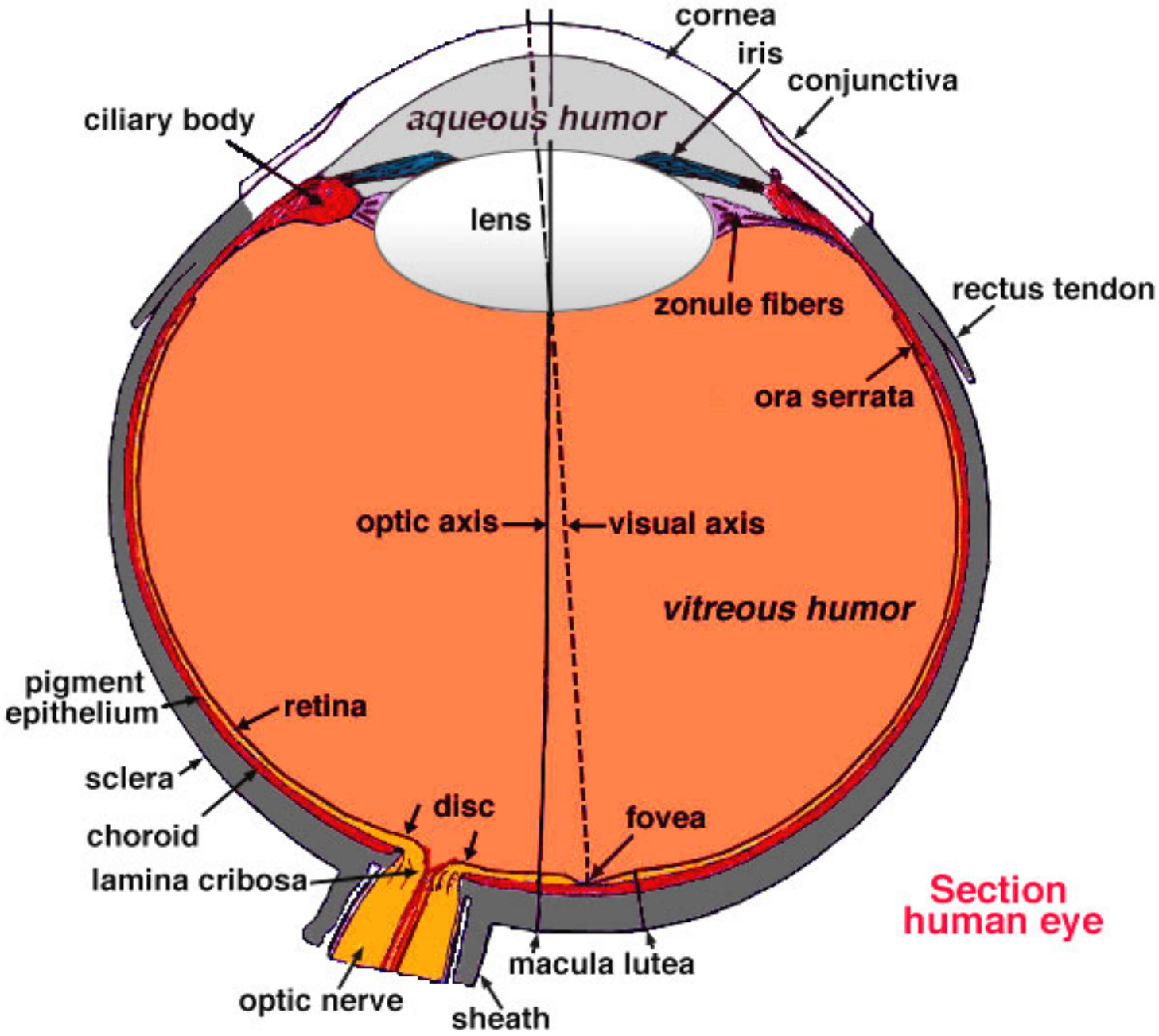


Retinal Scan for Identification

Iris Recognition



Where is the iris?

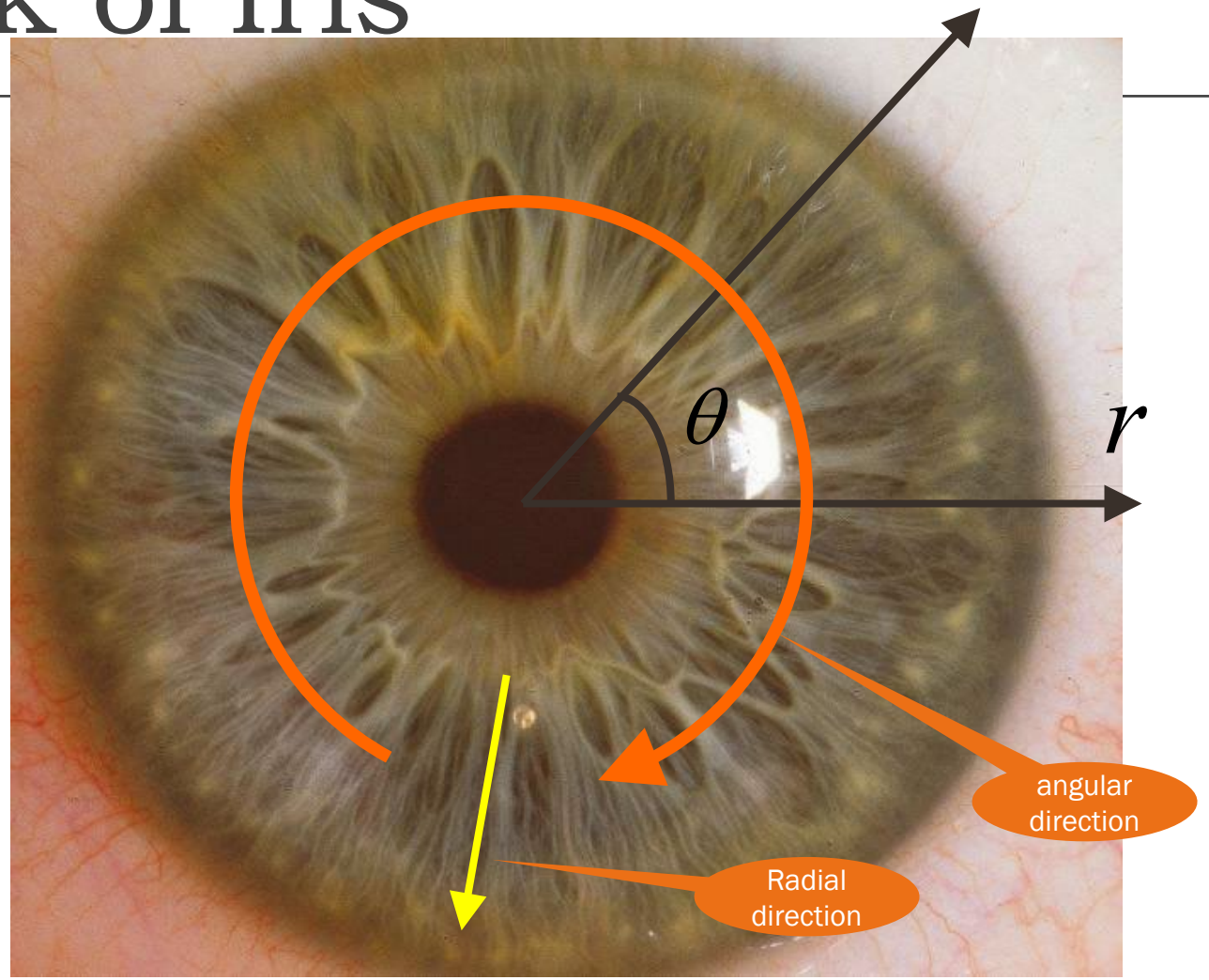


A Close Look of Iris

The Cartesian 2D coordinate system is not appropriate here.

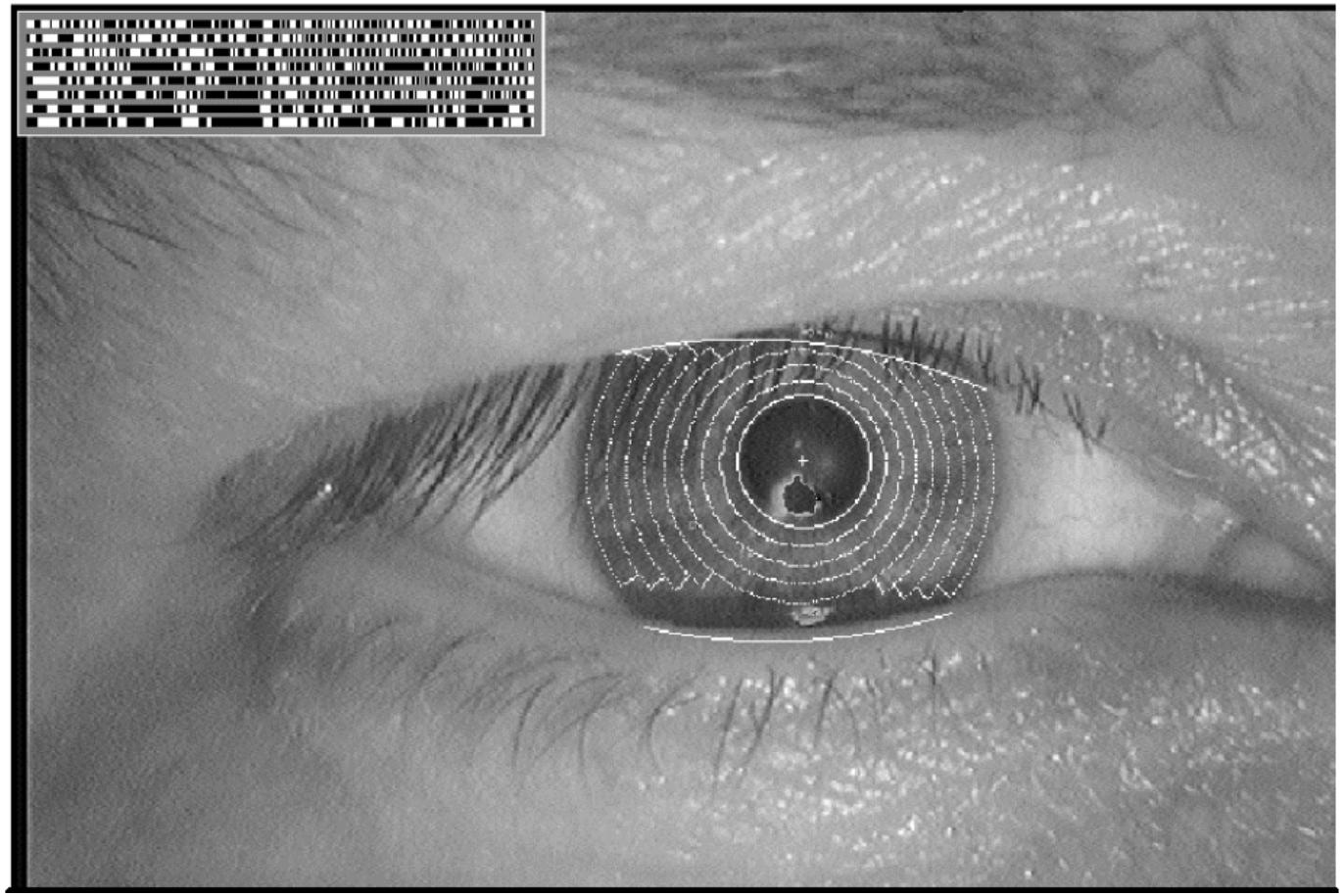
$$I(x,y) \leftrightarrow I(r,\theta)$$

Along which direction should we perform texture analysis?



http://www.cl.cam.ac.uk/users/jgd1000/

Polar Coordinate System for Iris Representation

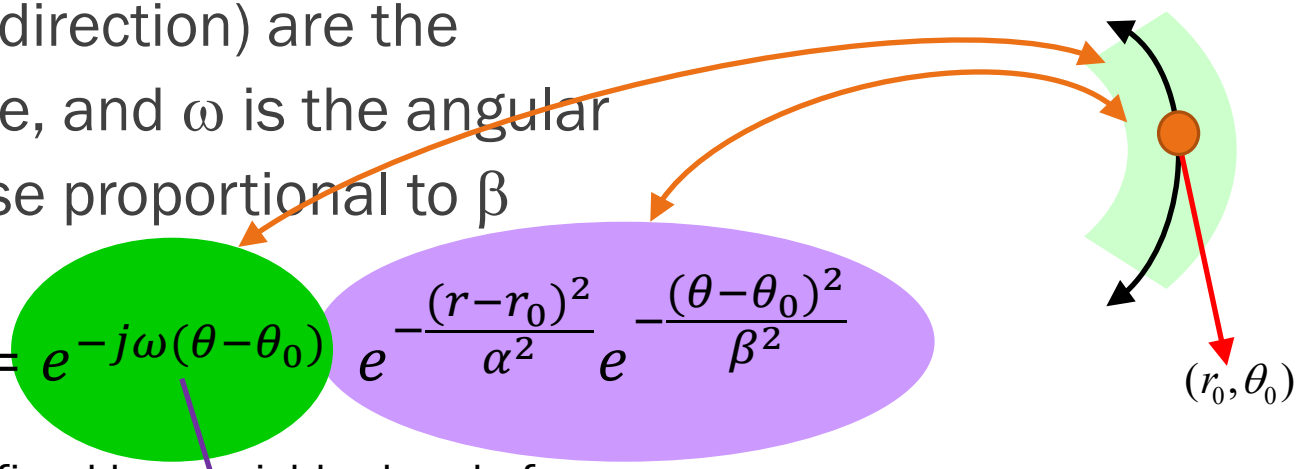


J. G. Daugman, "High confidence visual recognition of persons by a test of statistical independence," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 15, no. 11, pp. 1148-1161, Nov. 1993, doi: 10.1109/34.244676.

Polar Gabor Filtering

$$g(x,y) = e^{j2\pi(u_0x+v_0y)}e^{-\left\{\frac{x^2+y^2}{2\sigma^2}\right\}}$$

The two parameters, α (along the radial direction) and β (along the angular direction) are the multiscale 2D window size, and ω is the angular frequency that is in inverse proportional to β



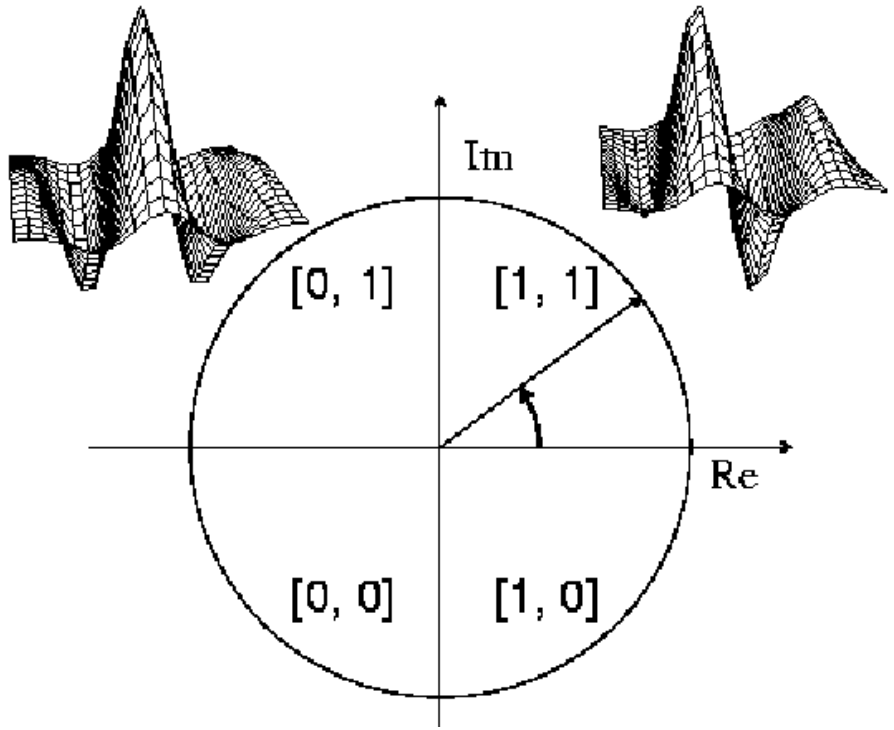
Projections from a local region defined by a neighborhood of (r_0,θ_0) in the iris image $I(\rho,\phi)$ onto a complex 2-D Gabor filter.

$$(g(\rho,\phi|r_0,\theta_0,\omega), I(\rho,\phi)) = \int_{\rho}\int_{\phi} e^{-j\omega(\theta_0-\phi)} e^{-\frac{(r_0-\rho)^2}{\alpha^2}} e^{-\frac{(\theta_0-\phi)^2}{\beta^2}} I(\rho,\phi)\, d\rho\, d\phi$$

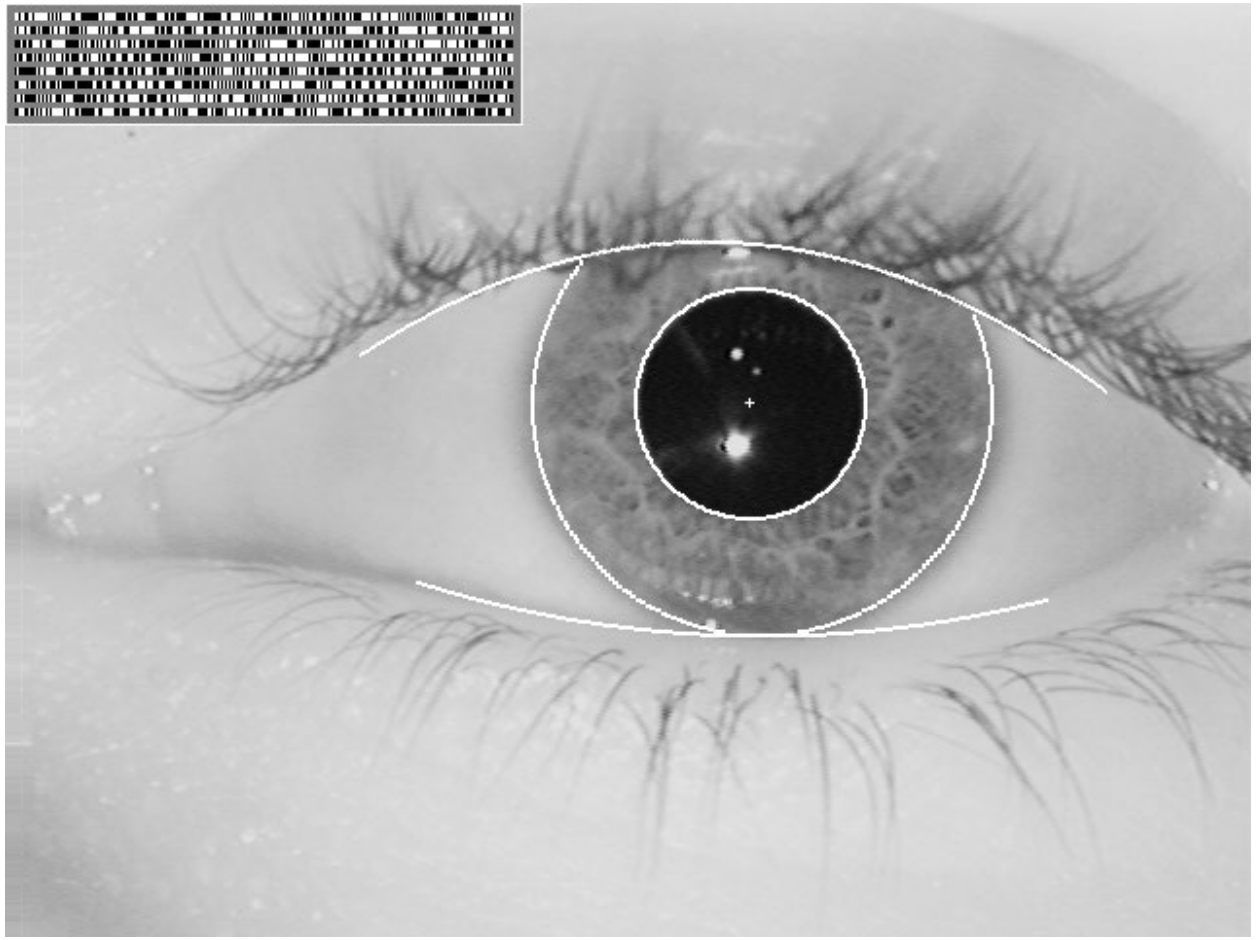
By changing $(r_0,\theta_0,\alpha,\beta,\omega)$, we can have a group of Gabor filters.

Iris Code Computation

$$\mathrm{Re} + j\,\mathrm{Im} = \int_{\rho}\int_{\varphi} e^{-j\omega(\theta_0-\varphi)} e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\varphi)^2/\beta^2} I(\rho,\varphi)\,d\rho\,d\varphi$$

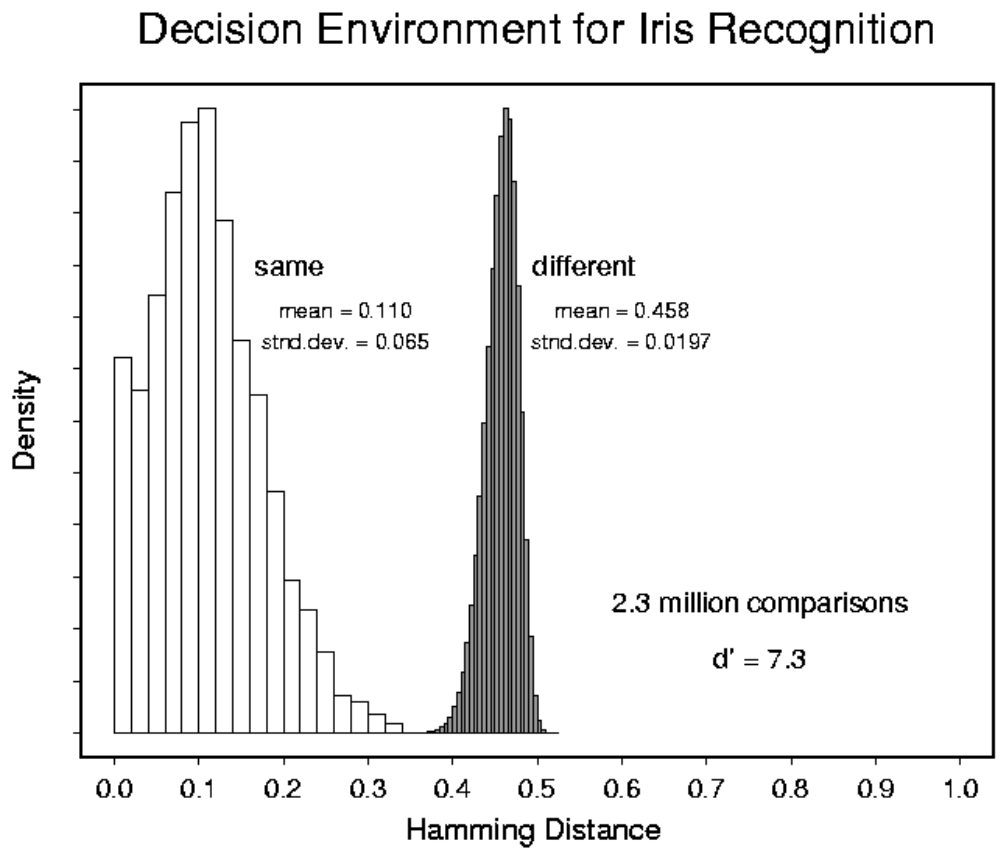


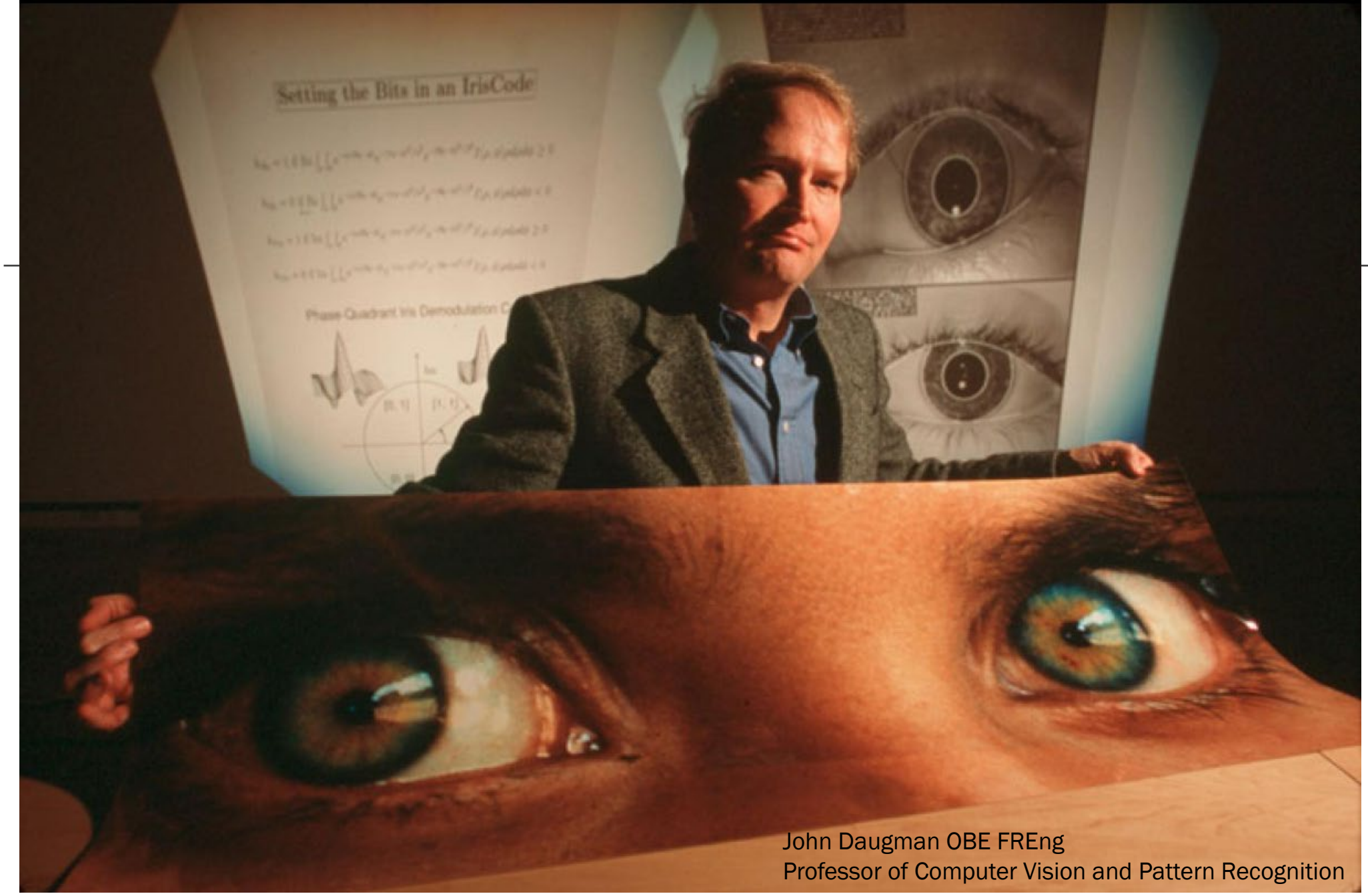
Iris Code (256 Bytes)



Iris Recognition: Iris Matching Engine

$$\text{Hamming Distance} = \frac{\|(codeA \otimes codeB) \cap maskA \cap maskB\|}{\|maskA \cap maskB\|}$$





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