

NFIQ2 for Contact-less Fingerprint Data: Case Study, Issues and Challenges

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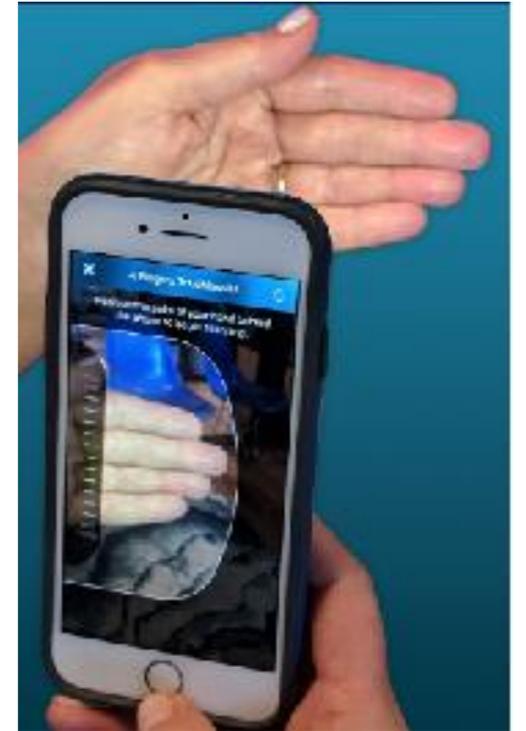
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Agenda

1. Introduction
2. Previous Works
3. Case Study with NFIQ2
4. Issues and Challenges

Introduction

- Contact-less fingerprint capturing offers many advantages:
 - Less hygienic concerns (COVID-19), no ghost fingerprints on capture device
 - Mobile capturing with smartphones
- Commercial mobile SDKs and stationary capture devices are available
- Environmental factors (lighting, contrast, etc.) are a challenge



Source: Veridium

Sample quality estimation algorithm comparable to NFIQ2 is needed to achieve high biometric performance and interoperability to legacy data!

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1. Introduction
2. **Previous Works**
3. Case Study with NFIQ2
4. Issues and Challenges

Previous Research

- Specific features for contactless fingerprints directly applied to photographs, in Labati et al. (2010), Li et al. (2013), Yang et al. (2013)
 - e.g. FFT frequencies, minutiae-based, learned features (neural network),
 - Machine learning-based aggregation (SVM)
- Basic image features, e.g. sharpness, in Kauba et al. (2021)
- Application of NFIQ 1 / NFIQ 2 to contactless fingerprints
 - e.g. in Labati et al. (2010), Wild et al. (2019), Priesnitz et al. (2020)
 - Specific pre-processing, e.g. local brightness & contrast adjustment, ridge frequency normalization, up- and down-scaling, ...

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4. Issues and Challenges

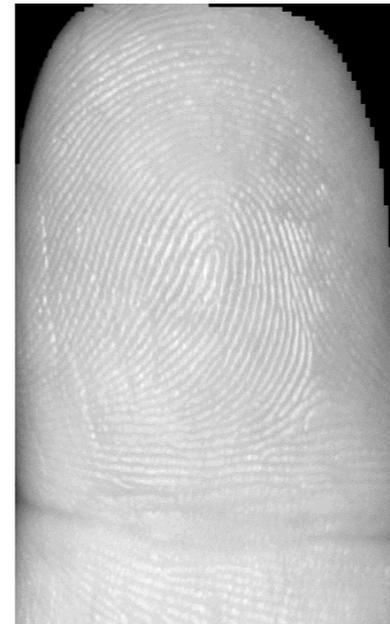
Case Study with NFIQ2

- 3 subjects, 8 Fingers
- 4 different smartphones
- 4 commercial SDKs (not always the latest version)



Case Study with NFIQ2

- All SDKs output pre-processed images
 - Segmentation and locally adaptive contrast enhancement
- Capture of full slap
 - Fingers may be captured at different points in time
- Real-time feedback to guide positioning (focus)

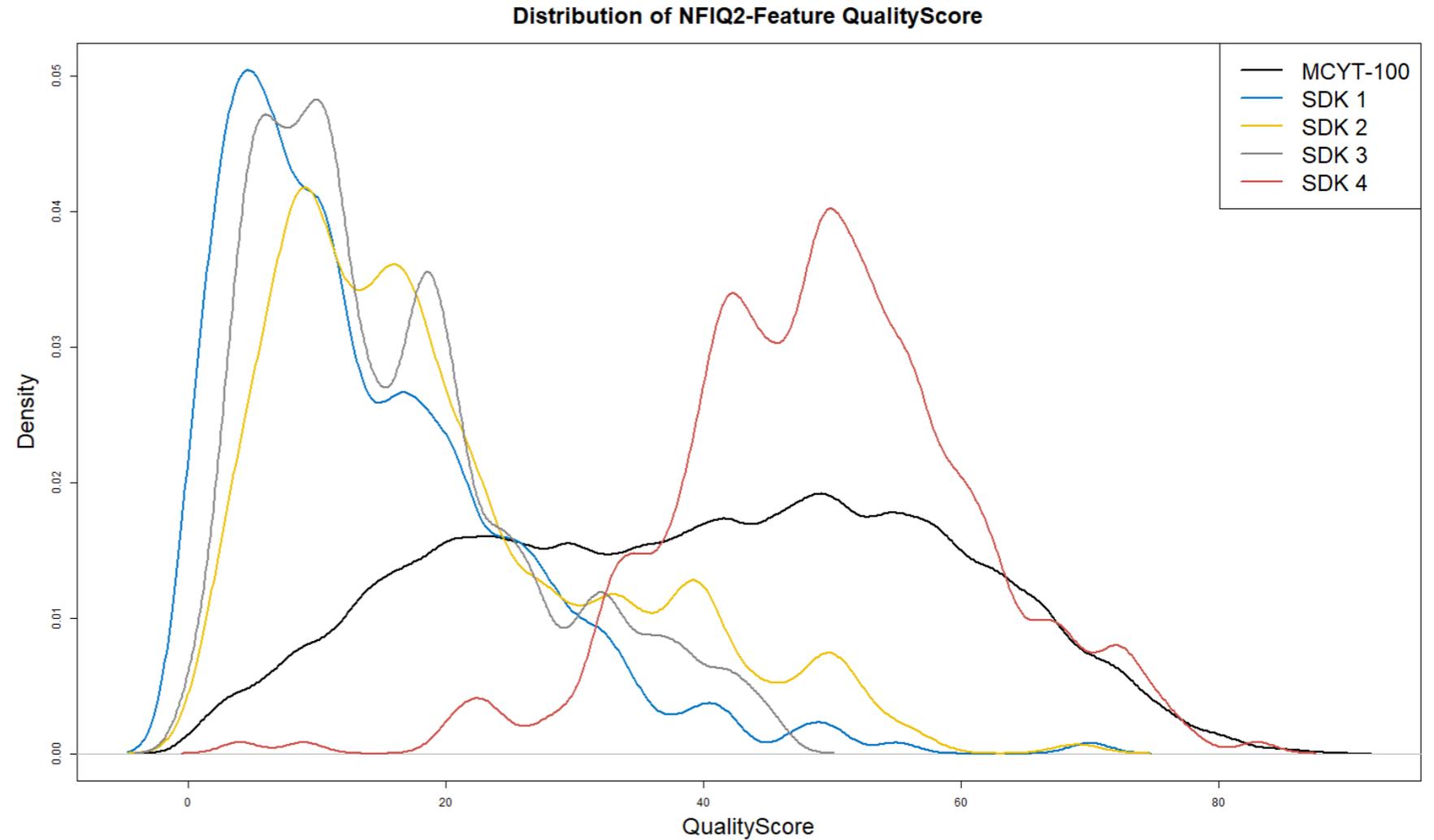


Case Study with NFIQ2

- NFIQ2 quality scores and features (NFIQ 2.1-pre) of pre-processed images
 - Comparison with optical contact-based fingerprints (MCYT-100, all 10 Fingers)
 - Also evaluation per SDK
- Genuine comparison scores with Neurotechnology VeriFinger 11.2
 - Using proprietary FMR
 - Utility as mean of genuine scores

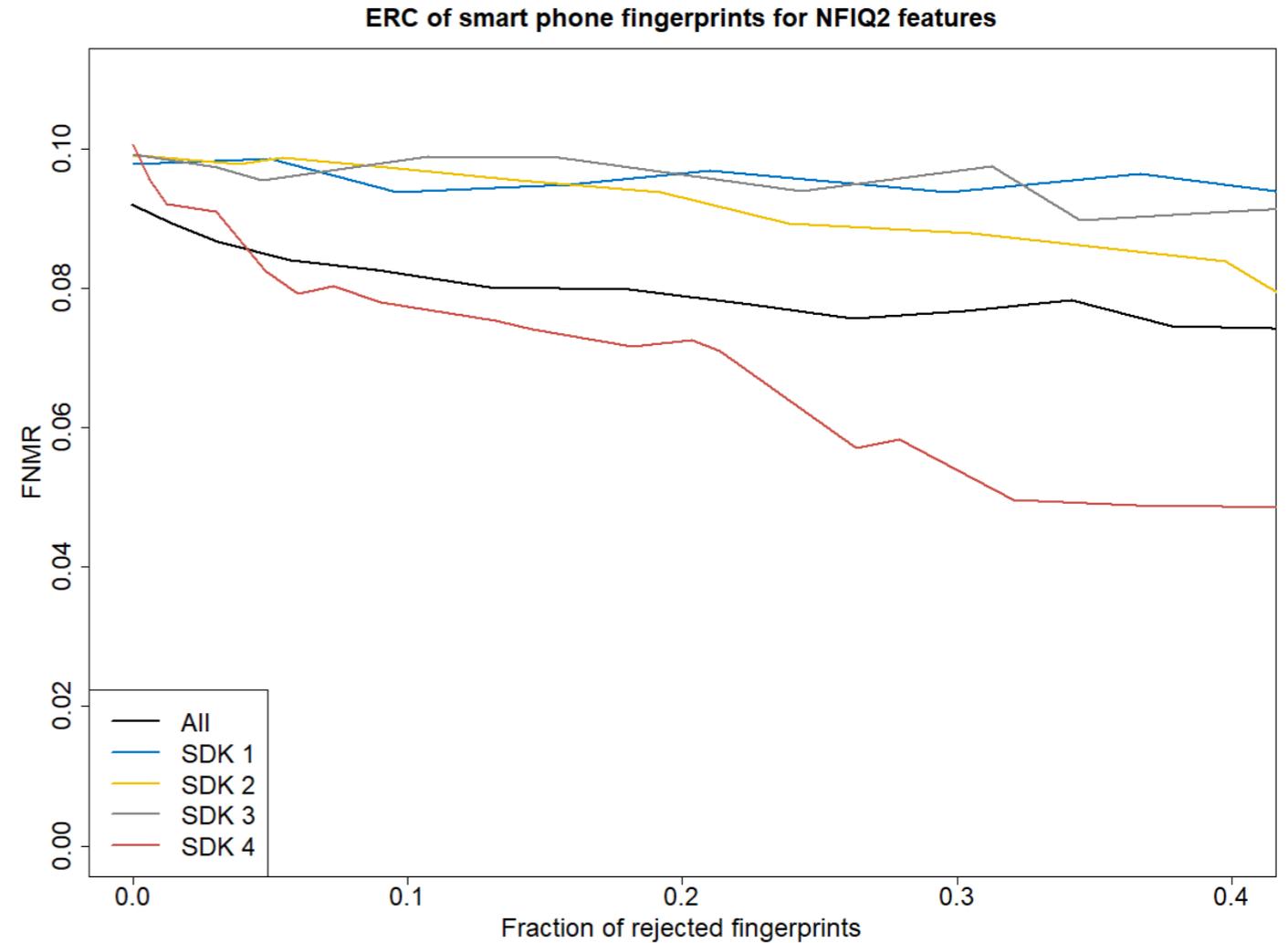
Case Study - NFIQ2 Scores

- Low NFIQ2 scores for 3 of the SDKs



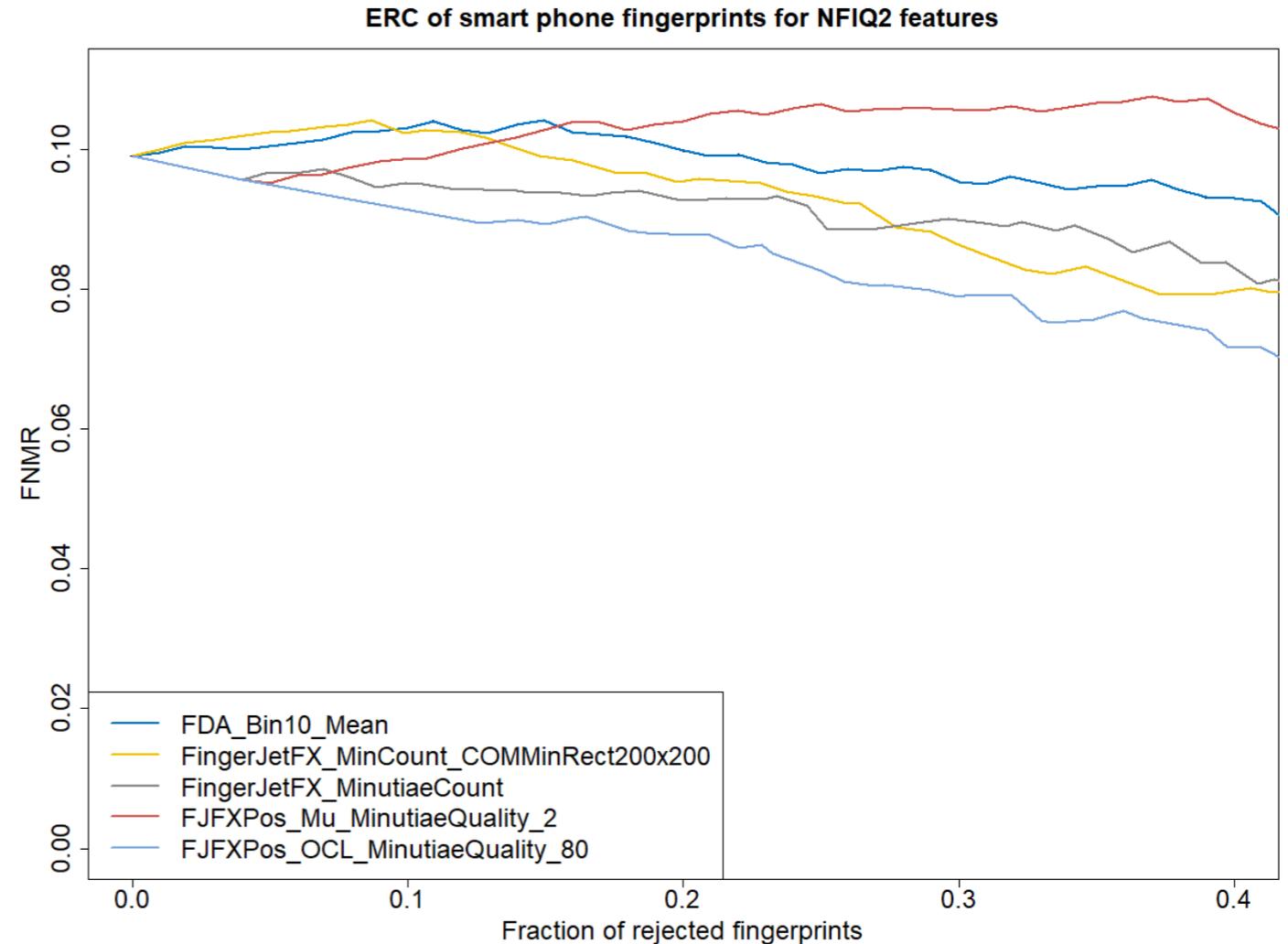
Case Study - NFIQ2 Scores

- Poor predictive power of NFIQ2 scores for 3 of the SDKs



Case Study – Predictive Power of NFIQ2 Scores

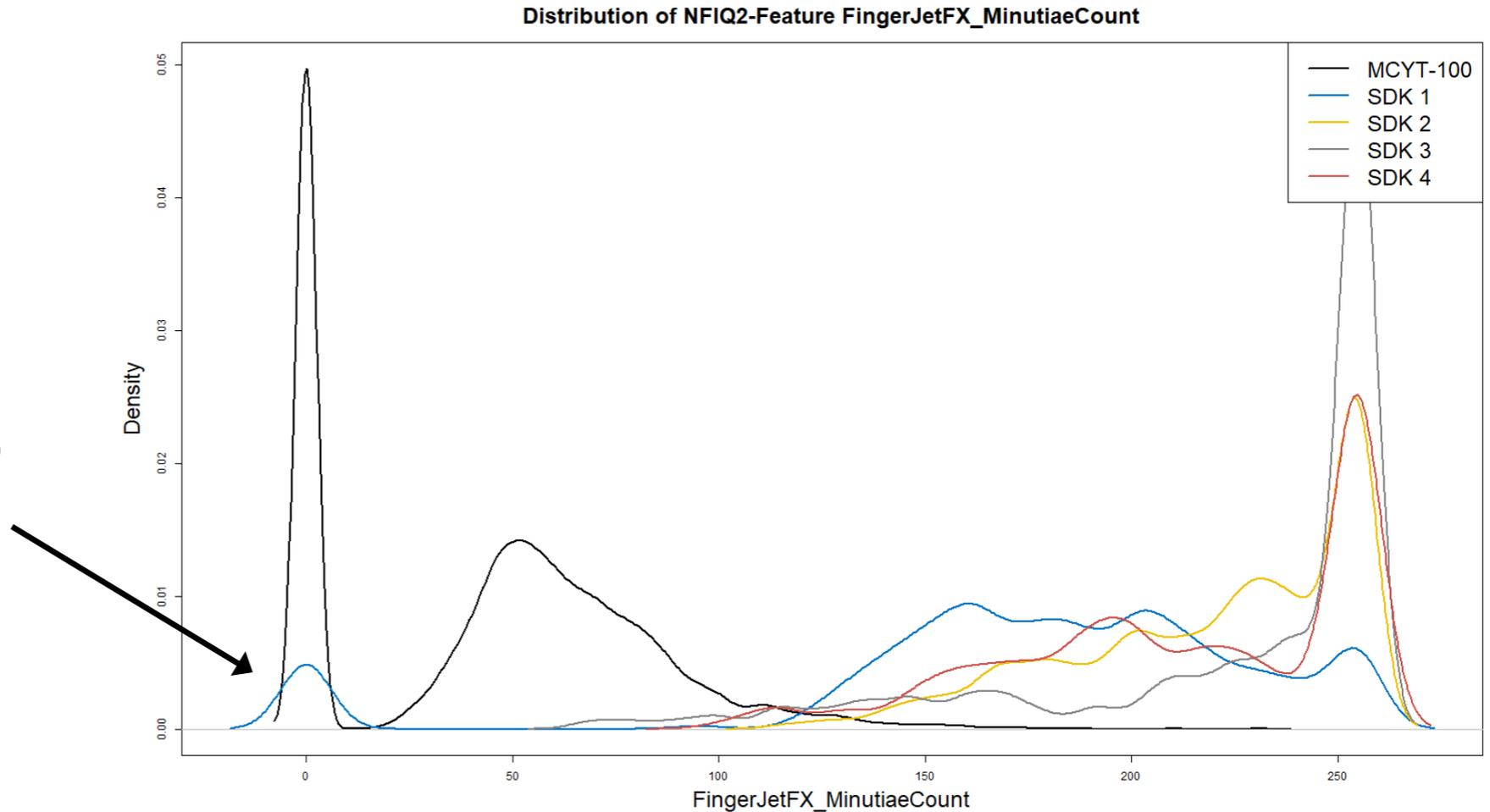
- Poor predictive power of FDA and most FJFX features
- FJFXPos_OCL_MinutiaeQuality performs best



Case Study – Feature FJFX Minutiae Count

- Much more minutiae detected in contactless fingerprints

Minutiae count is 0,
if foreground area
is too small



Case Study – FJFX Minutiae Count

- Many spurious minutiae detected
 - » In particular at boundary and second finger segment
 - » However: spurious minutiae have lower quality which explains better performance of OCL-based minutiae quality

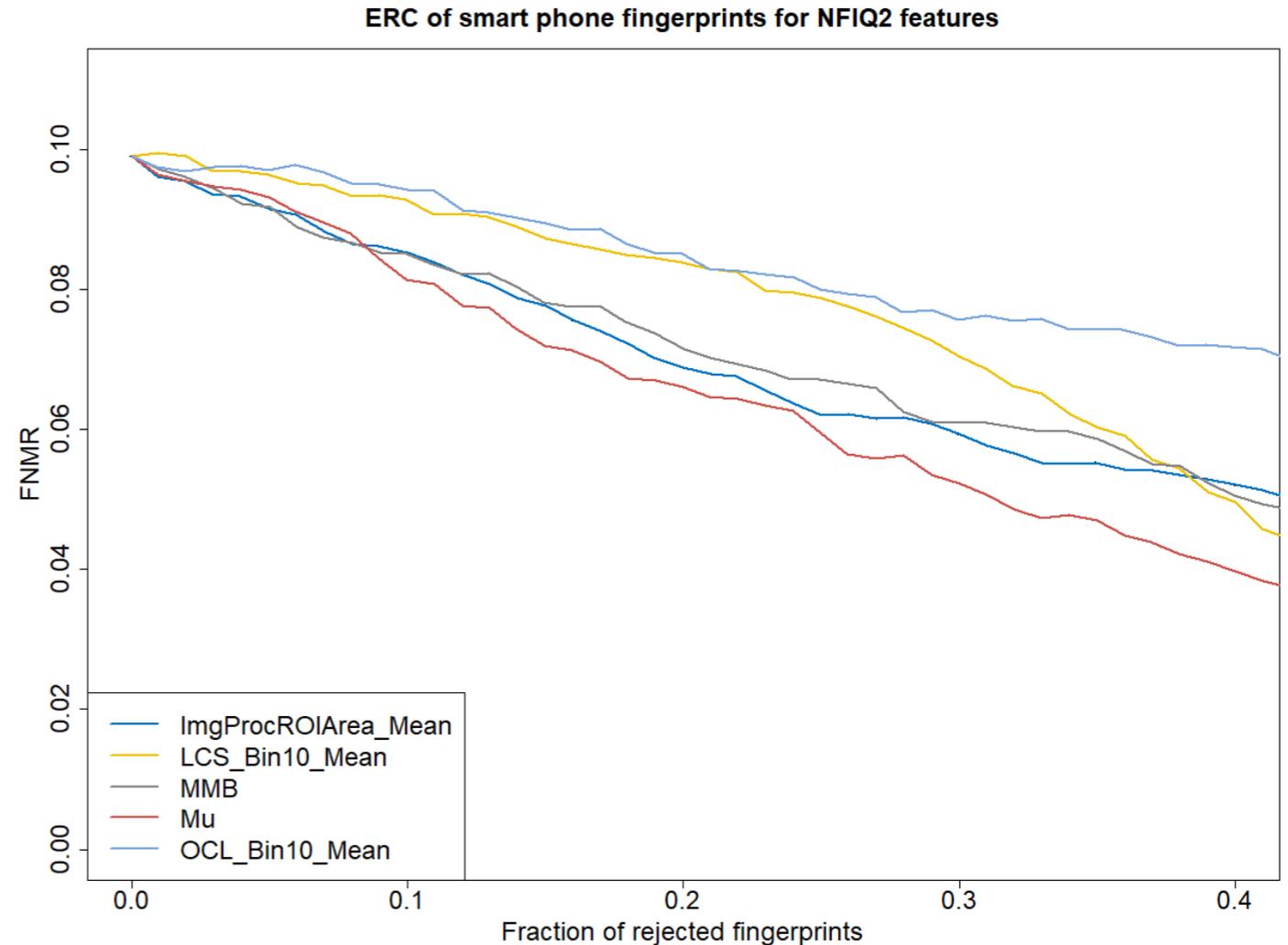
Brightness
indicates FJFX
minutiae quality



Case Study - Predictive Power of NFIQ2 Features (1)

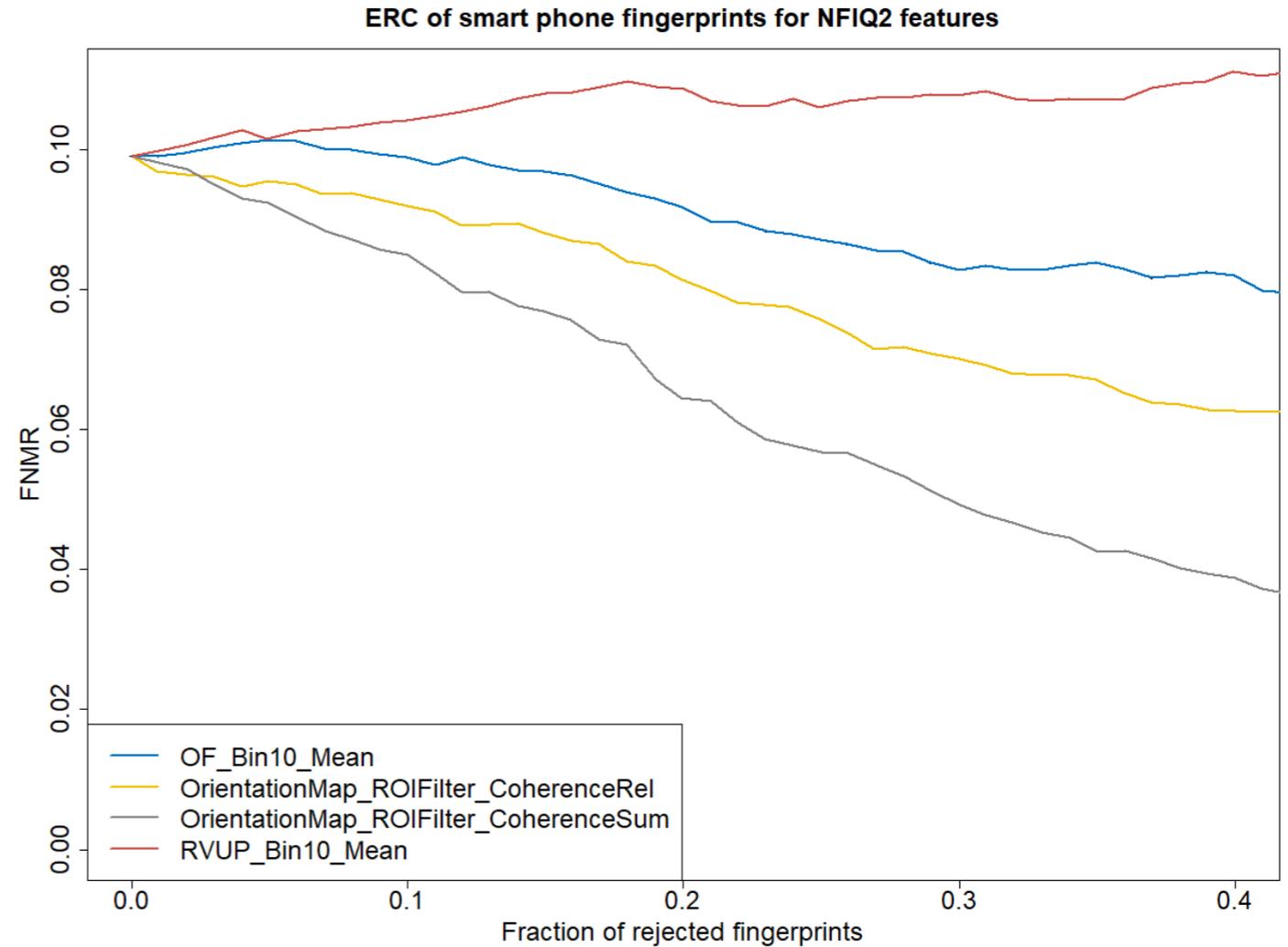
■ Better predictive power of
ImgProcROIArea_Mean, LCS, MMB, Mu

➤➤ Even better than NFIQ2 quality score



Case Study - Predictive Power of NFIQ2 Features (2)

- Better predictive power of features based on OrientationMap_ROIFilter_Coherence



Case Study – Correlation with Utility

- Some features have stronger correlations with utility than quality score

	QualityScore	FDA_Bin10_Me	FingerJetFX_Mi	FingerJetFX_Mi	FJFXPos_Mu_A	FJFXPos_OCL_	ImgProcROIAre	LCS_Bin10_Me	MMB	Mu	OCL_Bin10_Me	OF_Bin10_Mea	OrientationMap	OrientationMap	RVUP_Bin10_A	Utility
QualityScore	100	-45	-30	-14	59	65	45	42	5	20	70	-2	73	48	-75	20
FDA_Bin10_Mean	-45	100	-34	15	-74	-15	3	30	40	37	-29	37	-26	34	45	10
FingerJetFX_MinCount_COMMinRect200x200	-30	-34	100	15	25	-20	-31	-56	-28	-38	-18	-41	-23	-57	18	-23
FingerJetFX_MinutiaeCount	-14	15	15	100	1	-12	21	22	13	19	-23	17	-17	32	16	-8
FJFXPos_Mu_MinutiaeQuality_2	59	-74	25	1	100	32	21	2	-23	-13	38	-21	40	-3	-55	1
FJFXPos_OCL_MinutiaeQuality_80	65	-15	-20	-12	32	100	23	32	7	18	81	14	84	39	-53	30
ImgProcROIArea_Mean	45	3	-31	21	21	23	100	45	62	79	15	23	22	70	-22	26
LCS_Bin10_Mean	42	30	-56	22	2	32	45	100	23	42	27	50	37	77	-28	18
MMB	5	40	-28	13	-23	7	62	23	100	88	-2	20	0	49	6	31
Mu	20	37	-38	19	-13	18	79	42	88	100	7	31	11	66	-5	36
OCL_Bin10_Mean	70	-29	-18	-23	38	81	15	27	-2	7	100	-9	96	30	-63	27
OF_Bin10_Mean	-2	37	-41	17	-21	14	23	50	20	31	-9	100	1	37	1	6
OrientationMap_ROIFilter_CoherenceRel	73	-26	-23	-17	40	84	22	37	0	11	96	1	100	37	-63	26
OrientationMap_ROIFilter_CoherenceSum	48	34	-57	32	-3	39	70	77	49	66	30	37	37	100	-22	34
RVUP_Bin10_Mean	-75	45	18	16	-55	-53	-22	-28	6	-5	-63	1	-63	-22	100	-14
Utility	20	10	-23	-8	1	30	26	18	31	36	27	6	26	34	-14	100

Case Study – Conclusions

- Some NFIQ2 features are quite predictive
- Others may need tuning (e.g. FJFX features)

- New training needed

Agenda

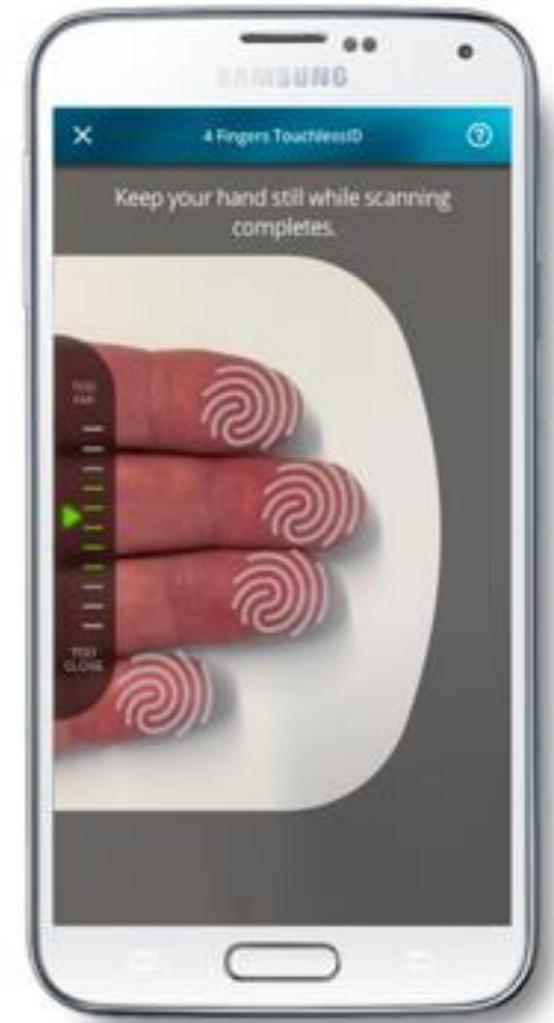
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Issues and Challenges

- Approximation of 500dpi resolution is a great challenge
 - Scale invariant quality measure (and matcher) would be favorable
 - Observation: Increase of resolution (scaling) often leads to increase of NFIQ2 score
- Peripheral areas may turn out problematic for NFIQ2
 - Should segmentation be a requirement?

Issues and Challenges (cont'd)

- Real-time user feedback is needed as positioning guidance for high quality contact-less fingerprint acquisition
 - >> NFIQ2 not suitable due to computational demands and required post-processing
 - >> Real-time computation required!
 - >> Quality estimation on the raw photo (RGB or grayscale) to avoid information loss
 - >> Second QA algorithm could be used for post-processed fingerprints



Source: Veridium

Issues and Challenges (cont'd)

- Unprocessed finger photos may have different quality features
 - Sharpness, contrast, brightness, etc.
 - ROI, FFT frequency spectrum, etc.
 - Deep-learning to learn quality features (training data needed)



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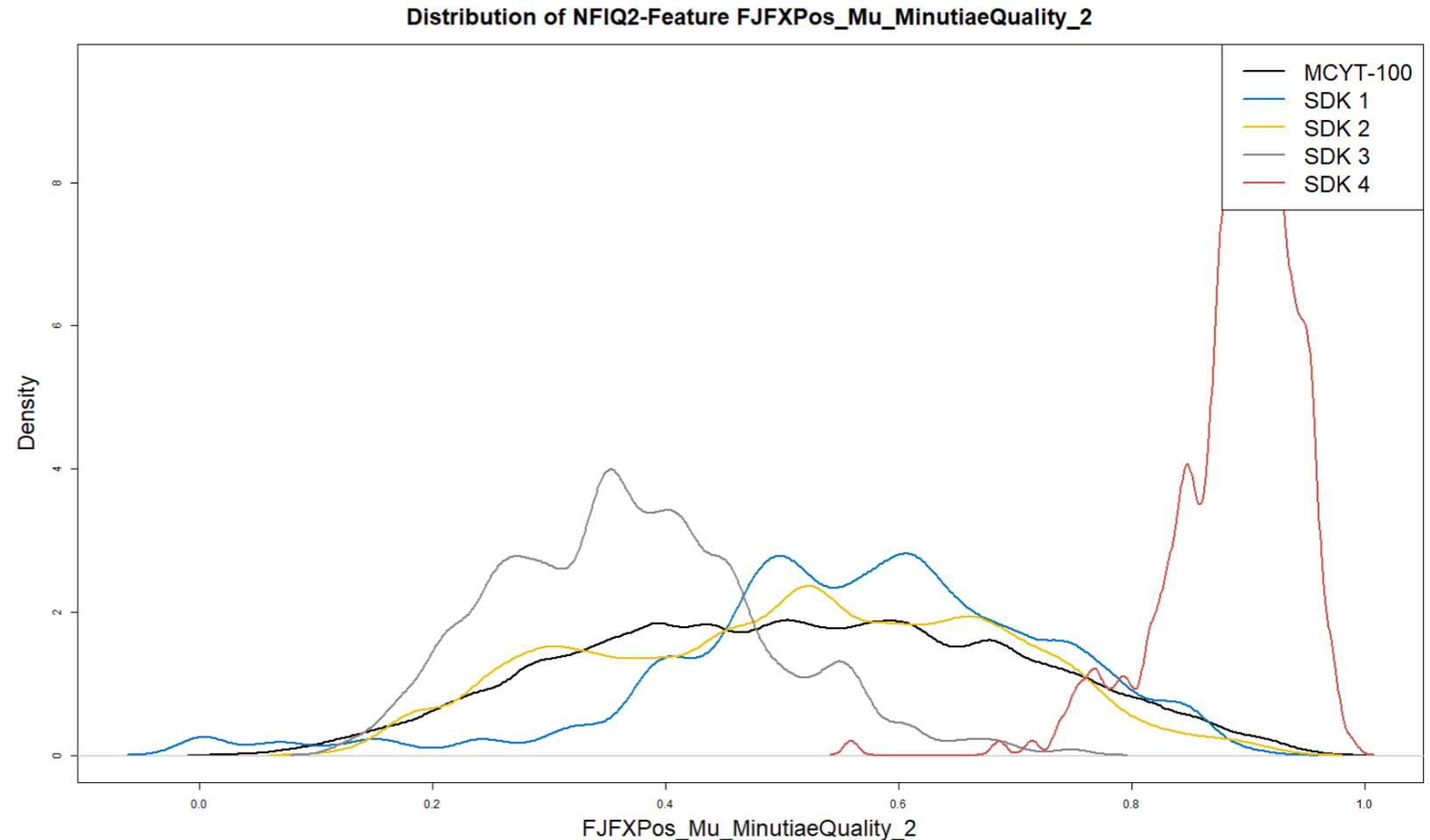
The logo for secunet, featuring the word "secunet" in a bold, sans-serif font. The letters "secunet" are black, and the letters "net" are red. The background of the slide is white with a large, curved red shape on the left side that tapers towards the top right.

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Case Study – FJFX Minutiae Quality Feature Q_{MIN}^{mu}

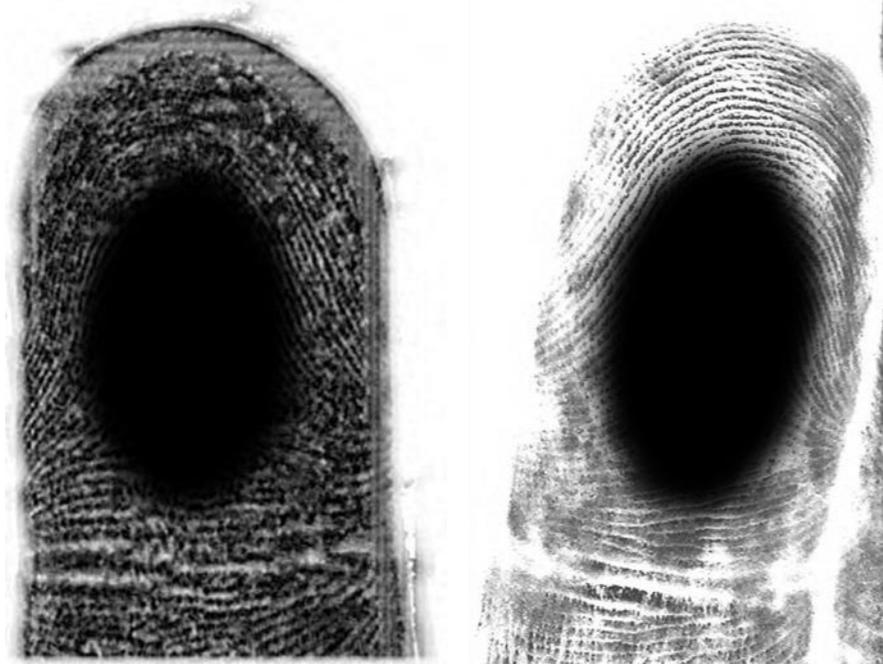
- Large differences between SDKs
 - » Very high values for one SDK
 - » Lower correlation with NFIQ2 score than for MCYT-100
- However: No big differences between SDKs for Q_{MIN}^{ocl}



Case Study – Feature Mu

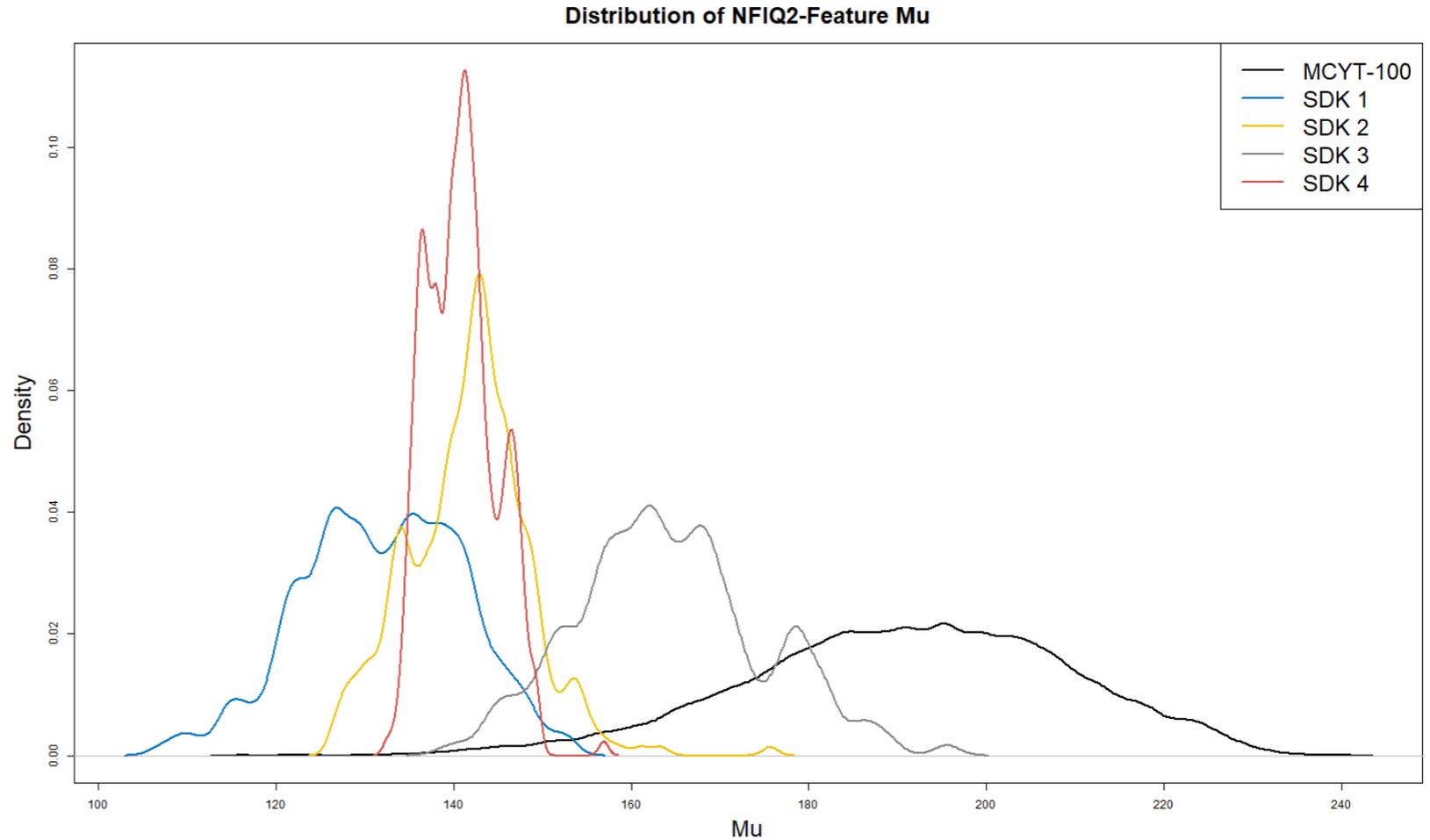
- Arithmetic mean of the gray scale input image

➤ Some contactless fingerprints are too dark



Mu = 109
NFIQ2 = 0

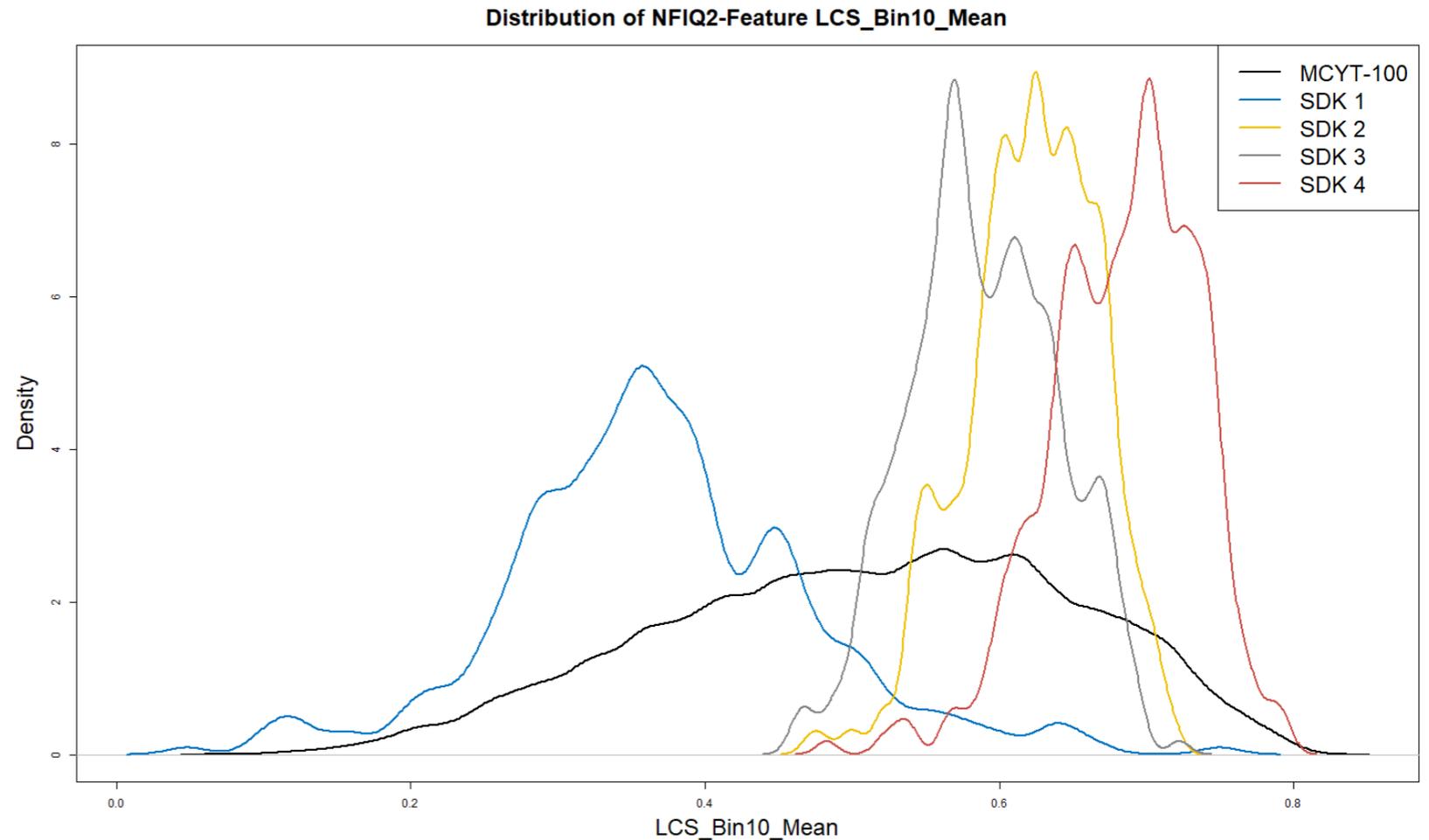
Mu = 196
NFIQ2 = 0



Case Study – Local Clarity Score (LCS_Mean)

- Large differences between SDKs

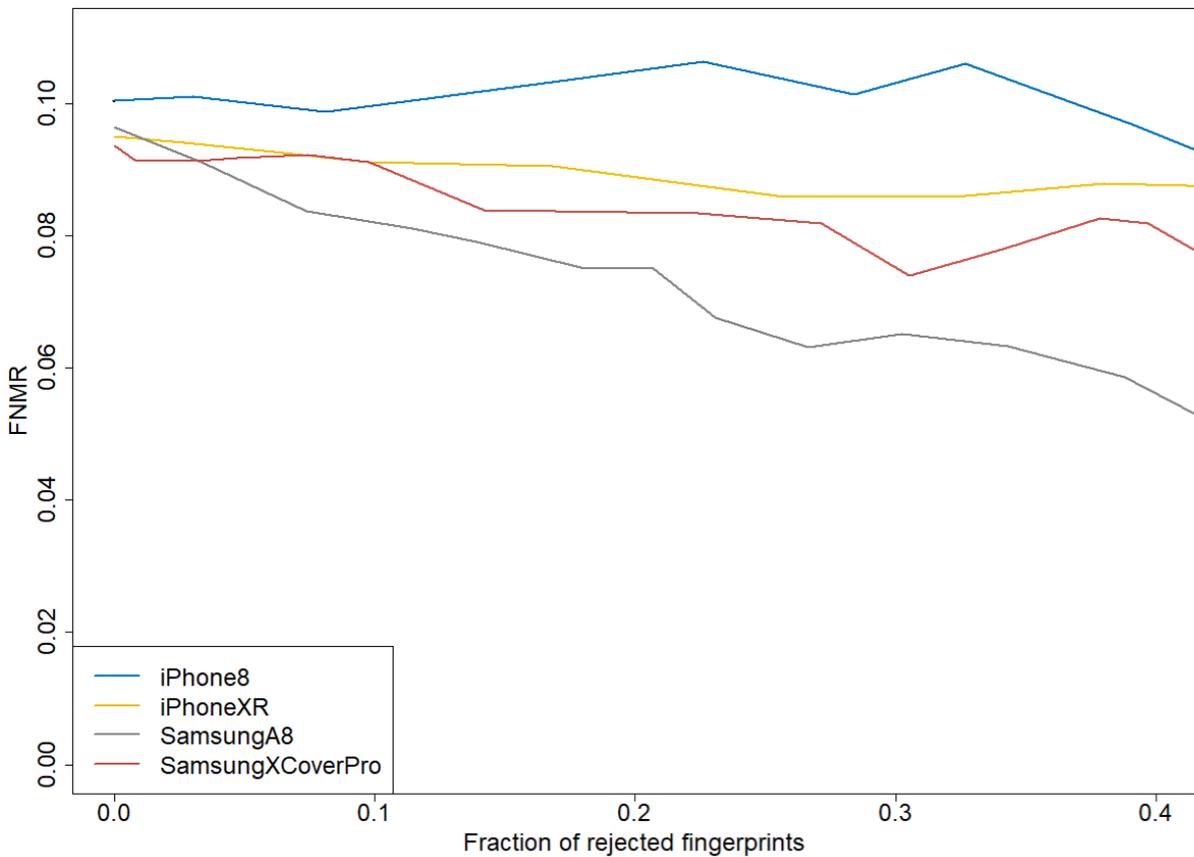
- Lower correlation with NFIQ2 score than for MCYT-100



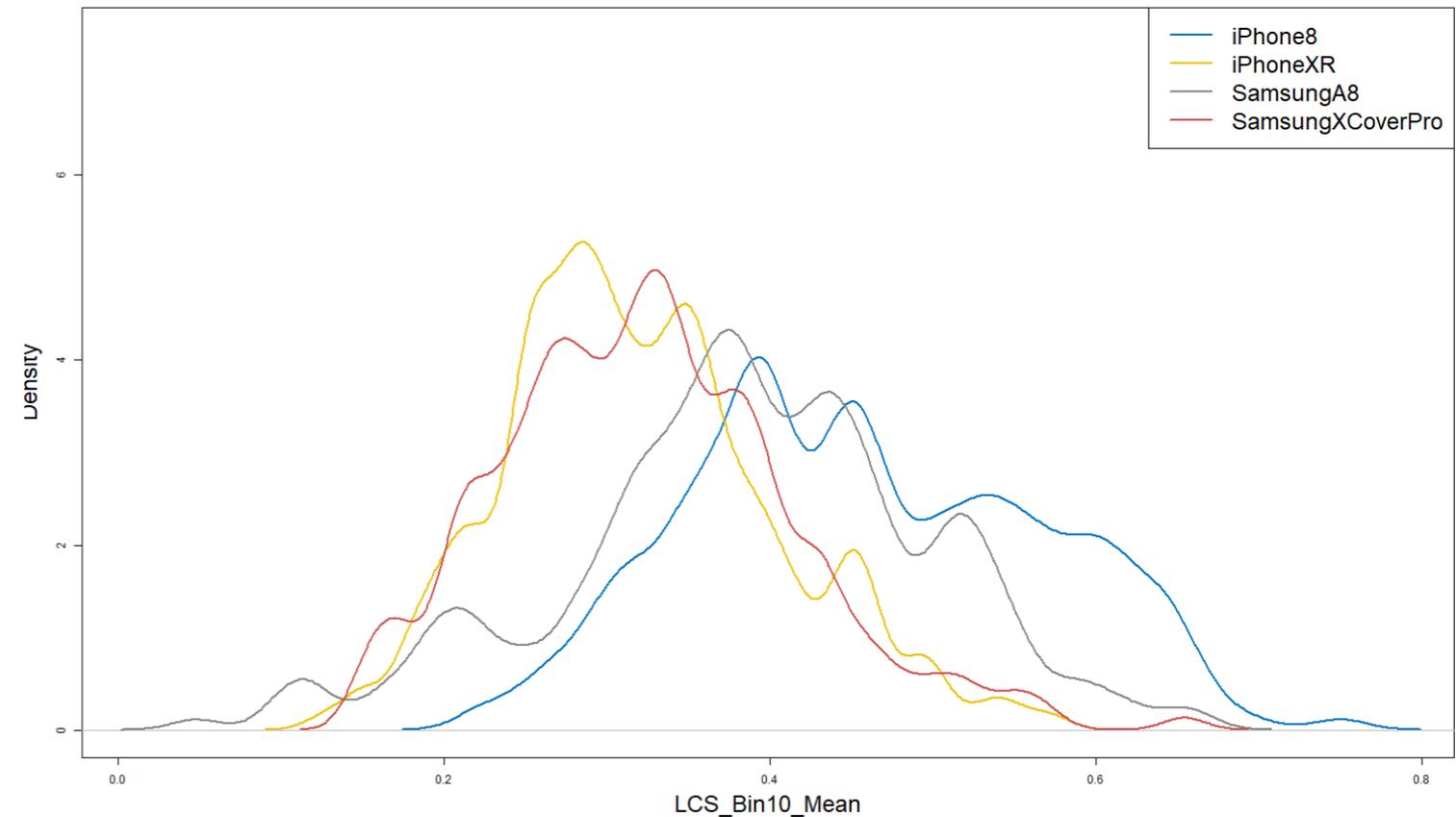
Case Study – Local Clarity Score (LCS_Mean) – Inter-Devices-Variance

- Smaller differences between different capture devices

ERC of smart phone fingerprints for NFIQ2 features

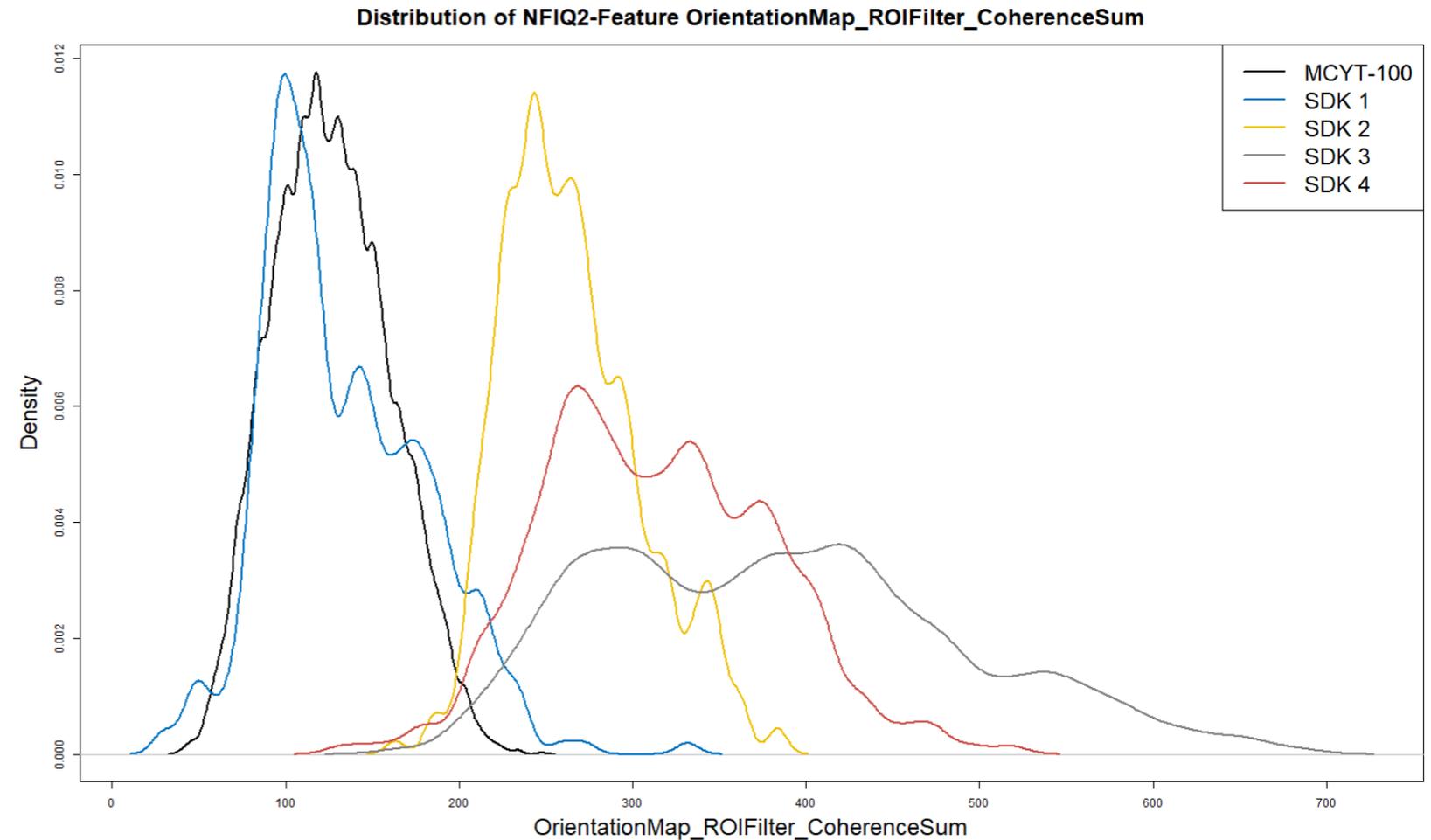


Distribution of NFIQ2-Feature LCS_Bin10_Mean



Case Study - OrientationMap_ROIFilter_Coherence_Sum

- Sum of coherence values [1] of orientation field estimation over all image blocks in the ROI



[1] M. Kass and A. Witkin. Analyzing oriented patterns. Computer vision, graphics, and image processing, 37(3):362–385, 1987.