STORAGE OF INTEROPERABLE FACE IMAGERY ON 2D BAR CODES

- ISO/IEC 18004:2024 **QR code**
- ISO/IEC 16022:2024 Data Matrix
- ISO/IEC 24778:2024 Aztec code

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STANDARDIZED vs. PROPRIETARY PAYLOADS

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A: CROP, RESIZE, COMPRESS

I: STANDARD IMAGE ENCODER e.g. JPEG

J: STANDARD IMAGE DECODER e.g. JPEG

01001111
01101010
01010100
10101010
10101010
0001 ...

01001111
01101010
01010100
10101010
10101010
0001 ....

Q: STANDARD QR EN- and DE-CODER

01101010
01010100
10101010
10101010
00011111
1010 ...

01101010
01010100
10101010
10101010
00011111
1010 ....

U: PROPRIETARY FACE IMAGE ENCODER

V: PROPRIETARY FACE IMAGE DECODER

Q: STANDARD QR EN- and DE-CODER

X: PROPRIETARY TEMPLATE ENCODER

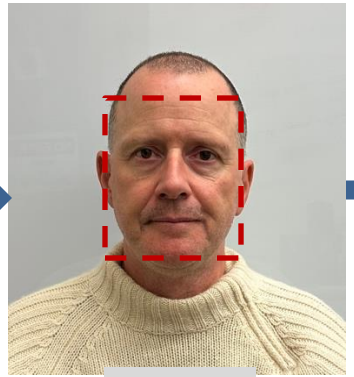
01101010
01010100
10101010
10101010
00011111
1010 ...

MATCHING

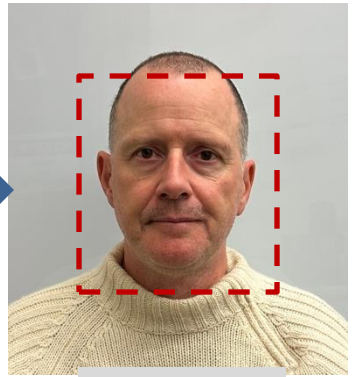
NO IMAGE!

CHAIN OF PROCESSING – ENCODING

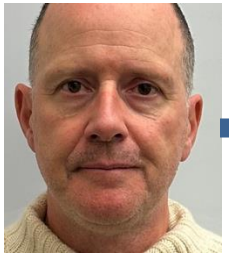
1: COLLECT ISO/ICAO



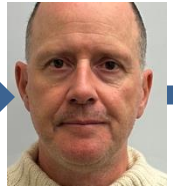
2: DETECT



3: SPECIFY ROI



4: CROP



5: RESIZE

6: COMPRESS

011010100101
010010101010
101010100001
11111010 ...

BINARY COMPRESSED BUFFER

7. QR ENCODE

PRIVATE KEY

QR CODE CONTAINING SIGNATURE + IMAGE + ERROR-CORRECTION

NIST ROLE :: PART I :: SURVEY OPEN METHODS

- ROI Specification: {0%, 10%, 20% … } crop margin
- In-plane rotation: {Yes, No}

- Anti-alias prefilter: {LPF, Blur kernel … }
- Resizing method: {Bicubic, Lanczos, …}
- Target width: {64, 80, 96, 128 … }

- Color: {24 bit, Luminance-only, 8 bit RGB 332, …}
- Compressor: {JPEG, JPEG-LI, JPEG-2000, WEBP, HEIC, … }

ORIG:160x200
41579 bytes

JPG: 87x109
1169 bytes

HEIC: 160x200
1164 bytes

WEBP: 160x200
1198 bytes

JPG-LI: 160x200
1201 bytes
Backwards compatible with JPEG so fully interoperable w installed base

JPG-XL 160x200
1087 bytes

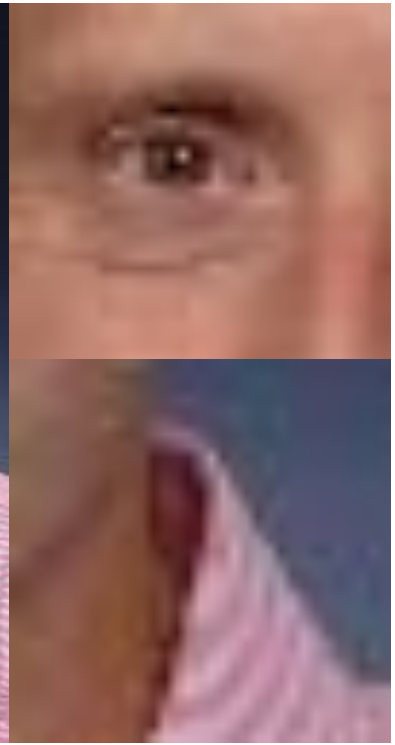
MOZJPG 96x120
1106 bytes

TARGET FILE SIZE: 1200 BYTES

IMAGE SIZE REDUCTION: AVOID ALIASING!

Source photo from camera

Retain only 1 in 64 pixels - every eighth pixel in x and y directions.



Aliasing: High frequency info appear at low frequencies.

TARGET FILE SIZE: 960 BYTES

ORIG: 1205x1326
509697 bytes

JPG: 64x70, 954 bytes

JPG-LI: 64x70, 955 bytes

HEIC: 64x70, 908 bytes

WEBP: 64x70, 938 bytes

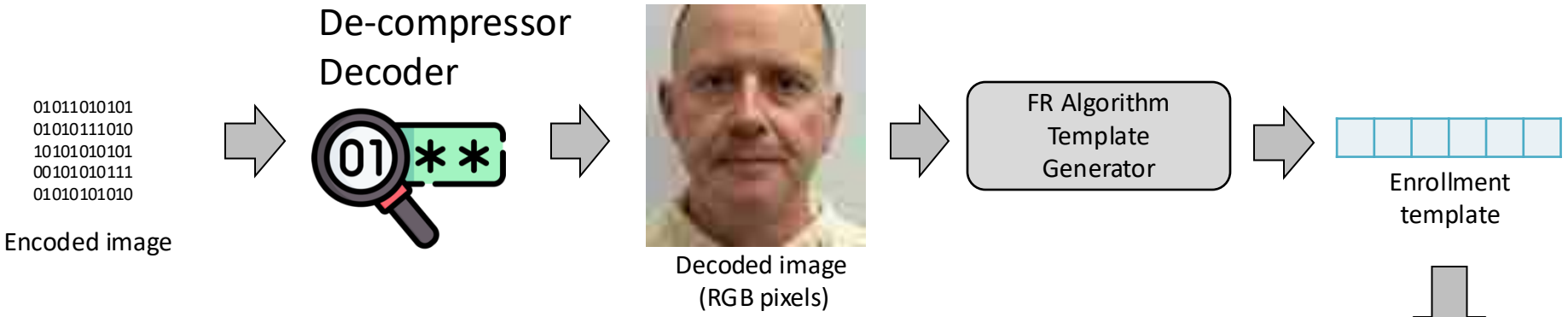
RGB 332

```
// encode: convert 3 channel 3 byte color pixel to compact 1 byte

unsigned char rgbTo332(unsigned char red, unsigned char green, unsigned char blue)
{
  return ((red/32) << 5) | ((green/32) << 2) | (blue/64);  // BIT SHIFT and LOGICAL OR
}
```

```
// decode: convert compact 1 byte to 3 channel 3 byte color pixel

void rgbFrom332(unsigned char colorIndex,
           unsigned char &red, unsigned char &green, unsigned char &blue)
{
  unsigned char value = (colorIndex >> 5) & 0x07;  red   = value != 7 ? (value*255)/7 : 255;
           value = (colorIndex >> 2) & 0x07;  green = value != 7 ? (value*255)/7 : 255;
           value = (colorIndex >> 0) & 0x03;  blue  = value != 3 ? (value*255)/3 : 255;
}
```

Adapted from https://github.com/r-lyeh-archived/rgb332/blob/master/rgb332.cpp

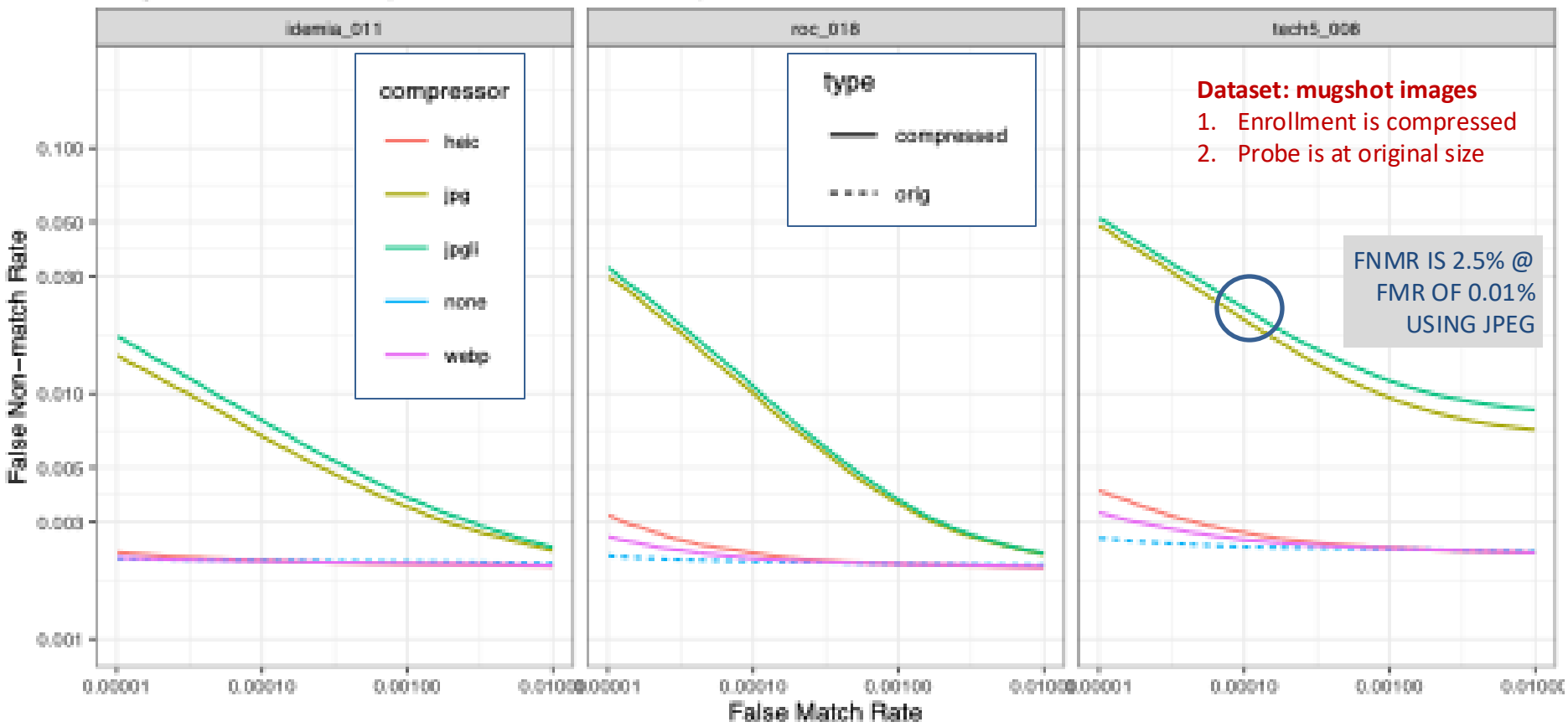
CHAIN OF PROCESSING – DECODING + MATCHING



1. Encoded image is decompressed by its corresponding decoder
2. The decoder produces a decompressed image in the form of RGB pixels
3. The decoded RGB pixels are provided as input to a face recognition algorithm template generator
4. An enrollment template is generated by the face recognition algorithm
5. That enrollment template is then compared against other probe templates with the same face recognition algorithm

Enrollment template is compared that is different probe templates

COMPRESSION TO: 960 BYTES, AT WIDTH 64 PIXELS

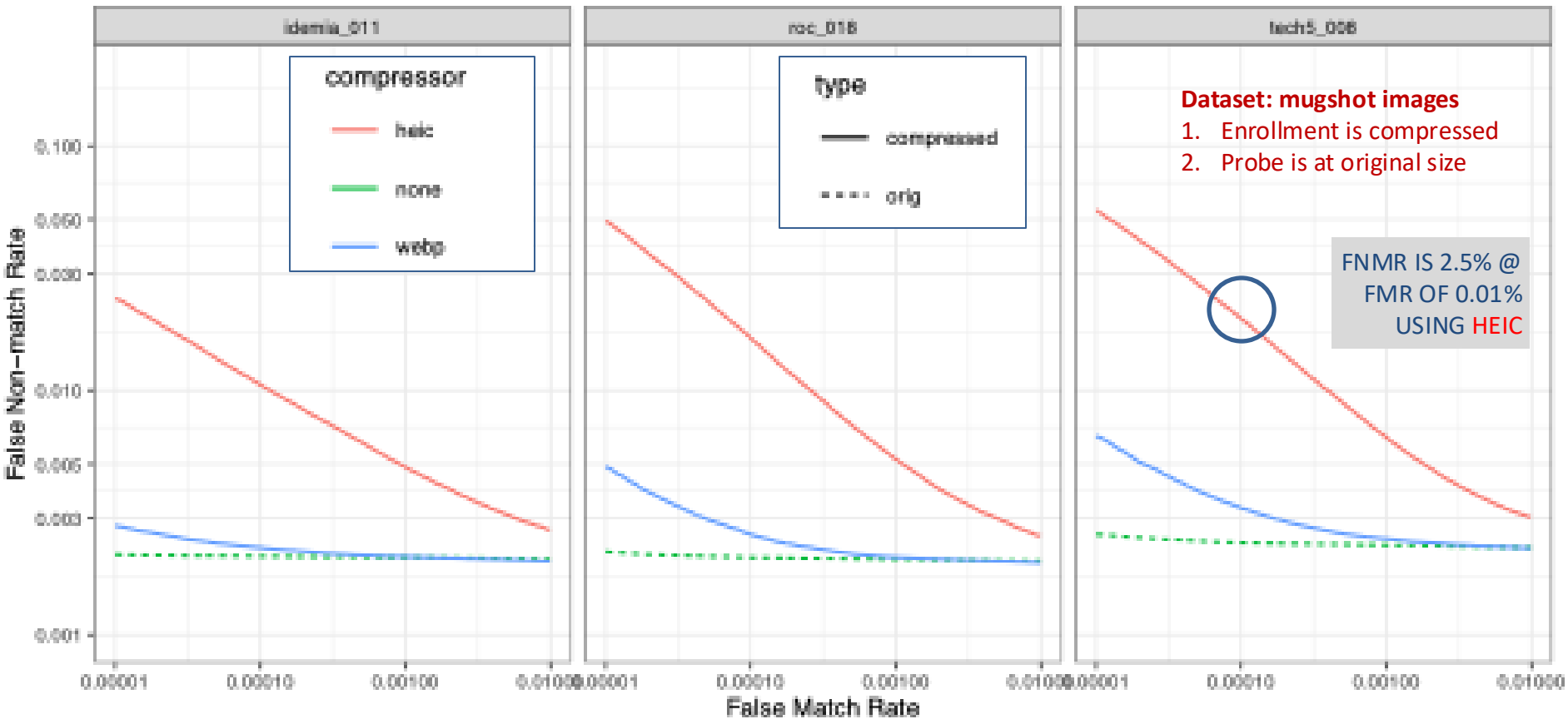


Dataset: mugshot images

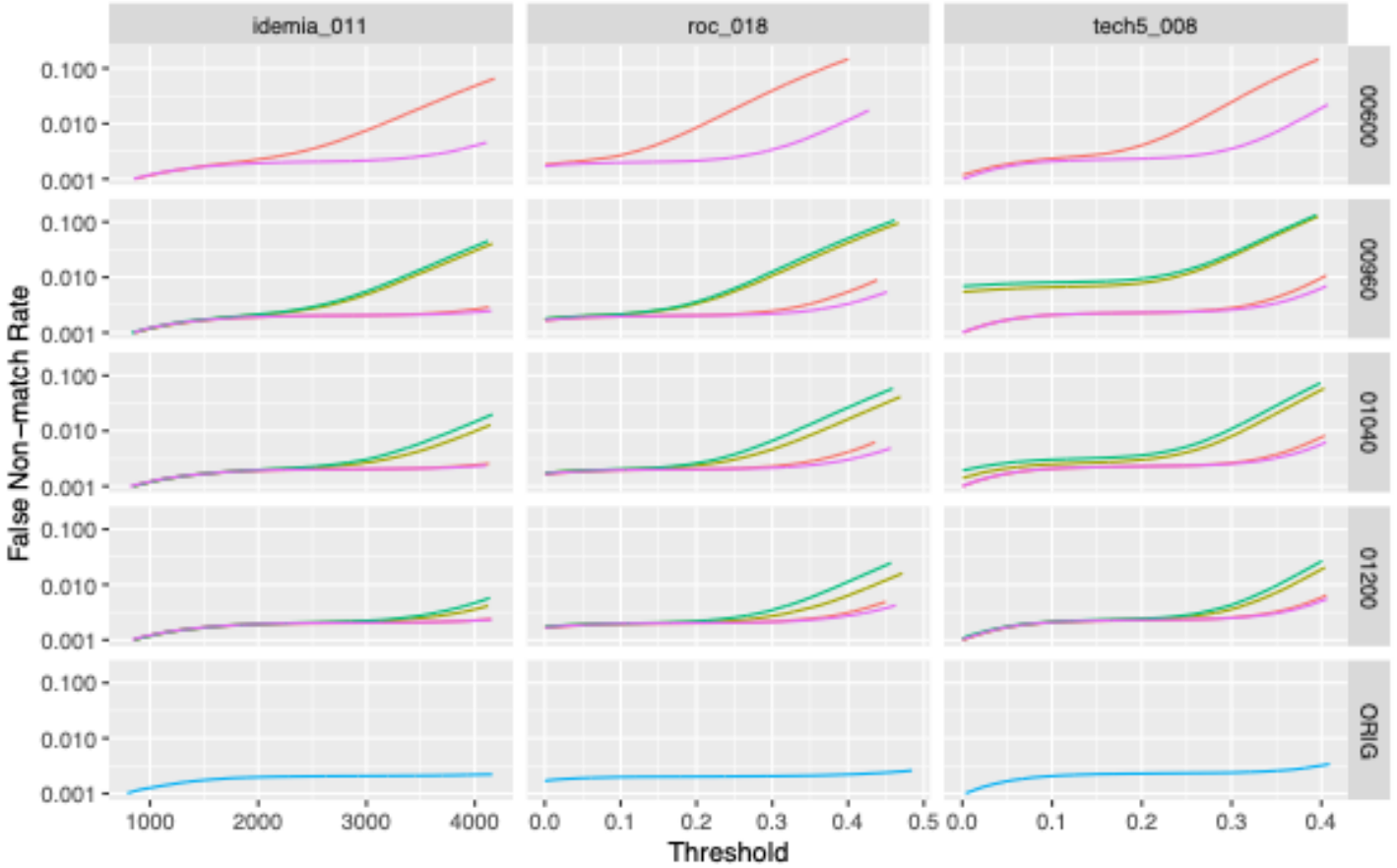
1. Enrollment is compressed
2. Probe is at original size

FNMR IS 2.5% @ FMR OF 0.01% USING JPEG

COMPRESSION TO: 600 BYTES AT WIDTH = 64 PIXELS



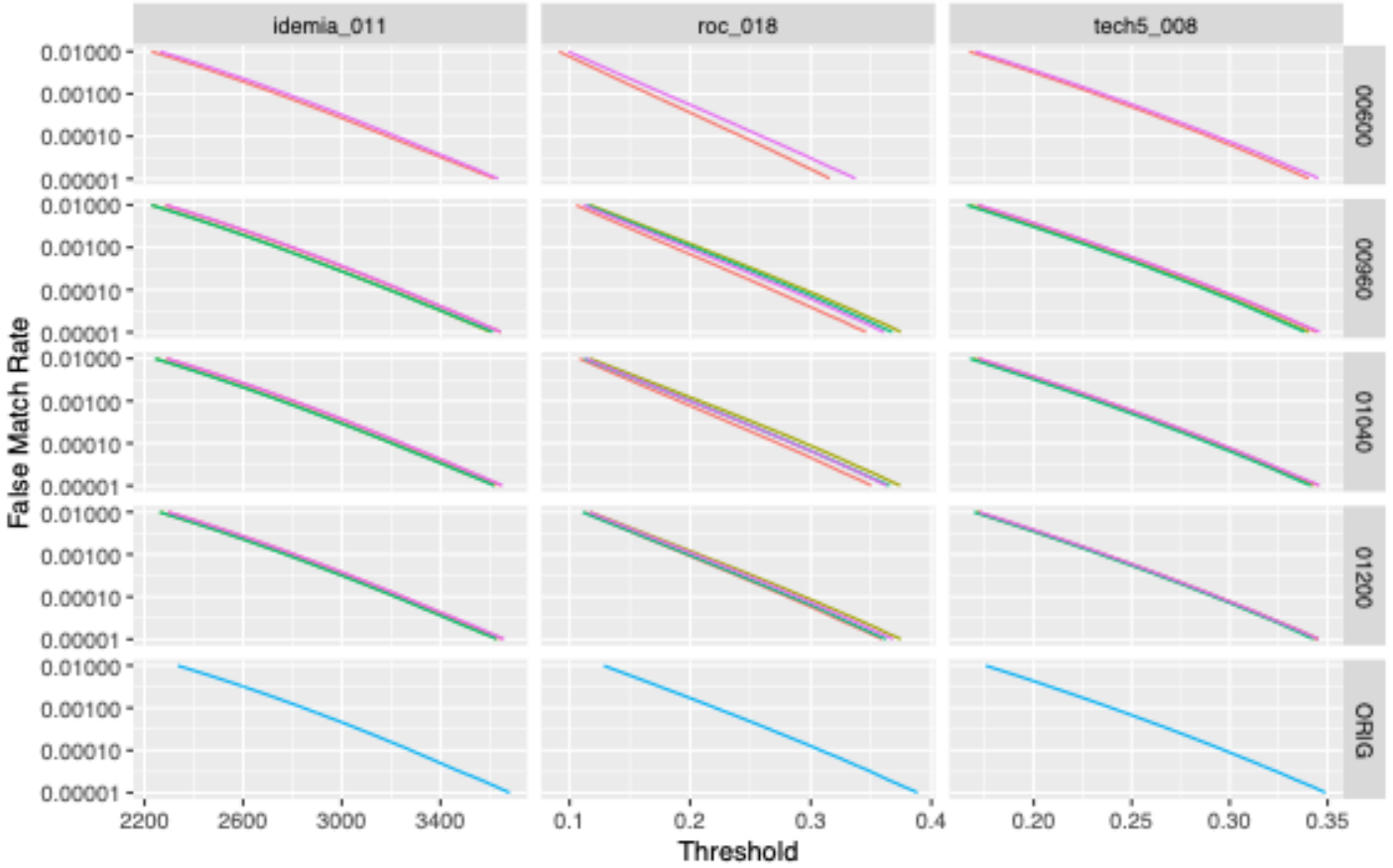
DIFFERENT VIEW :: FNMR(THRESHOLD)



600 BYTES

ORIGINAL

DO FALSE MATCH RATES TAKE OFF ?



600 BYTES

ORIGINAL

NIST ROLE :: PART II :: MEASURE ACCURACY OF PROPRIETARY SOLUTIONS

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- Usual NIST modus operandi: Open free black box test | C++ | public results
- API
  - returnCode encode(const Image &originalFace, const int targetSize, uchar &compact)
  - returnCode decode(const uchar &compact, Image &reconstructedFace)

UNKNOWN HUMAN CAPABILITY:
PERCEPTION ⟶ COMPARISON ⟶ FRAUD DETECTION

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ORIG: 1205x1326: 509697 B

JPG: 64x70, 954 bytes

WEBP: 64x70, 938 bytes

Summary

NIST Survey

- NIST will produce a report on how to prepare compact images for QR codes under constraints
  - Standardized data
  - Low accuracy loss (over a pool of FR models)
- Report will survey over
  - Crop margin
  - Image dimensions
  - Resize method
  - Compressor

Next: NIST to run open benchmark

- Developer's submit compact image encoders and decoders
- Publish accuracy + speed + example images.

Bigger Picture

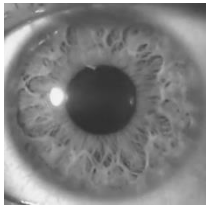
- Compact images smaller than many developers' templates
  - Most accurate developer recently: 594 bytes
- Compressors
  - JPEG is ancient, has artifacts
  - Replacements designed for multimedia (TV etc.)
  - Can a face-specific compressor be built ⟶ tested ⟶ standardized?
- Humans are in-the-loop
  - Are not very accurate
  - Are not helped by extreme lossy compression
  - Human tests lacking but
    - Accuracy (compact) < Accuracy (high quality)
  - Alternatives …


Patrick Grother


Kayee Hanaoka (+ Mei Ngan)


Austin Hom


(not) Mei Ngan


Jim Matey


Joyce Yang

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THANK YOU

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