Iritech,Inc.
Technology with the Iris

Introducing Unsegmented Polar Data Format with Performance Evaluation

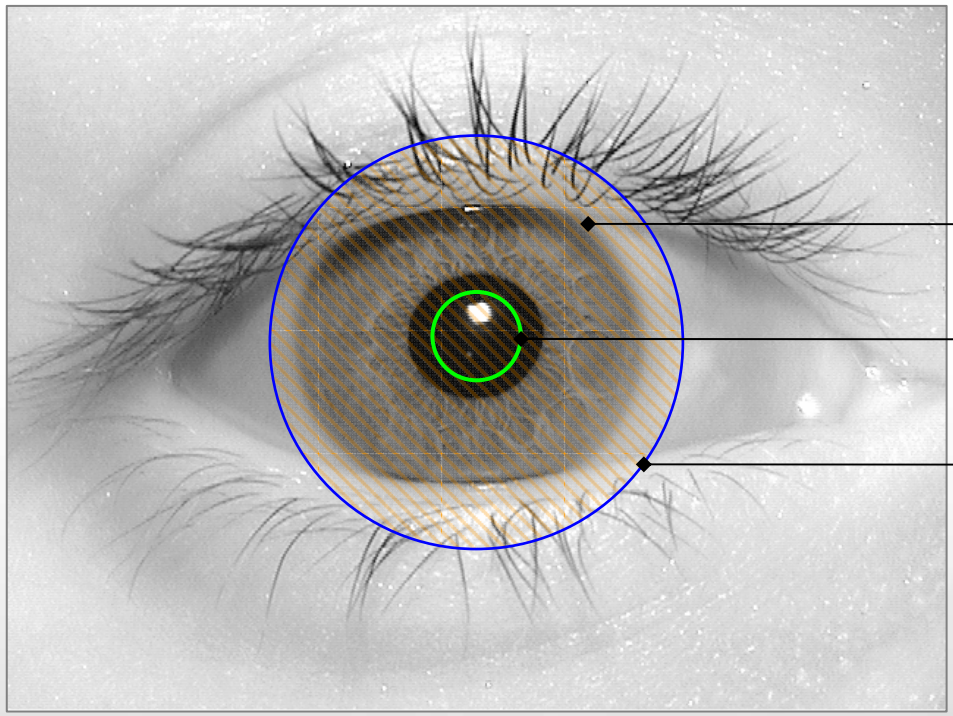
NIST Biometric Workshop II

November 6, 2007

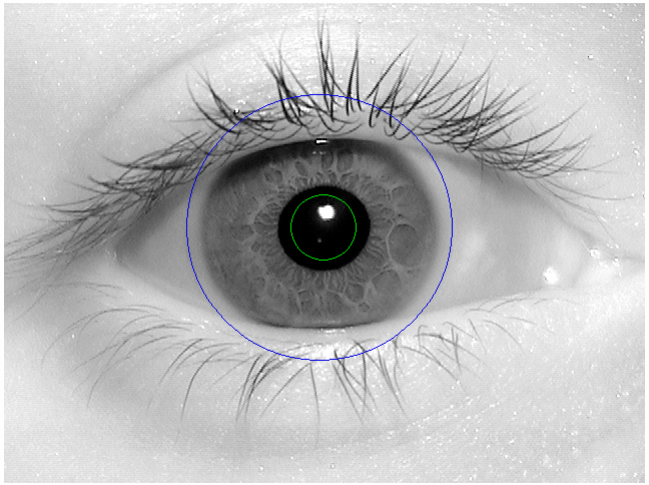
Contents

1. What is the Unsegmented Polar Data Format?
2. File Size of Unsegmented Polar Data
3. Visual Quality of Restored Rectilinear Data
4. Iris Recognition Test Result
5. Discussion

1. What is the Unsegmented Polar Data Format?

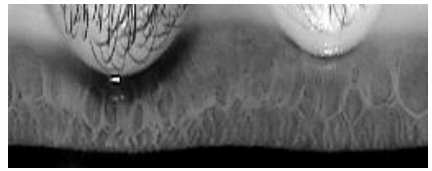


Generation of Unsegmented Polar Data



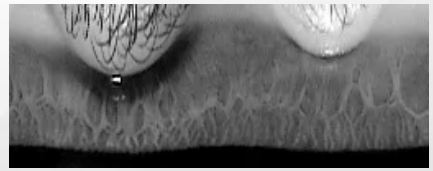
(a) Original NIST 246996 Image

polar transform



(b) Unsegmented polar rectangle

Compress



(c) Compressed unsegmented polar rectangle

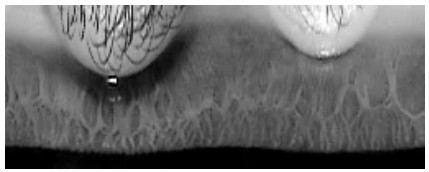
storing

Storage

- This compresseNovember 6, 2007d unsegmented polar rectangle(C) is to be stored

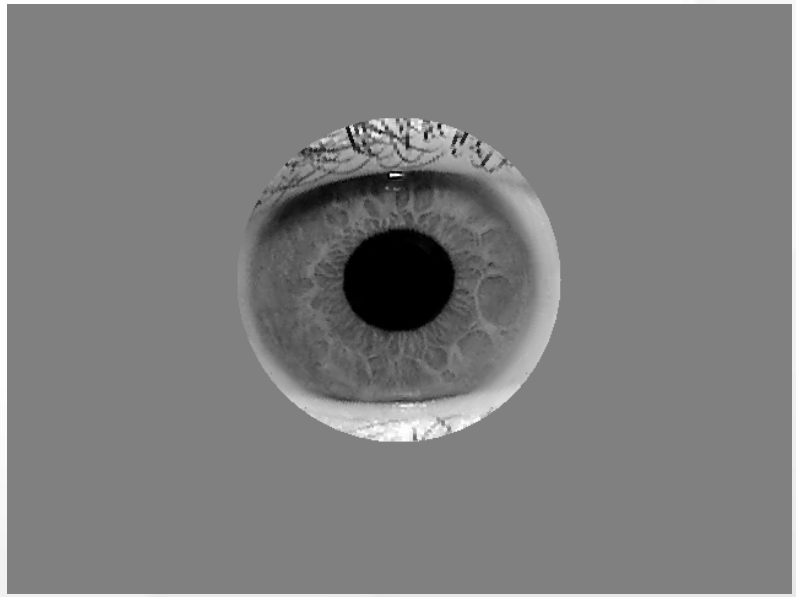
Restoration of Rectilinear Image

Storage



Stored unsegmented polar rectangle

Inverse Polar Transform



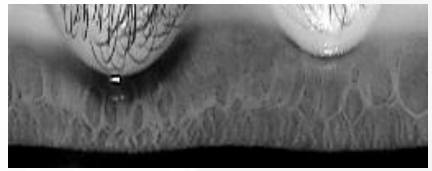
(d) Recovered rectilinear image

Effect of Discretization (Pixel Interpolation)

- Under the polar transform & the inverse polar transform, the pixels in the rectilinear image do not match in 1:1 manner with the pixels in the polar rectangle.

Given

Polar Transform



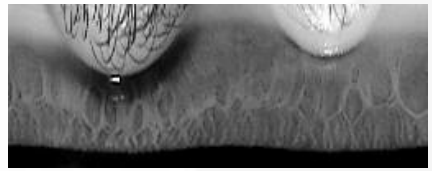
Polar Rectangle Data

Pixel values of the polar rectangle have to be assigned (interpolated).

Effect of Discretization (Pixel Interpolation)

Inverse

Polar Transform



Polar Rectangle Data

Given

Pixel values of the rectilinear image have to be assigned (interpolated).

Two Interpolation Schemes

- **Simple Interpolation Scheme**

- Polar Transform

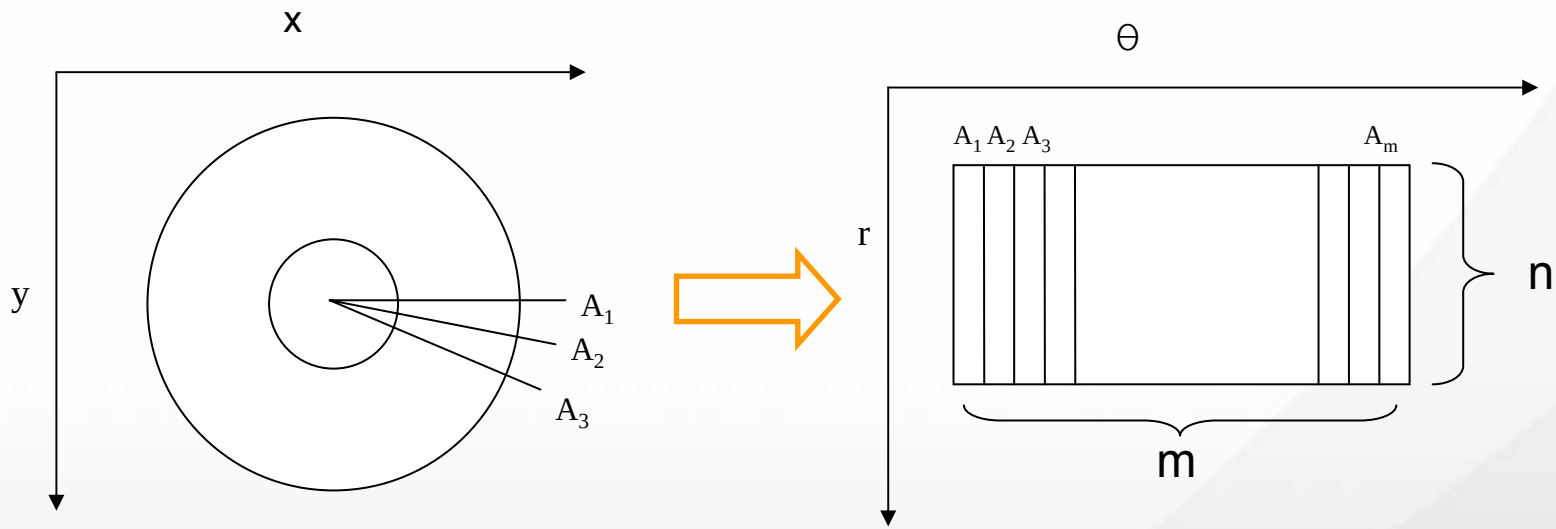
a. Choose m rays of equally-spaced angle from the center of polar co-ordinates.

b. Each of these rays from the inner circle to the outer circle is divided into n equal subintervals.

c. The pixel center in the rectilinear image nearest to the center of such subintervals is mapped into the polar rectangle.

d. The polar rectangle of size m x n is constructed by taking the corresponding pixel values.

Two Interpolation Schemes



Rectilinear Image **Polar Image**

Two Interpolation Schemes

- **Simple Interpolation Scheme**

- Inverse Polar Transform

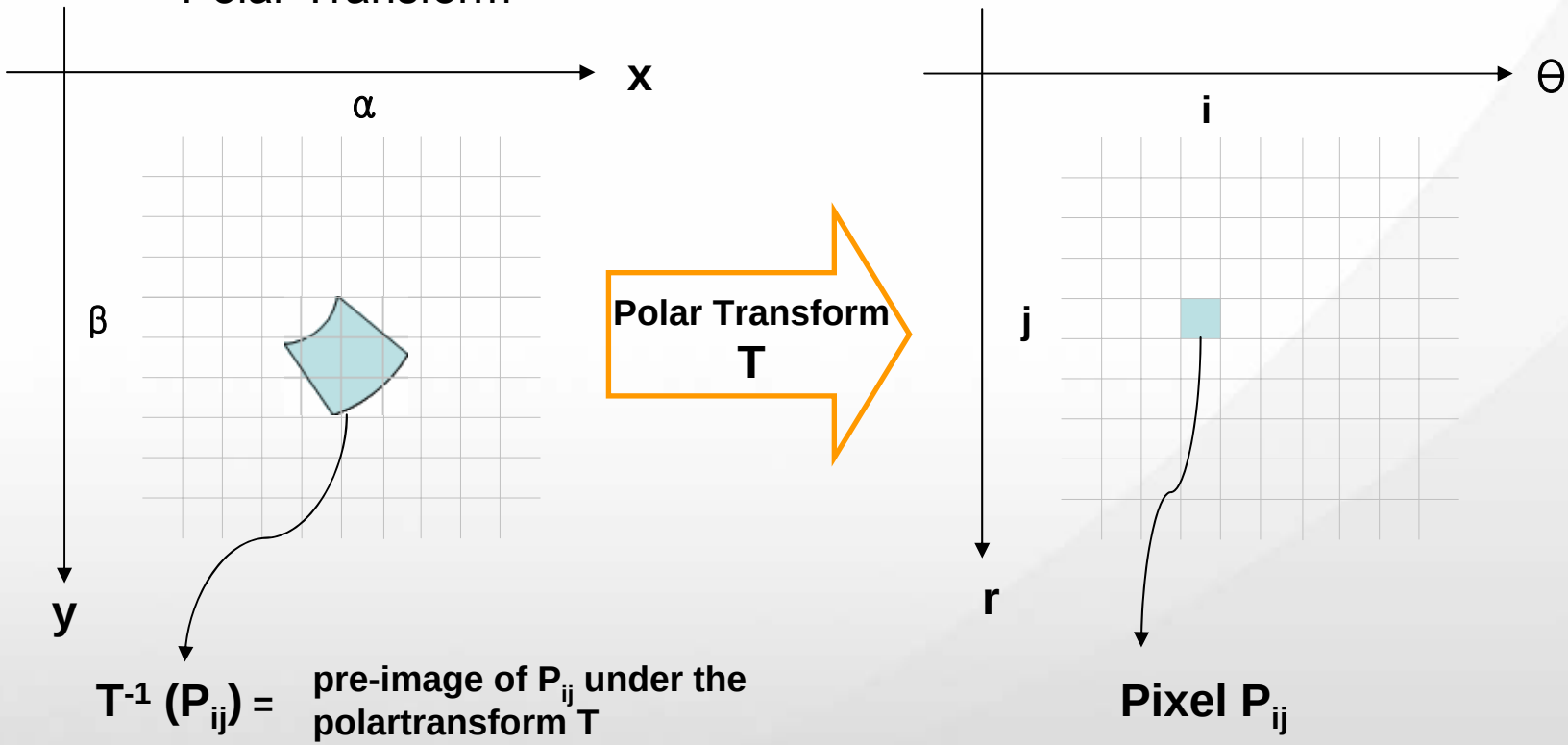
a. The inverse procedure of the above scheme.

b. Same pixel in the rectilinear image may be rewritten many times → do overwriting.

c. Some pixel in the rectilinear image may be missed by this inverse procedure → do angular copying of the nearest pixel along the circular area.

- **Weighted Interpolation Scheme**

  - Polar Transform



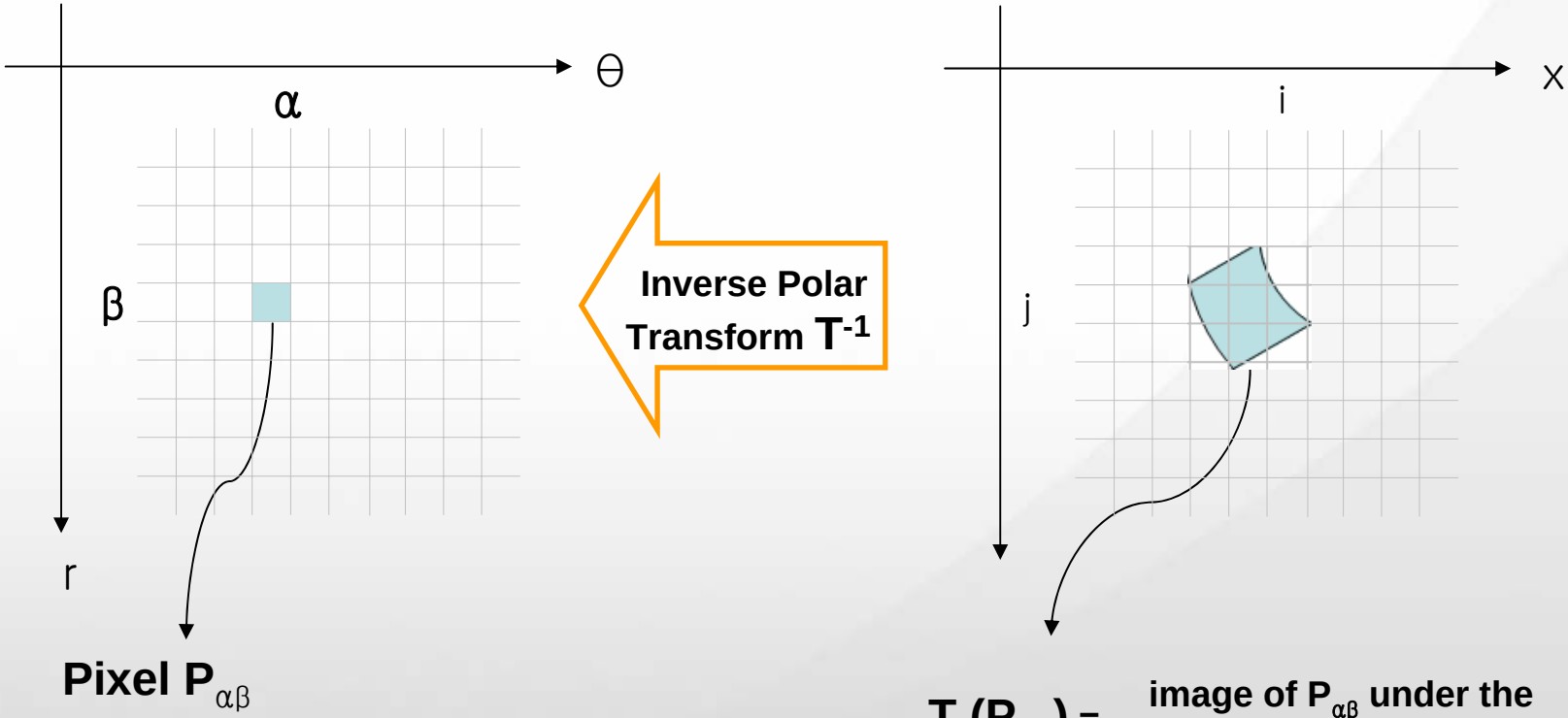
$$W_{\alpha\beta} = \frac{Area(T^{-1}(P_{ij}) \cap P_{\alpha\beta})}{Area(T^{-1}(P_{ij}))}$$

$P_{\alpha\beta}$: Pixel with co-ordinate (α,β) in the rectilinear image

$$\text{Value of } P_{ij} = \sum_{\alpha,\beta} W_{\alpha\beta} \times [value\ of\ P_{\alpha\beta}]$$

- **Weighted Interpolation Scheme**

  - Inverse Polar Transform

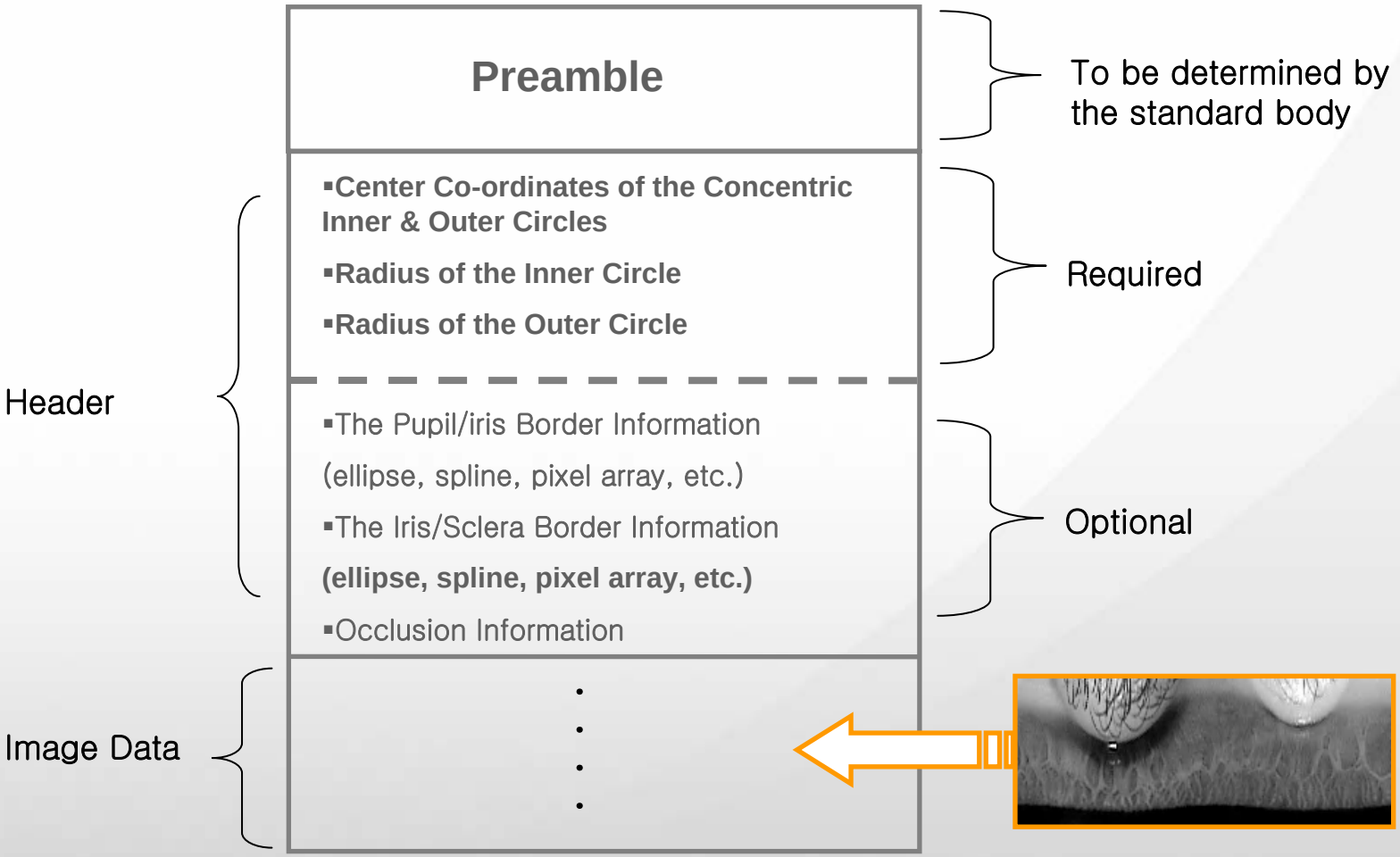


$T(P_{\alpha\beta})$ = image of $P_{\alpha\beta}$ under the polar transform

$$W_{ij} = \frac{Area(T(P_{\alpha\beta}) \cap P_{ij})}{Area(T(P_{\alpha\beta}))}$$

$$\text{Value of } P_{\alpha\beta} = \sum_{i,j} W_{ij} \times [value\ of\ P_{ij}]$$

Data Format


Preamble
To be determined by the standard body
▪Center Co-ordinates of the Concentric Inner & Outer Circles
▪Radius of the Inner Circle
▪Radius of the Outer Circle
Required
Header
▪The Pupil/iris Border Information
(ellipse, spline, pixel array, etc.)
▪The Iris/Sclera Border Information
(ellipse, spline, pixel array, etc.)
▪Occlusion Information
Optional
Image Data

How to Use Unsegmented Polar Data in Iris Recognition

- By the Inverse Polar Transform, restore the rectilinear image(d) from the stored compressed unsegmented polar data(c).
- Treat this restored rectilinear image(d) as if it were an original.
- For segmentation, user has two options:

1st Option (Ignoring the Optional Data)

Run one's own segmentation algorithm for the restored rectilinear image while ignoring the optional data.

2nd Option (Utilizing the Optional Data)

If optional data is supplied, make use of the segmentation information. Therefore no need to have one's own segmentation algorithm.

2. File Size of Unsegmented Polar Data

Original: ICE Right Eye Database

Original File Size: 301KB

QF	Interpolation Scheme	Mean (KB)	Standard Deviation (KB)	Reduction Ratio
130	Simple	3.0	0.21	100.3
	Weighted	3.0	0.21	100.3
90	Simple	2.1	0.15	148.3
	Weighted	2.1	0.15	148.3
70	Simple	1.6	0.12	188.1
	Weighted	1.6	0.11	188.1

File Size under JPEG2000 Compression with Interpolation Scheme

Original: IriTech Right Eye Database

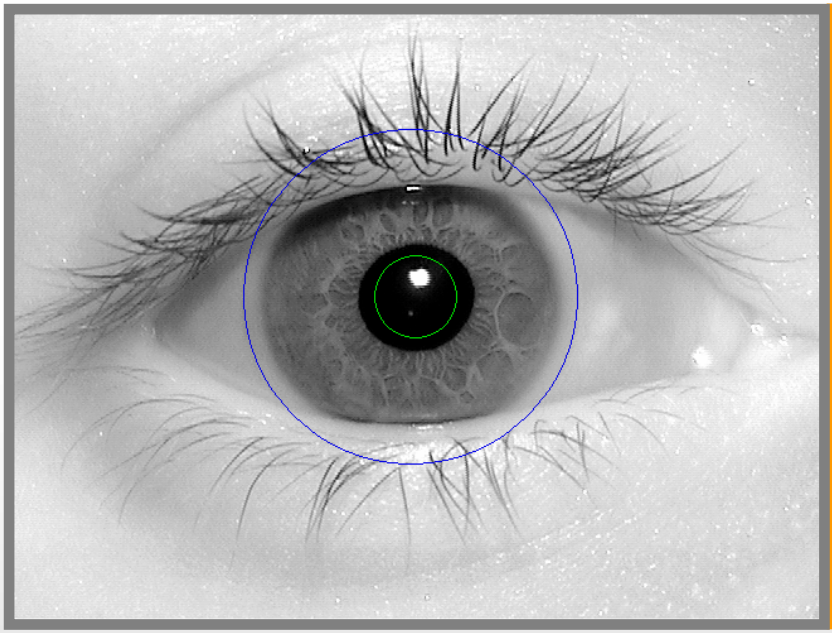
(captured by IriTech's Iris Recogniton Camera)

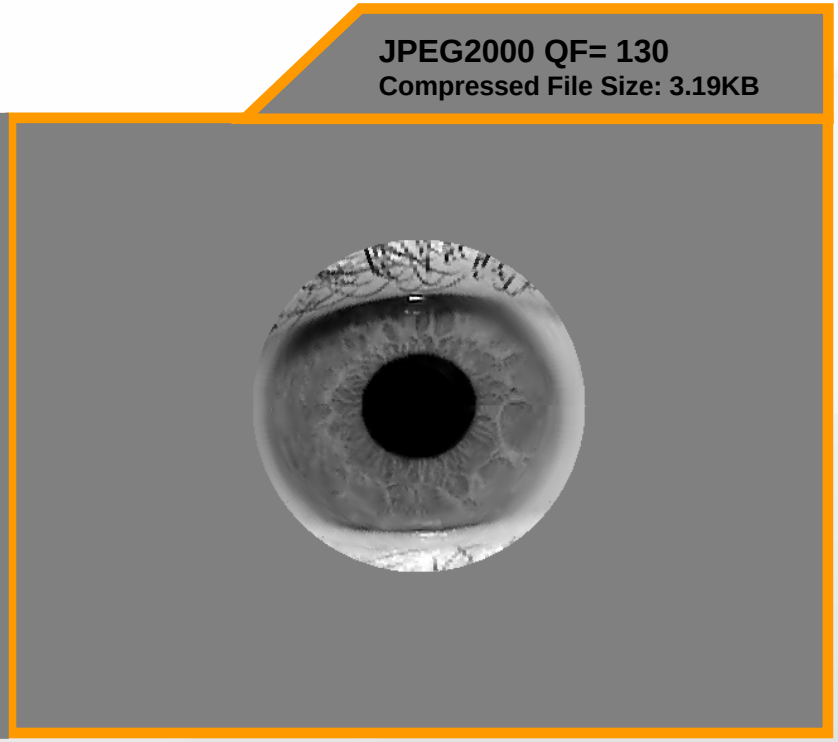
Original File Size: 301KB

QF	Interpolation Scheme	Mean (KB)	Standard Deviation (KB)	Reduction Ratio
130	Simple	2.9	0.14	103.8
	Weighted	2.9	0.15	103.8
90	Simple	2.0	0.12	150.5
	Weighted	2.0	0.11	150.5
70	Simple	1.6	0.08	188.1
	Weighted	1.6	0.08	188.1

File Size under JPEG2000 Compression with Interpolation Scheme

3. Visual Quality of Restored Rectilinear Data

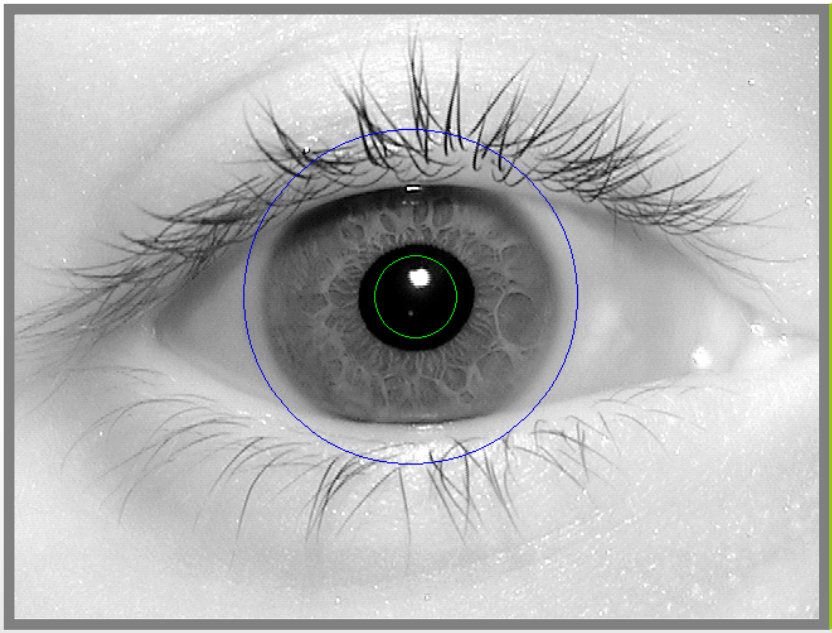


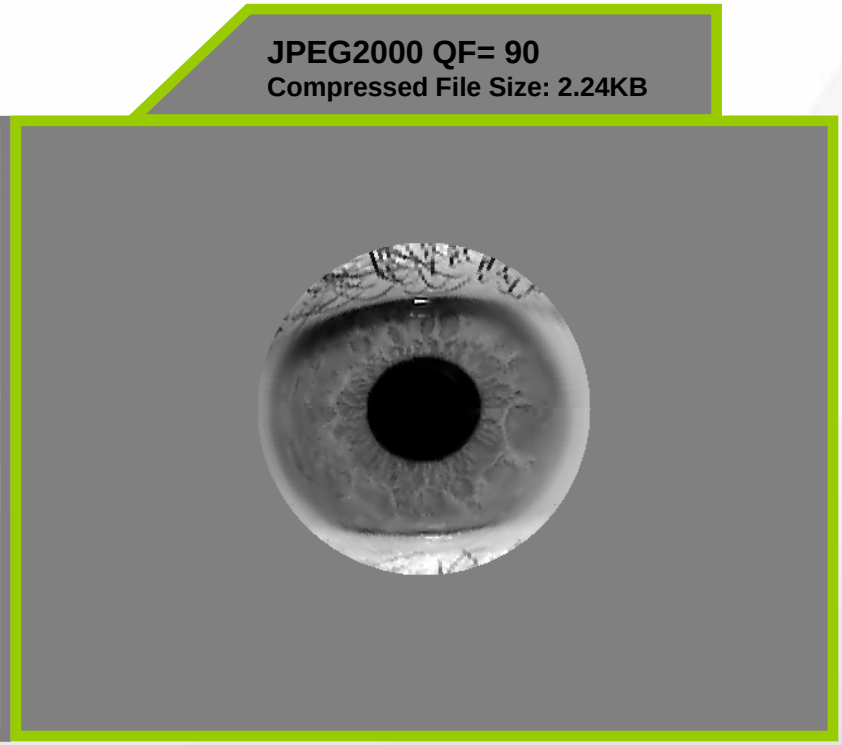


Original NIST 246996 Image

Restored Rectilinear Image with Simple Interpolation Scheme

3. Visual Quality of Restored Rectilinear Data

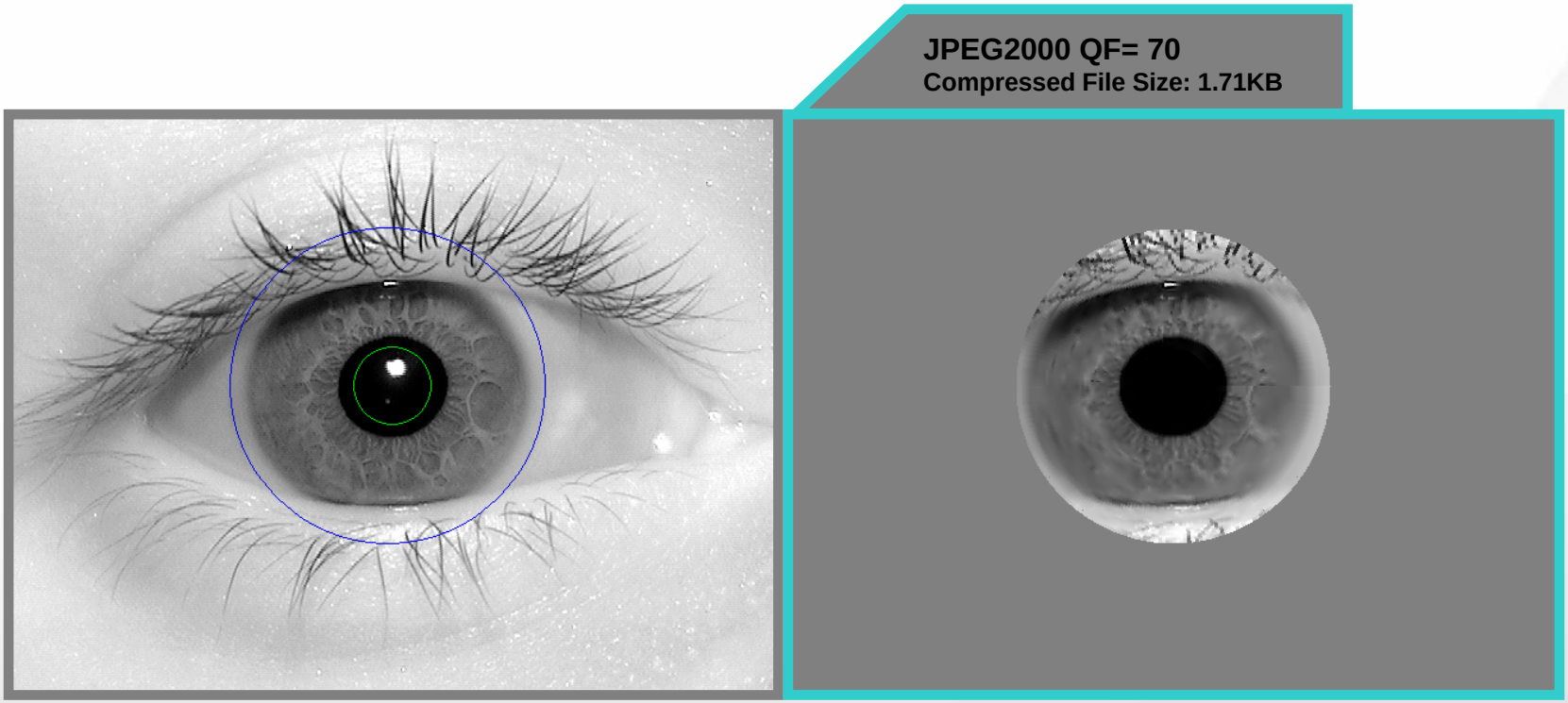




Original NIST 246996 Image

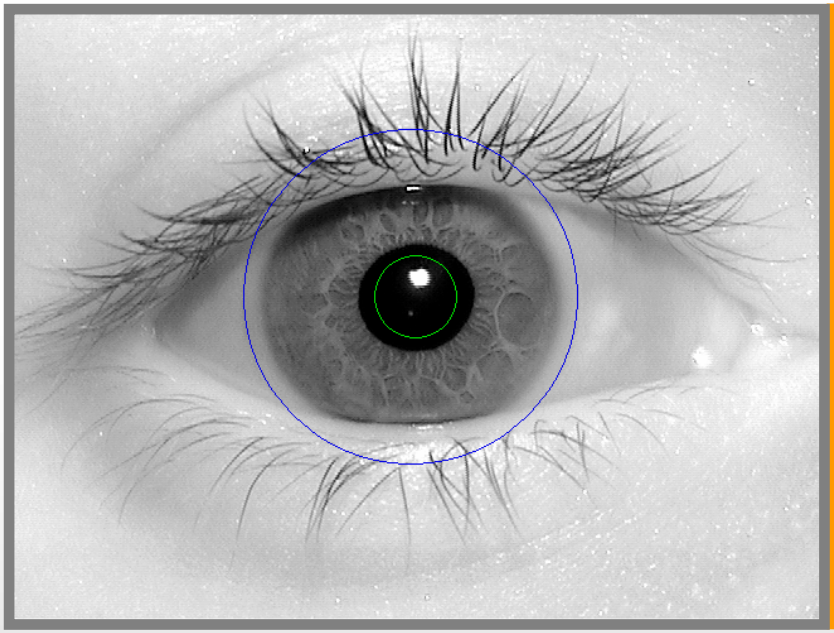
Restored Rectilinear Image with Simple Interpolation Scheme

3. Visual Quality of Restored Rectilinear Data

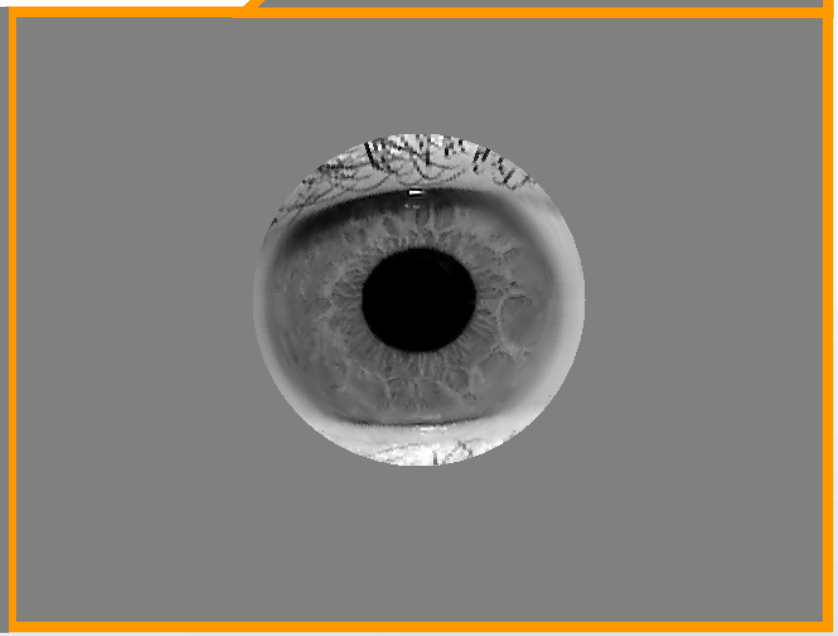


Original NIST 246996 Image

Restored Rectilinear Image with Simple Interpolation Scheme

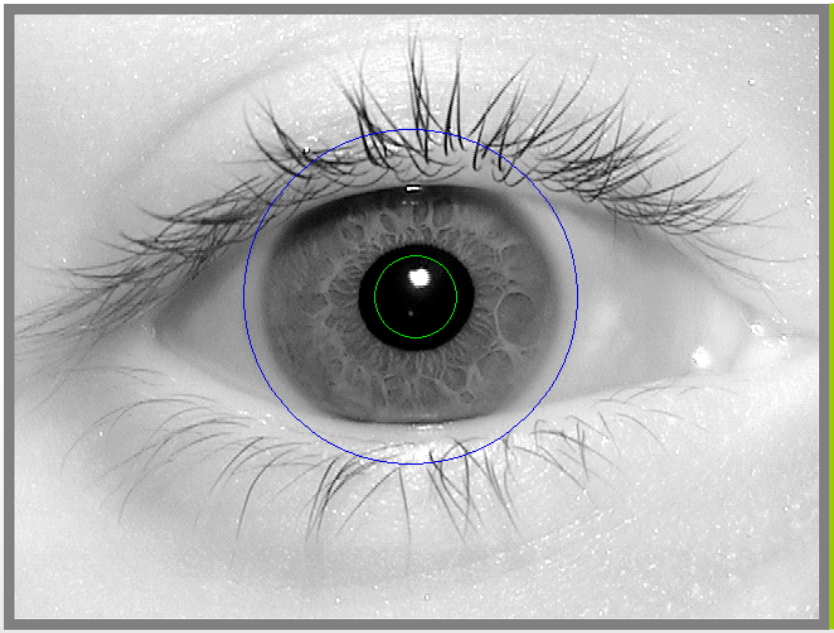


JPEG2000 QF= 130
Compressed File Size: 3.19KB

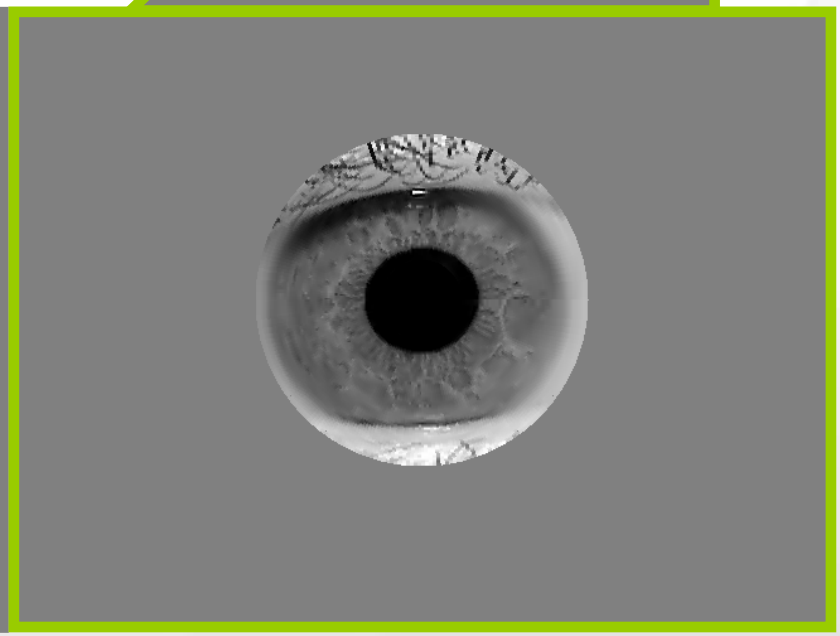


Original NIST 246996 Image

Restored Rectilinear Image with Weighted Interpolation Scheme

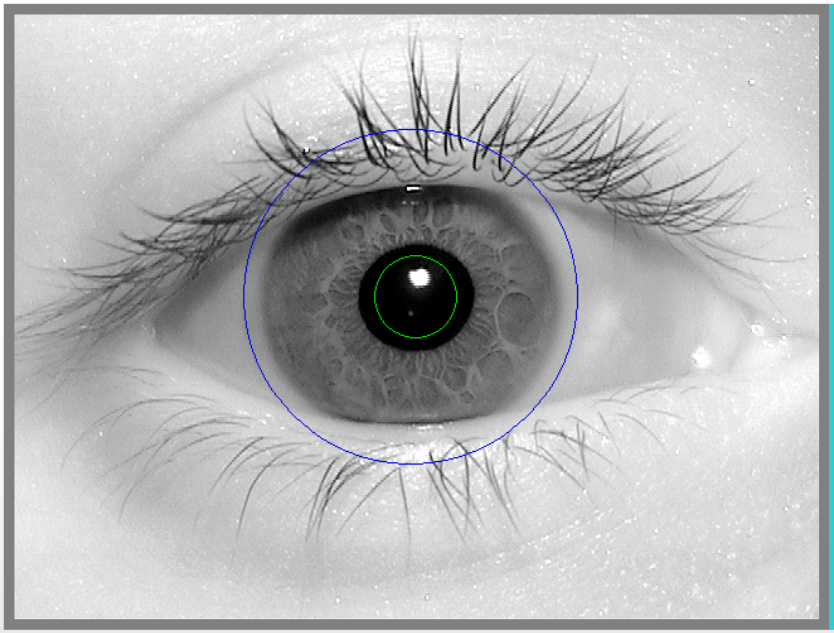


JPEG2000 QF= 90
Compressed File Size: 2.24KB

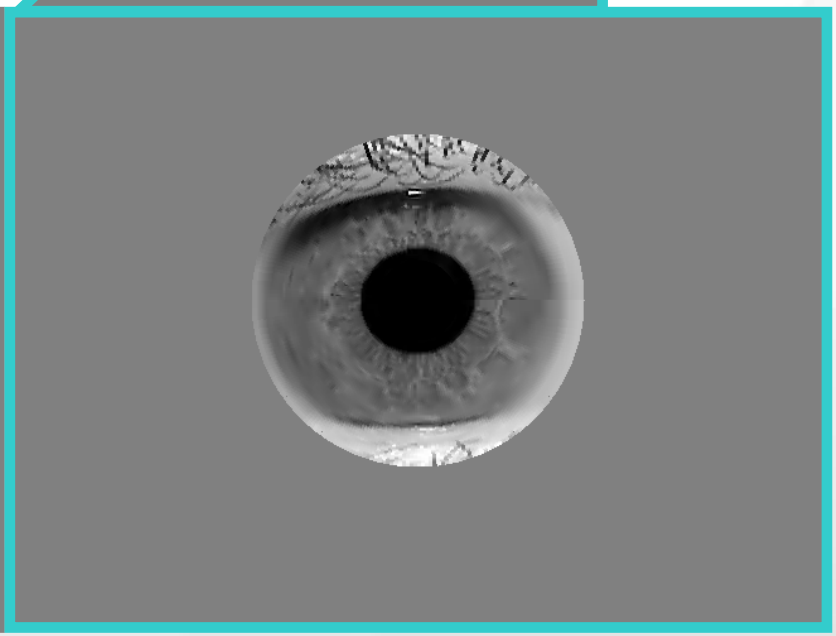


Original NIST 246996 Image

Restored Rectilinear Image with Weighted Interpolation Scheme



JPEG2000 QF= 70
Compressed File Size: 1.71KB



Original NIST 246996 Image

Restored Rectilinear Image with Weighted Interpolation Scheme

4. Iris Recognition Test Result

Error Rate Degradation

Quality Factor	Interpolation Scheme	Mean File size (KB)	EER	FRR@ FAR=10^{-4}	EER Degradation Ratio*	FRR Degradation Ratio**
Original	Simple	301	0.00139	0.00232	1.000	1.000
130	Simple	3.0	0.00147	0.00271	1.058	1.168
	Weighted	3.0	0.00155	0.00271	1.054	1.168
90	Simple	2.1	0.00186	0.00332	1.338	1.431
	Weighted	2.1	0.00170	0.00286	1.156	1.233
70	Simple	1.6	0.00240	0.00518	1.727	2.233
	Weighted	1.6	0.00216	0.00418	1.469	1.802

JPEG2000

- **Test Image Set: ICE Right Eye 1426 Images**
- **Algorithm: IriTech Algorithm**

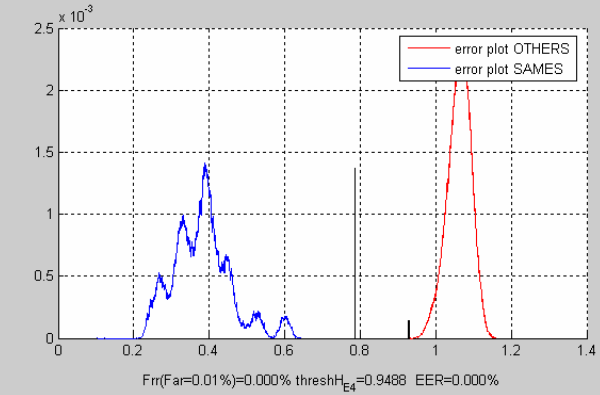
* EER Degradation Ratio = EER (Compressed)/ EER (Original)

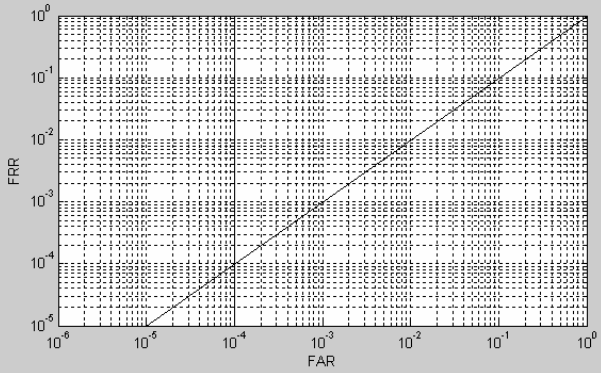
** FRR Degradation Ratio = FRR@FAR=10^{-4}(Compressed)/ FRR@FAR=10^{-4}(Original)

ROC Curve of IriTech Images under Various Compression Ratio

JPEG2000

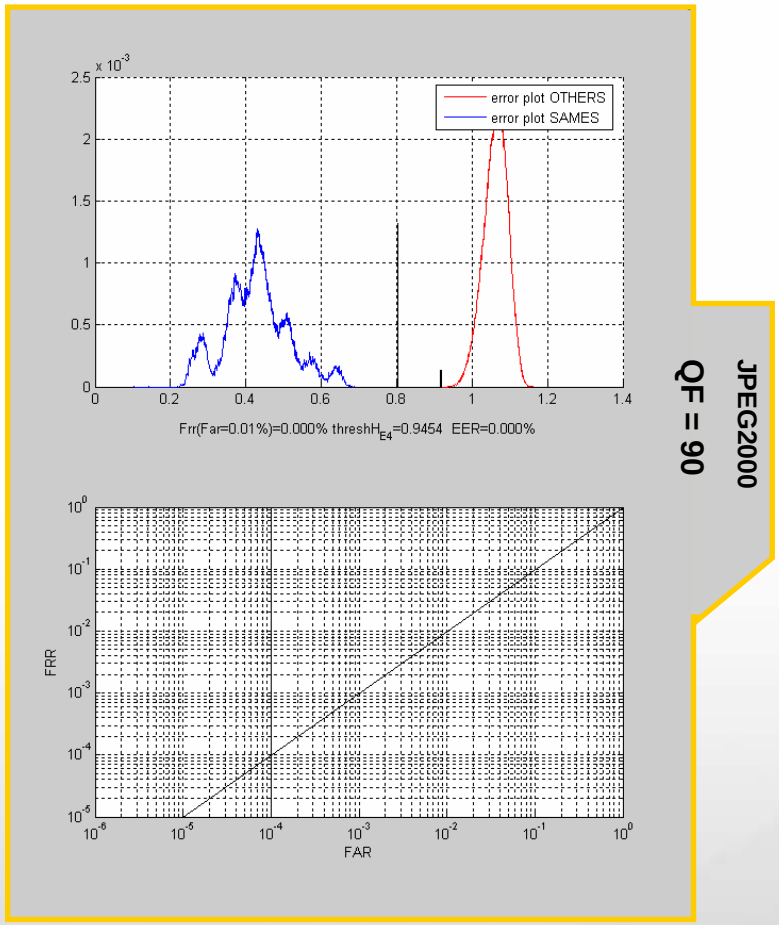
QF = 130





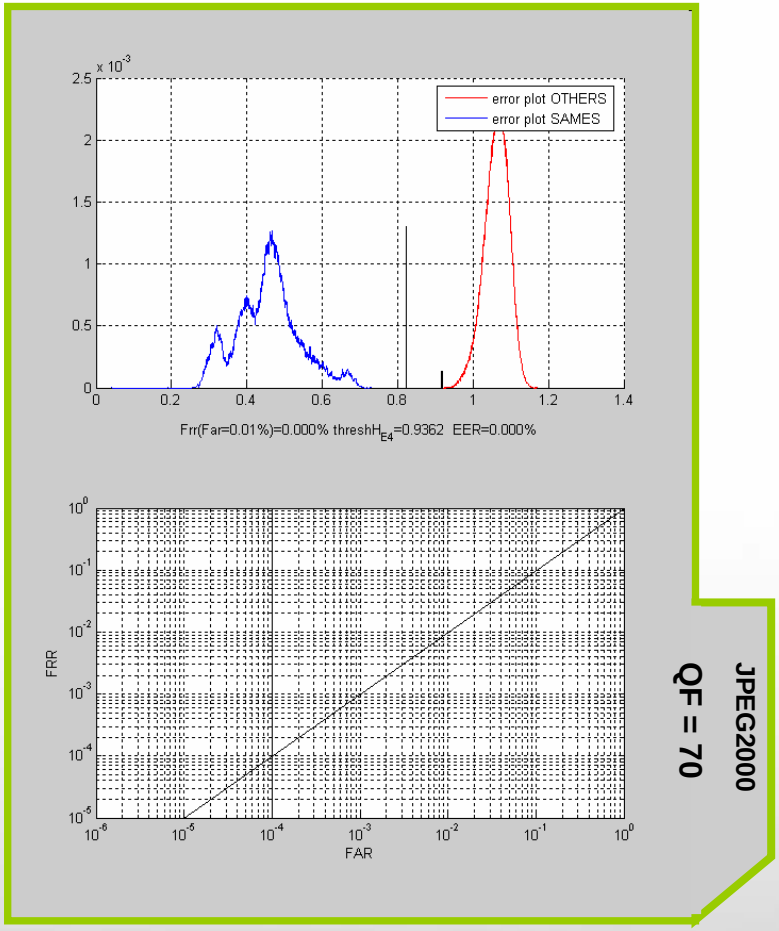
- **Interpolation: Simple Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**

ROC Curve of IriTech Images under Various Compression Ratio



- **Interpolation: Simple Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**

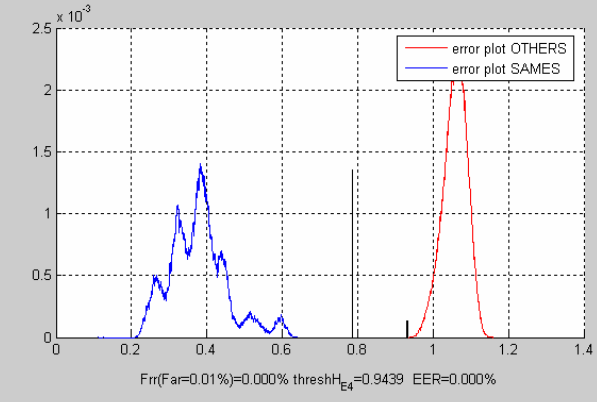
ROC Curve of IriTech Images under Various Compression Ratio

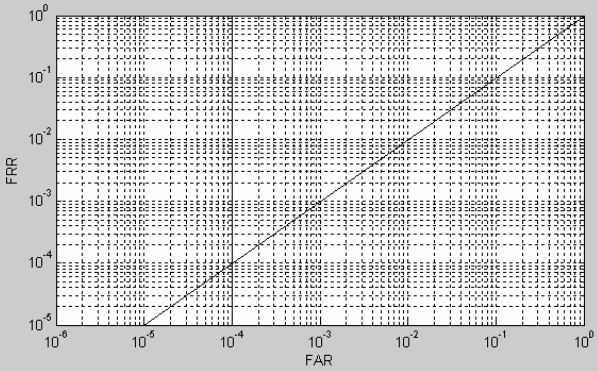


- **Interpolation: Simple Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**

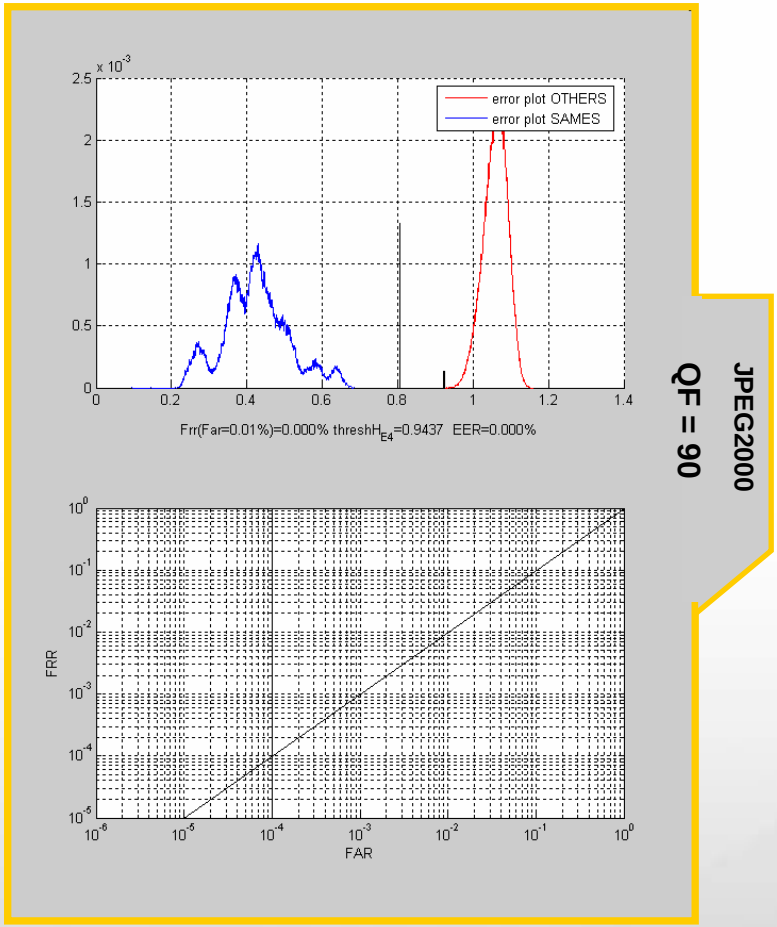
JPEG2000

QF = 130

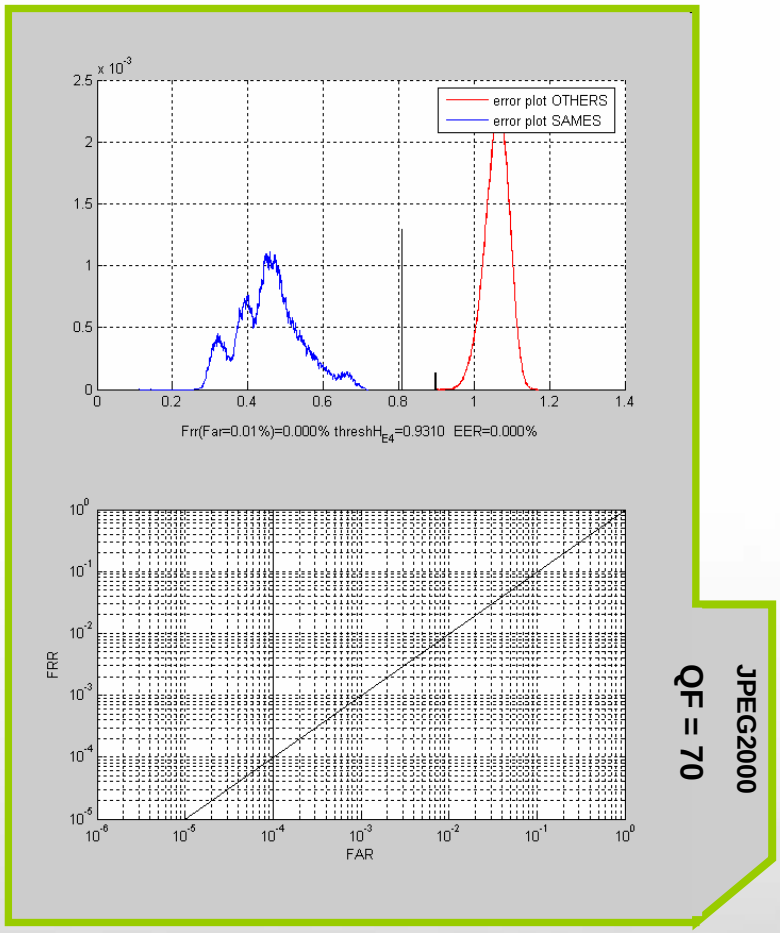




- **Interpolation: Weighted Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**

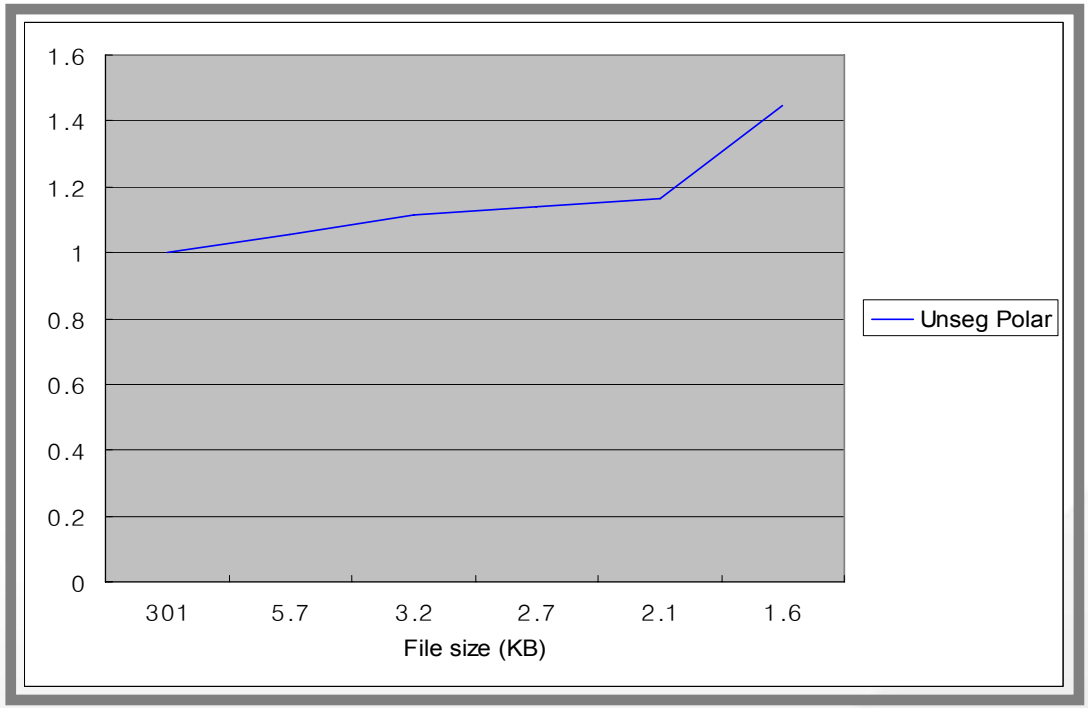


- **Interpolation: Weighted Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**



- **Interpolation: Weighted Interpolation Method**
- **Test Image Set:**
  IriTech Right Eye 1031 Images
  (Captured by IriTech Iris Recognition Camera)
- **Algorithm: IriTech Algorithm**

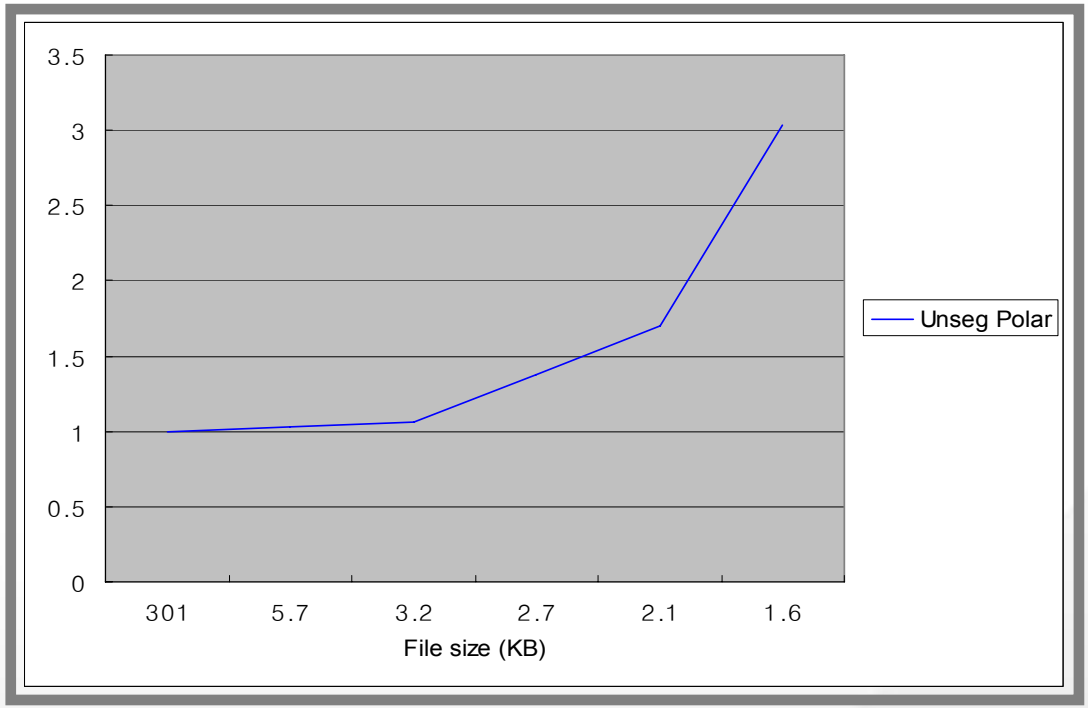
Error Rate Degradation Due to Compression



EER Degradation Ratio for JPEG2000 with Simple Interpolation Scheme

File size (KB)	301.0	3.2	2.1	1.6
Unseg Polar	1.000	1.115	1.165	1.446

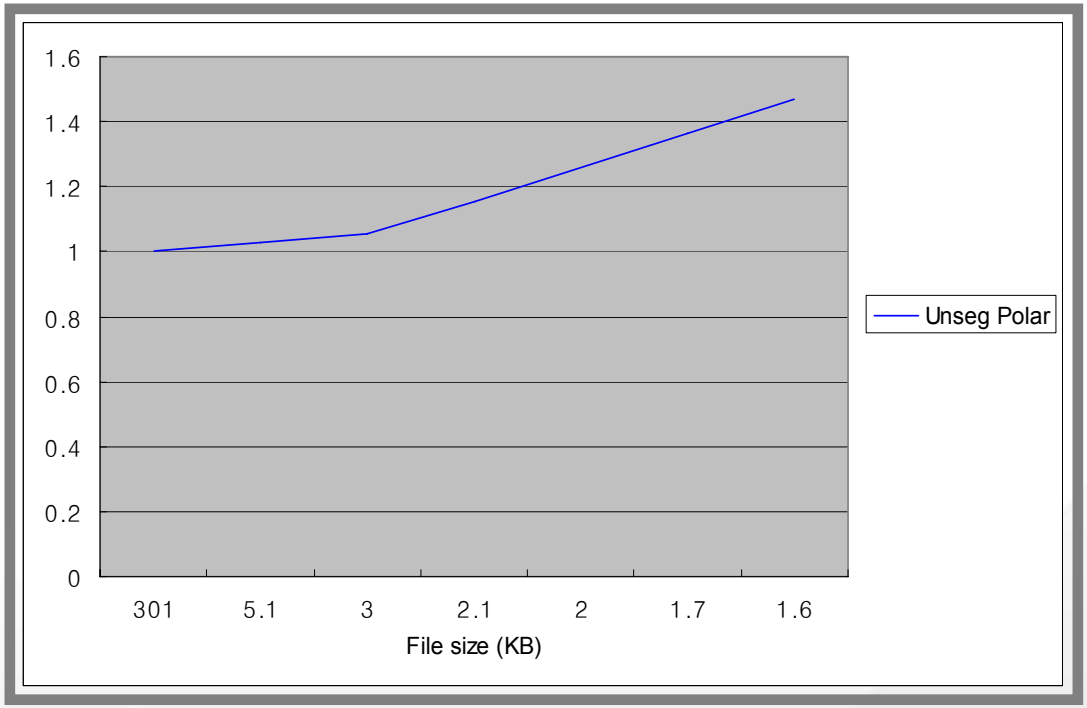
- Test Image Set: ICE Right Eye 1426 Images
- Algorithm: IriTech Algorithm



FRR@FAR=10^{-4} Degradation Ratio for JPEG2000 with Simple Interpolation Scheme

File size (KB)	301.0	3.2	2.1	1.6
Unseg Polar	1.000	1.065	1.698	3.034

- Test Image Set: ICE Right Eye 1426 Images
- Algorithm: IriTech Algorithm

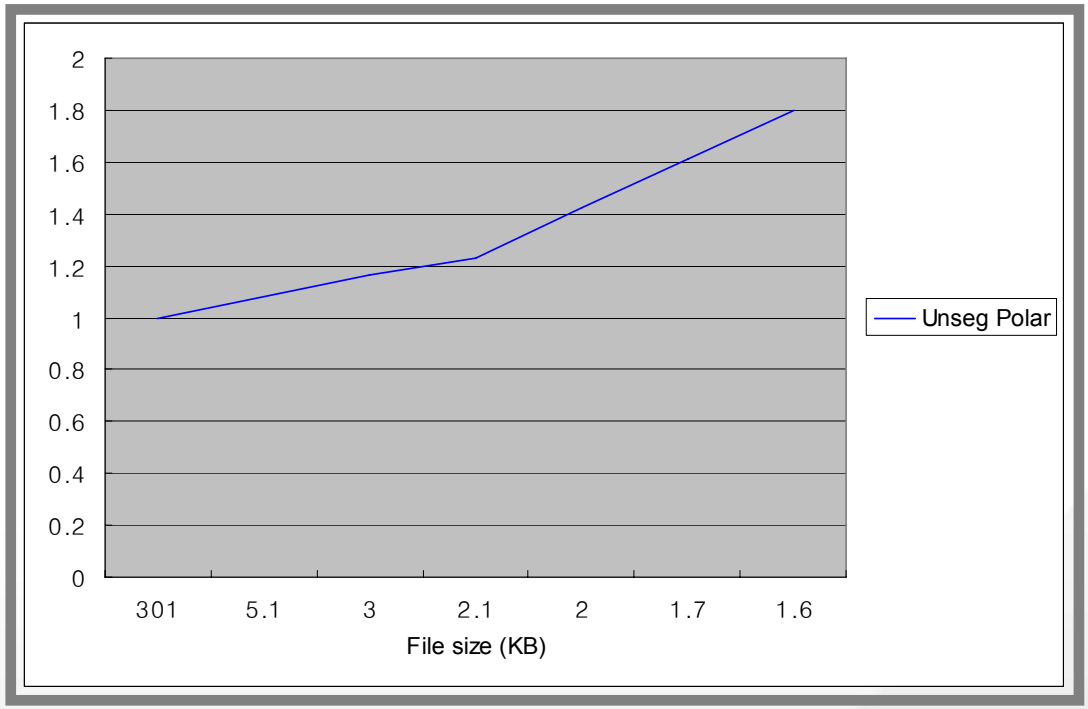


EER Degradation Ratio for JPEG2000 with Weighted Interpolation Scheme

File size (KB)	301.0	3.0	2.1	1.6
Unseg Polar	1.000	1.054	1.156	1.469

•Test Image Set: ICE Right Eye 1426 Images

•Algorithm: IriTech Algorithm

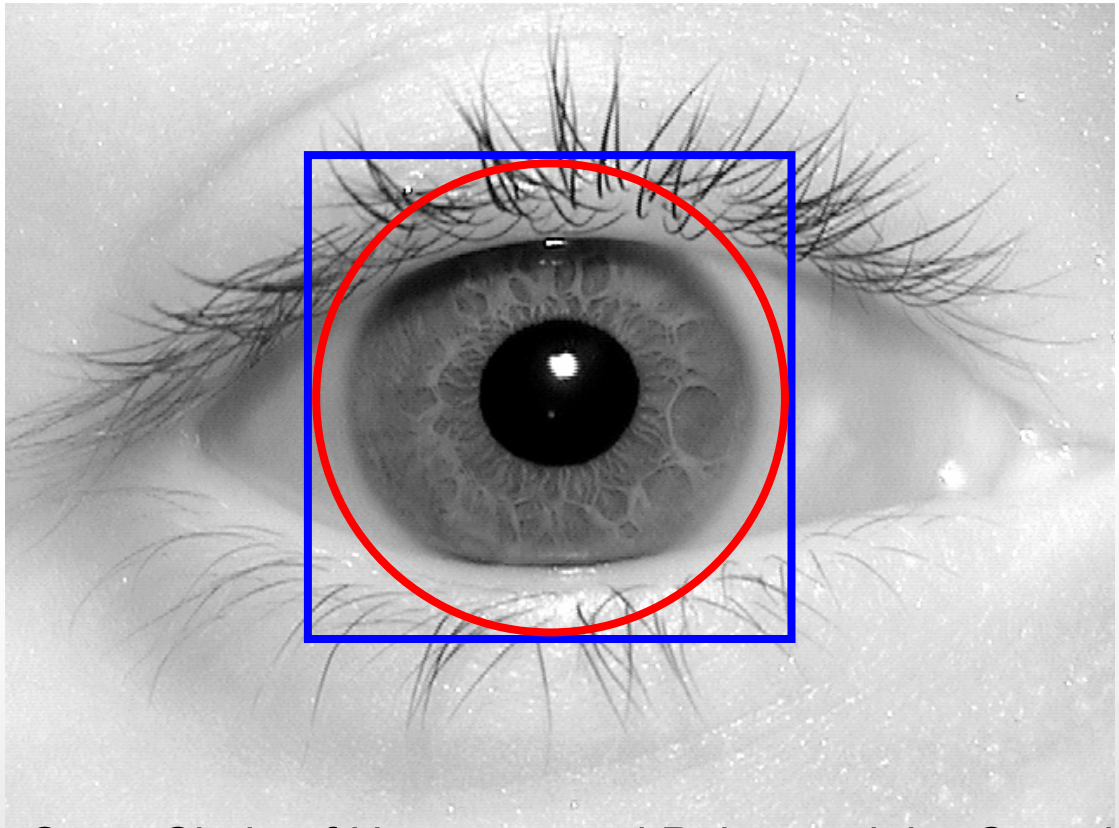


FRR@FAR=10^{-4} Degradation Ratio for JPEG2000 with weighted Interpolation Scheme

File size (KB)	301.0	3.0	2.1	1.6
Unseg Polar	1.000	1.168	1.233	1.802

- Test Image Set: ICE Right Eye 1426 Images
- Algorithm: IriTech Algorithm

5. Discussion



- Finding Outer Circle of Unsegmented Polar and the Cropping Region of Dr Daugman have almost the Same Level of Difficulty.
- ROI Masking = ?

- **Pixel value interpolation schemes do not affect significantly either the visual image quality or the error rates, although the weighted interpolation scheme seems to be slightly better.**

- **This proves the Robustness of the unsegmented polar data format.**

THANK YOU!!!