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

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Agenda

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

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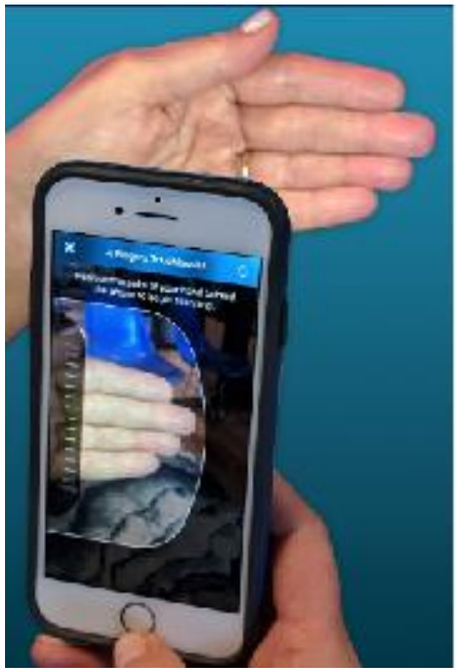
Introduction

- 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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2. **Previous Works**

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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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Case Study with NFIQ2

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

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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)

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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

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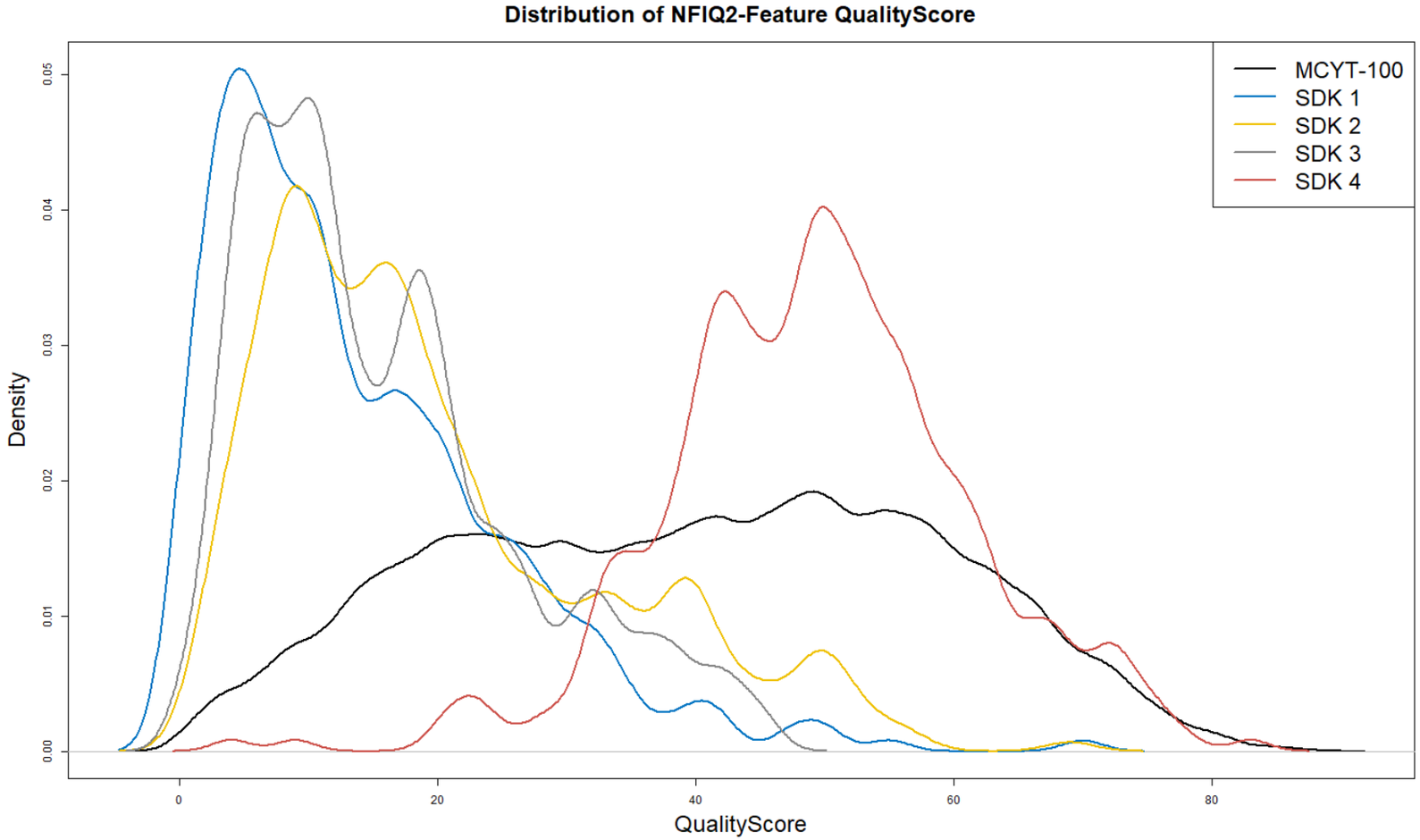
Case Study - NFIQ2 Scores

- Low NFIQ2 scores for 3 of the SDKs



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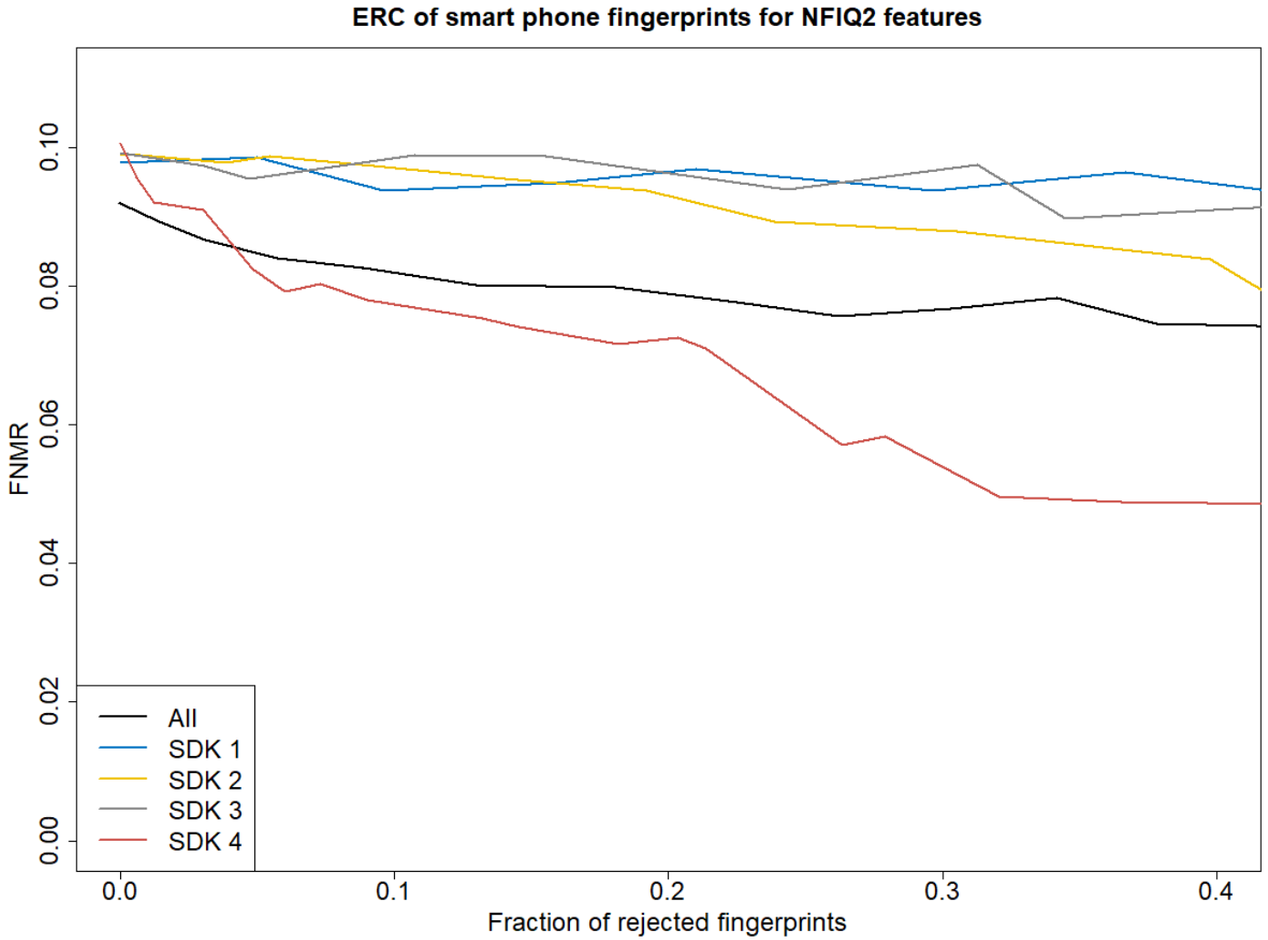
Case Study - NFIQ2 Scores

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



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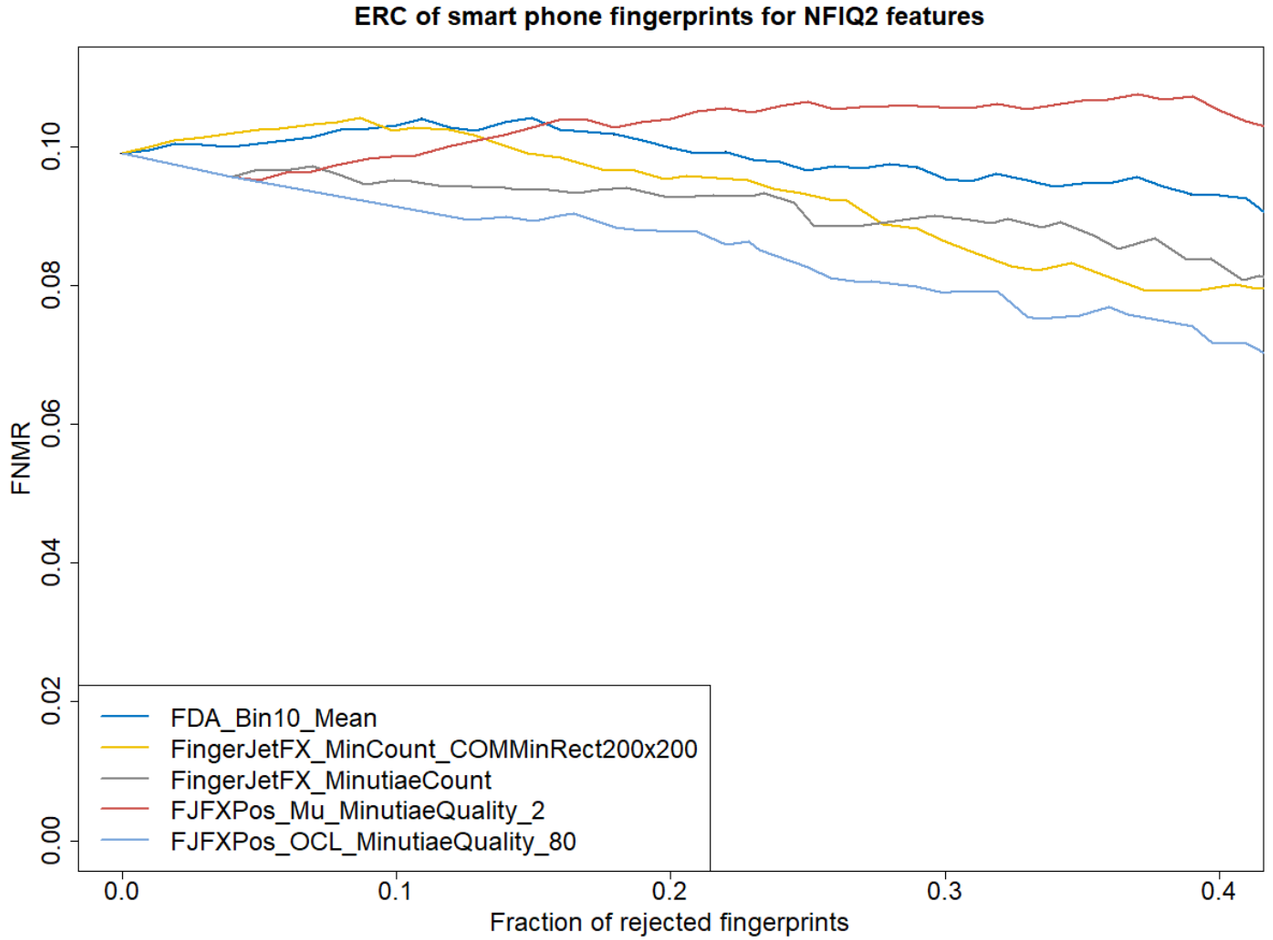
Case Study – Predictive Power of NFIQ2 Scores

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



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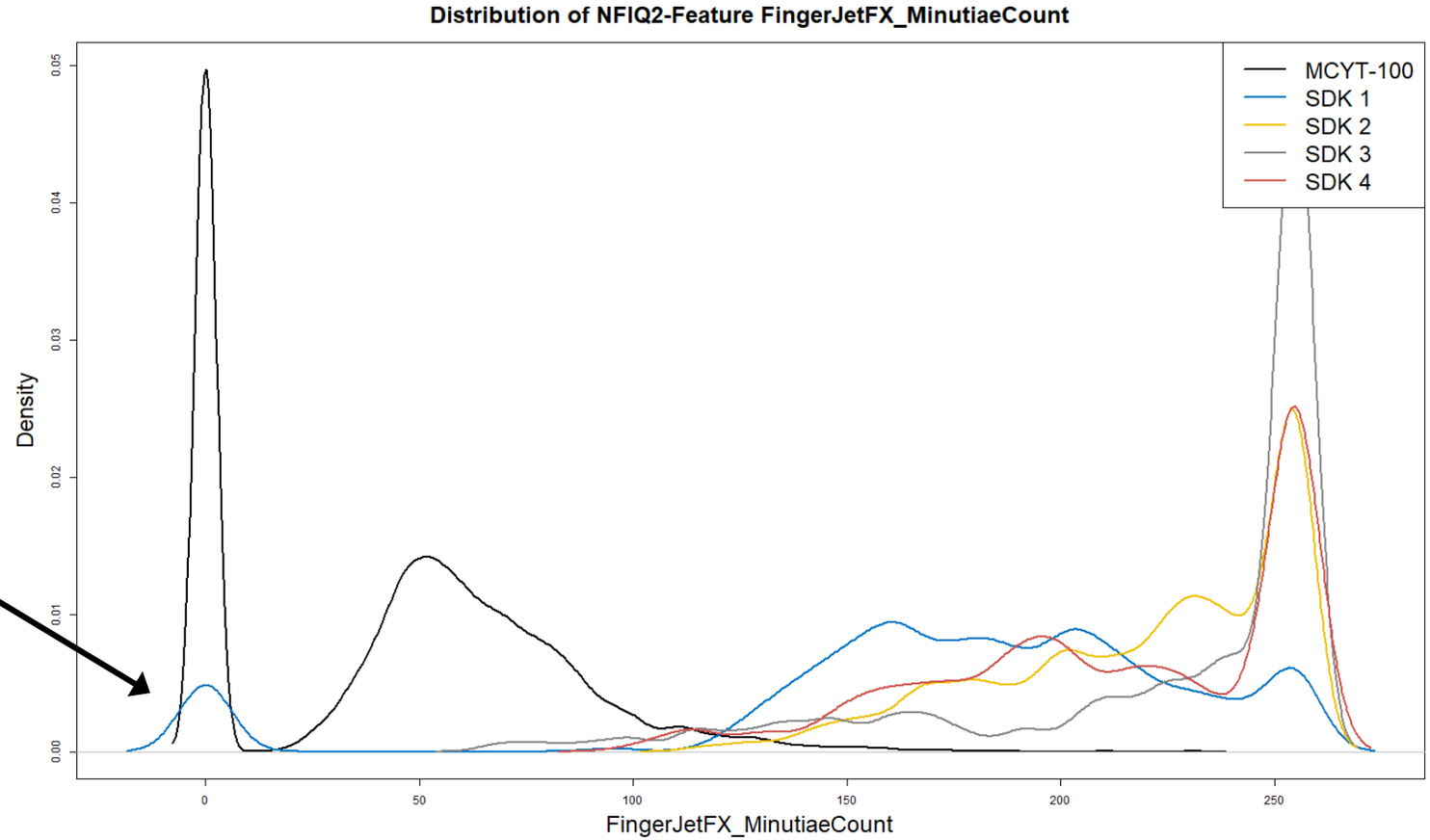
Case Study – Feature FJFX Minutiae Count

- Much more minutiae detected in contactless fingerprints

Minutiae count is 0, if foreground area is too small



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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 mintutiae quality

Brightness indicates FJFX minutiae quality

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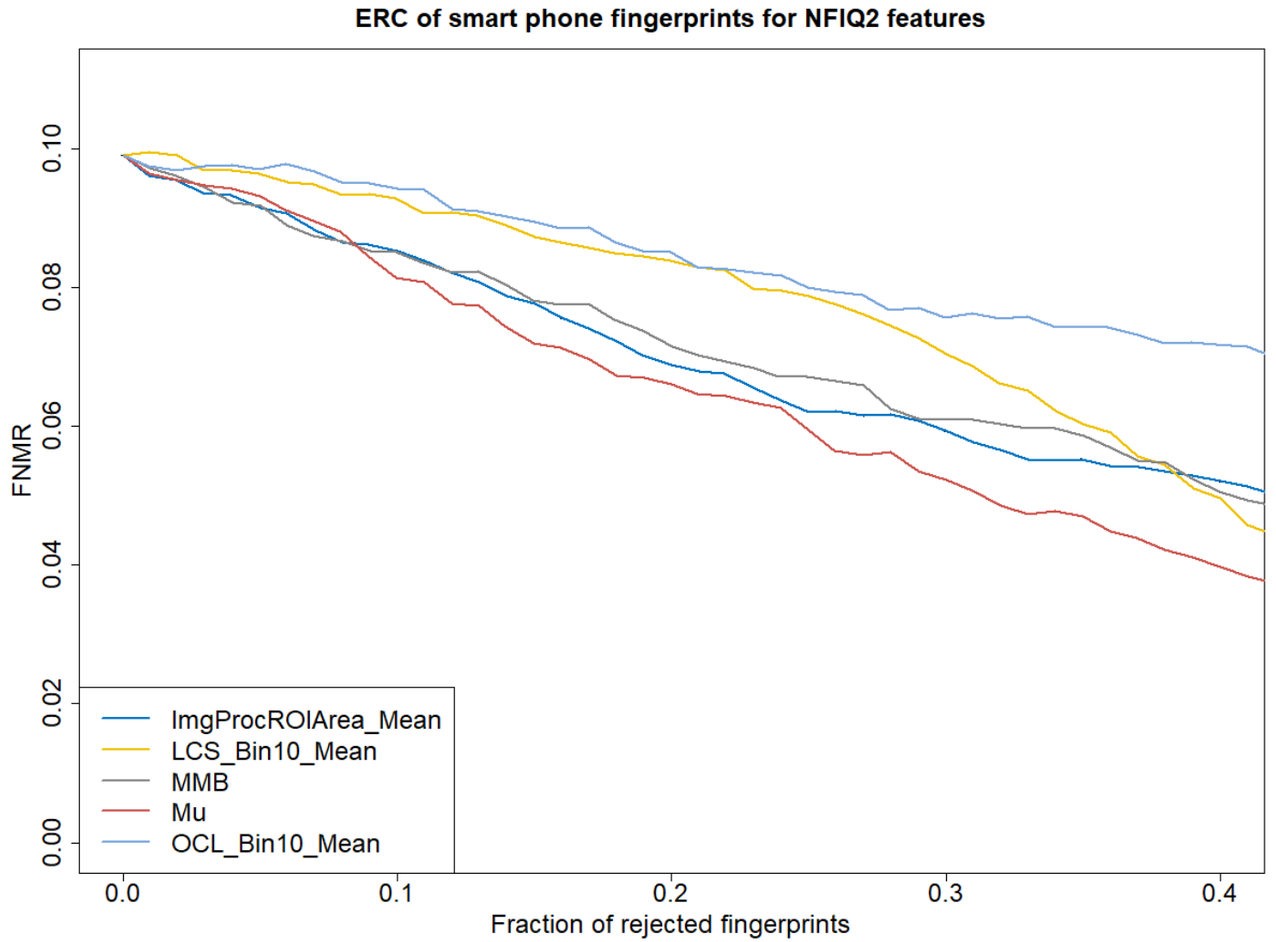
Case Study - Predictive Power of NFIQ2 Features (1)

- Better predicitive power of ImgProcROIArea_Mean, LCS, MMB, Mu
  - Even better than NFIQ2 quality score



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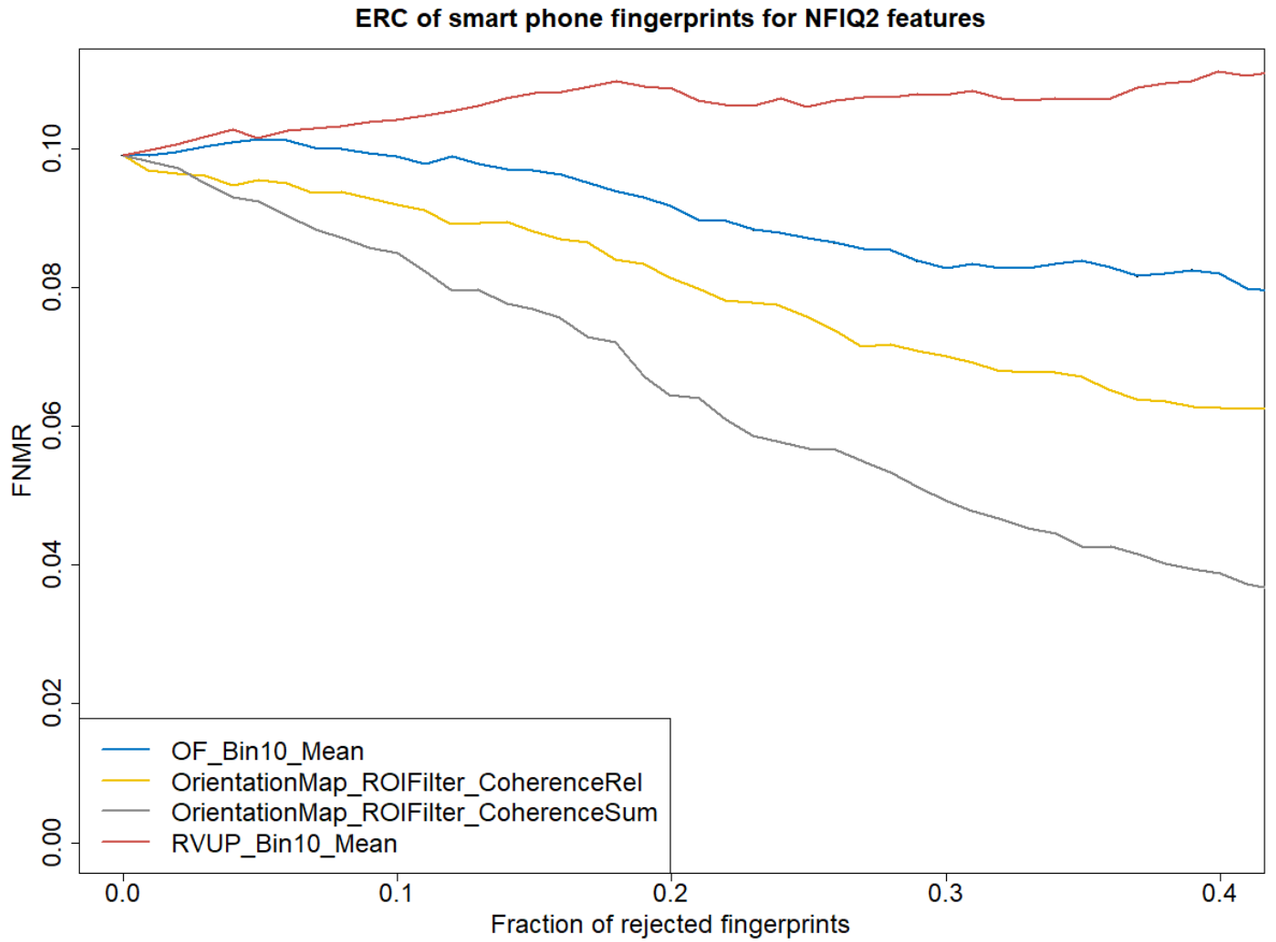
Case Study - Predictive Power of NFIQ2 Features (2)

- Better predicitive power of features based on OrientationMap_ROIFilter_Coherence



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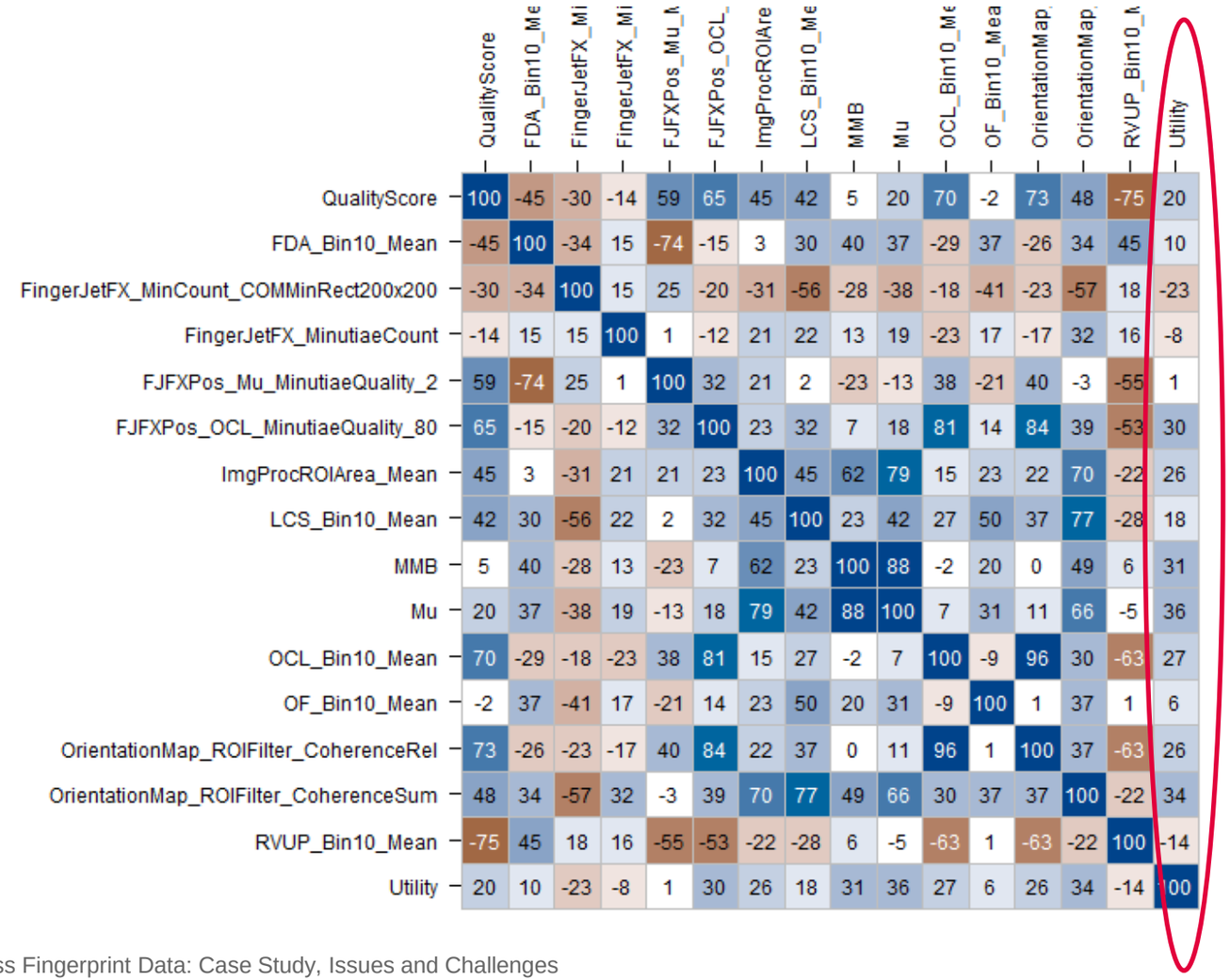
Case Study – Correlation with Utility

- Some features have stronger correlations with utility than quality score



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Case Study – Conclusions

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

- New training needed

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4. **Issues and Challenges**

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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

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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)

Source: Veridium

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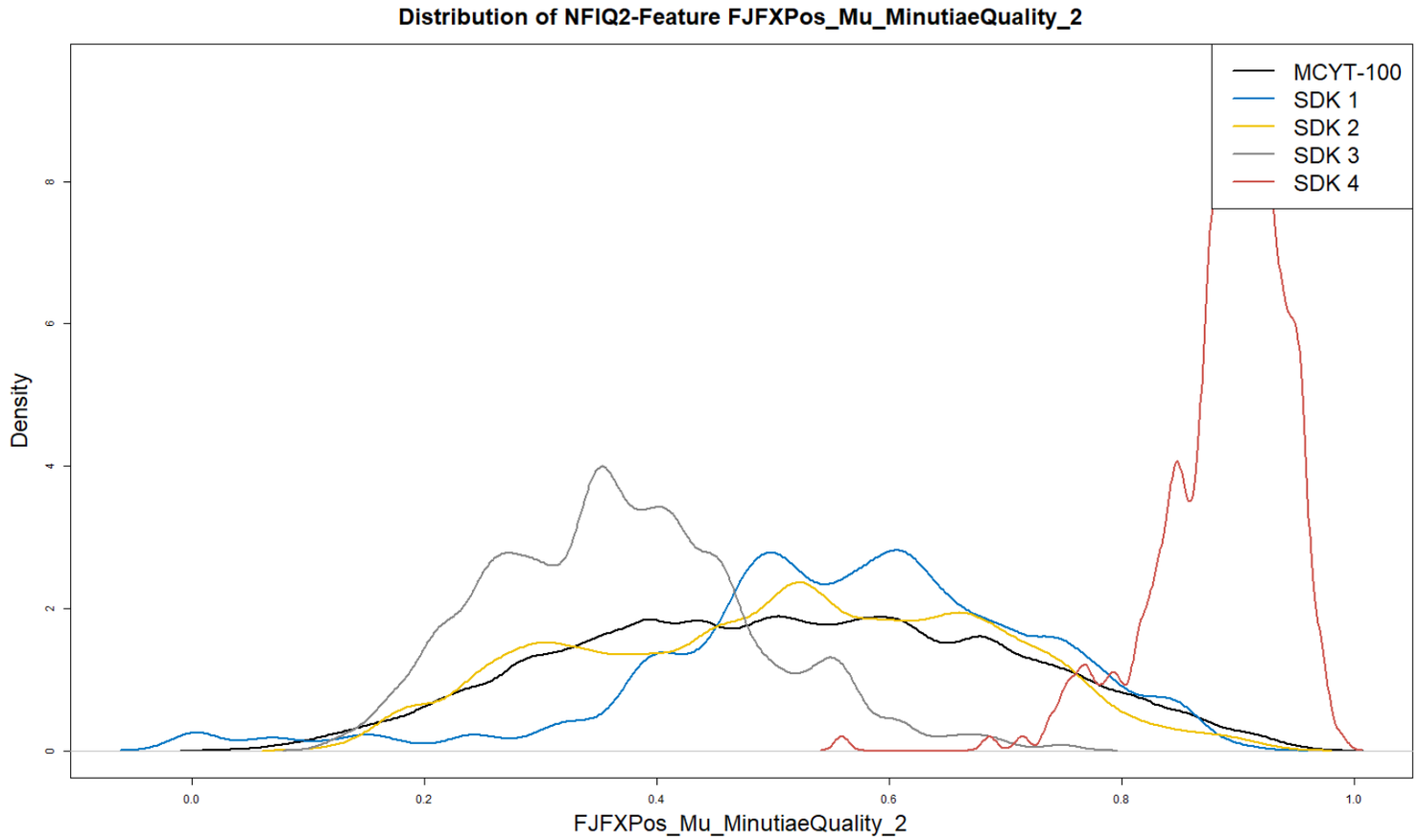
Case Study – FJFX Minutiae Quality Feature Q_{MIN}^{mu}

- 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}



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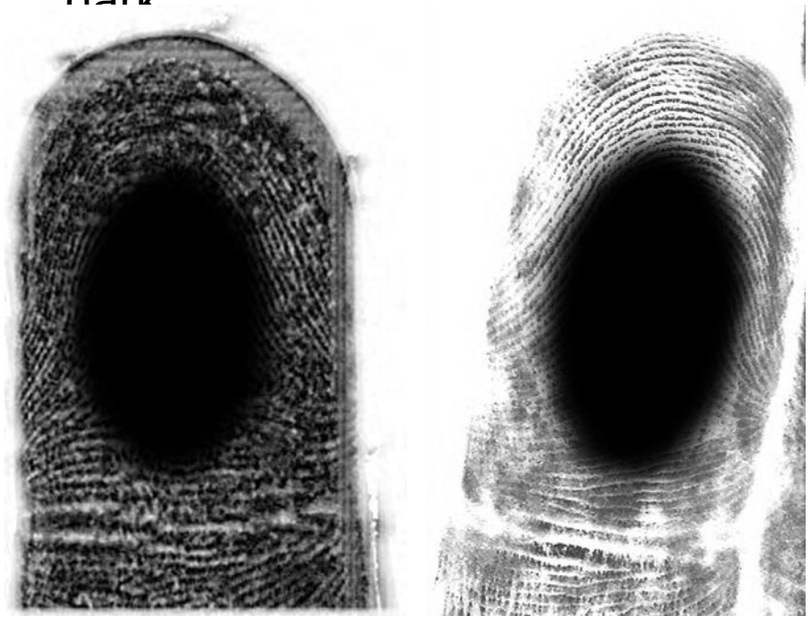
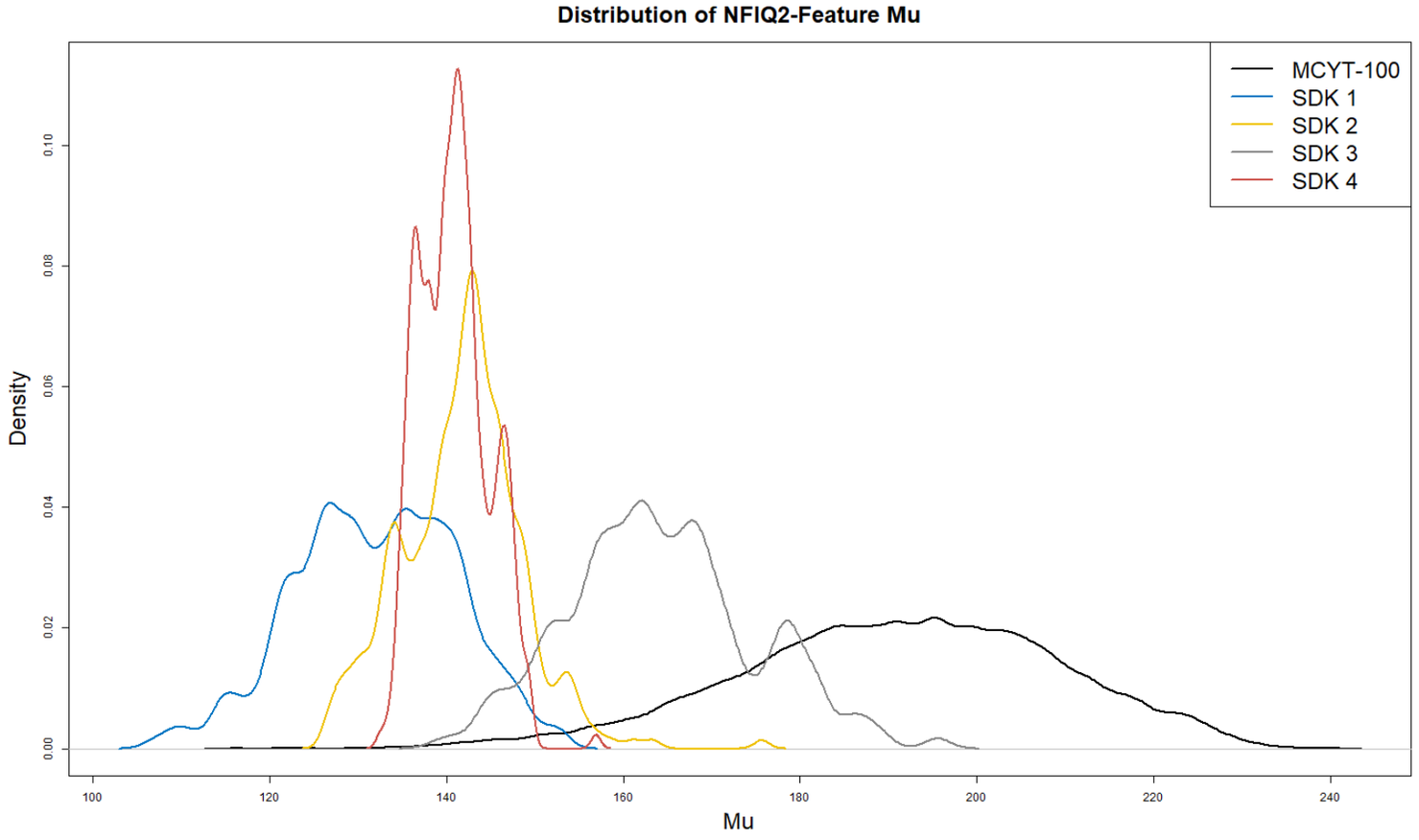
Case Study – Feature Mu

- Arithmetic mean of the gray scale input image
  - Some contactless fingerprints are too dark



Mu = 109
NFIQ2 = 0

Mu = 196
NFIQ2 = 0



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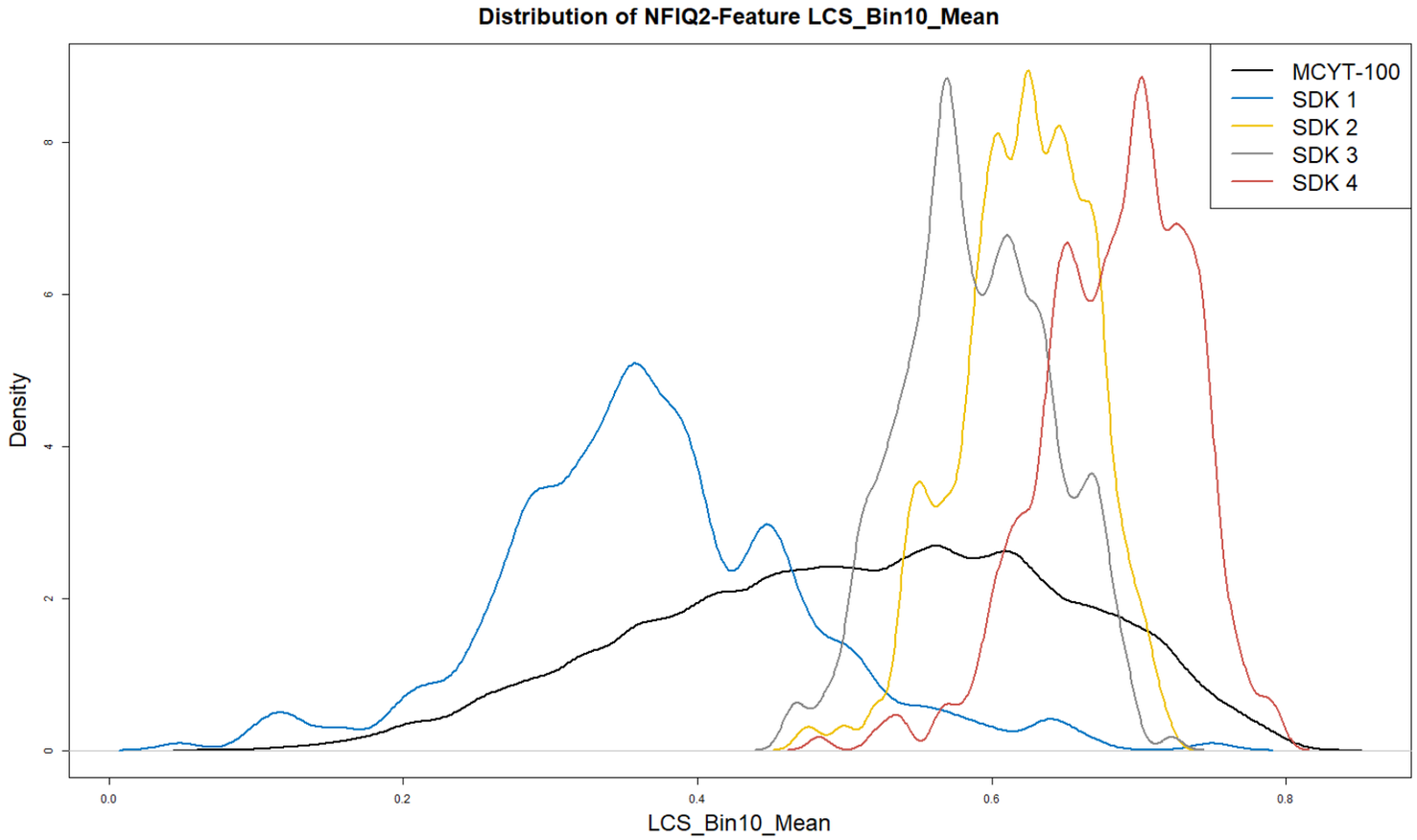
Case Study – Local Clarity Score (LCS_Mean)

- Large differences between SDKs
  - Lower correlation with NFIQ2 score than for MCYT-100



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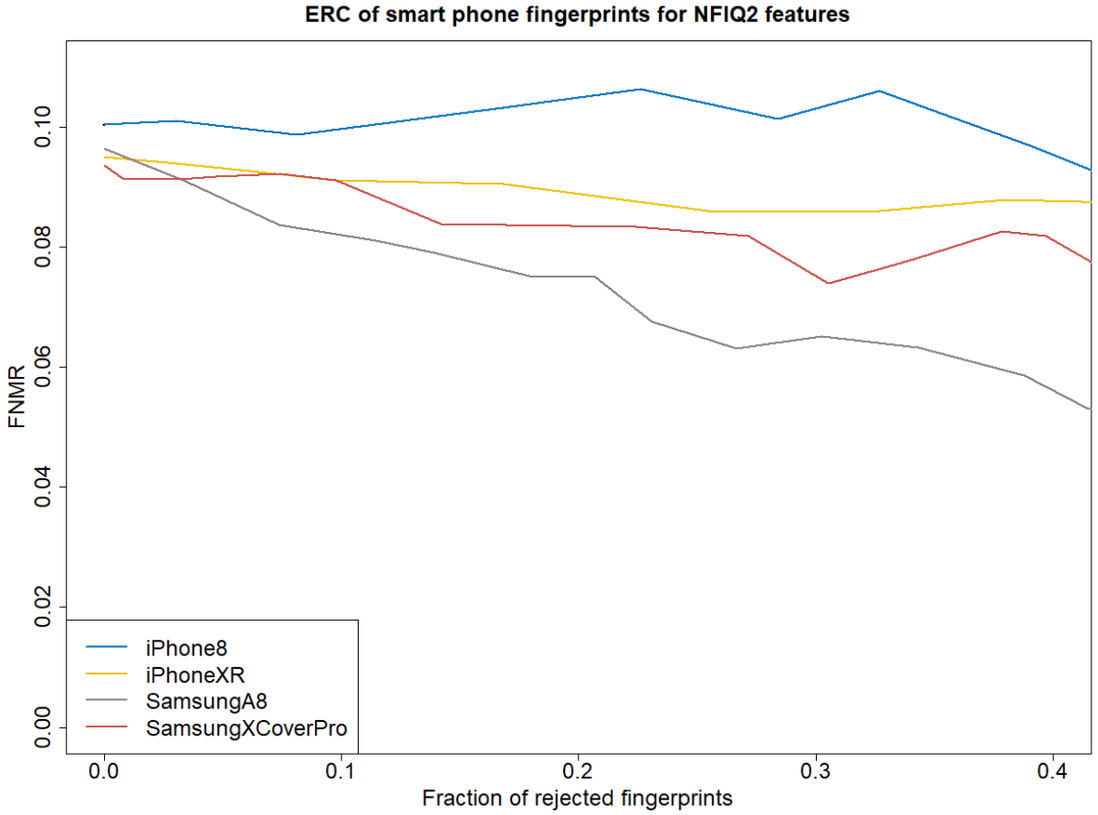
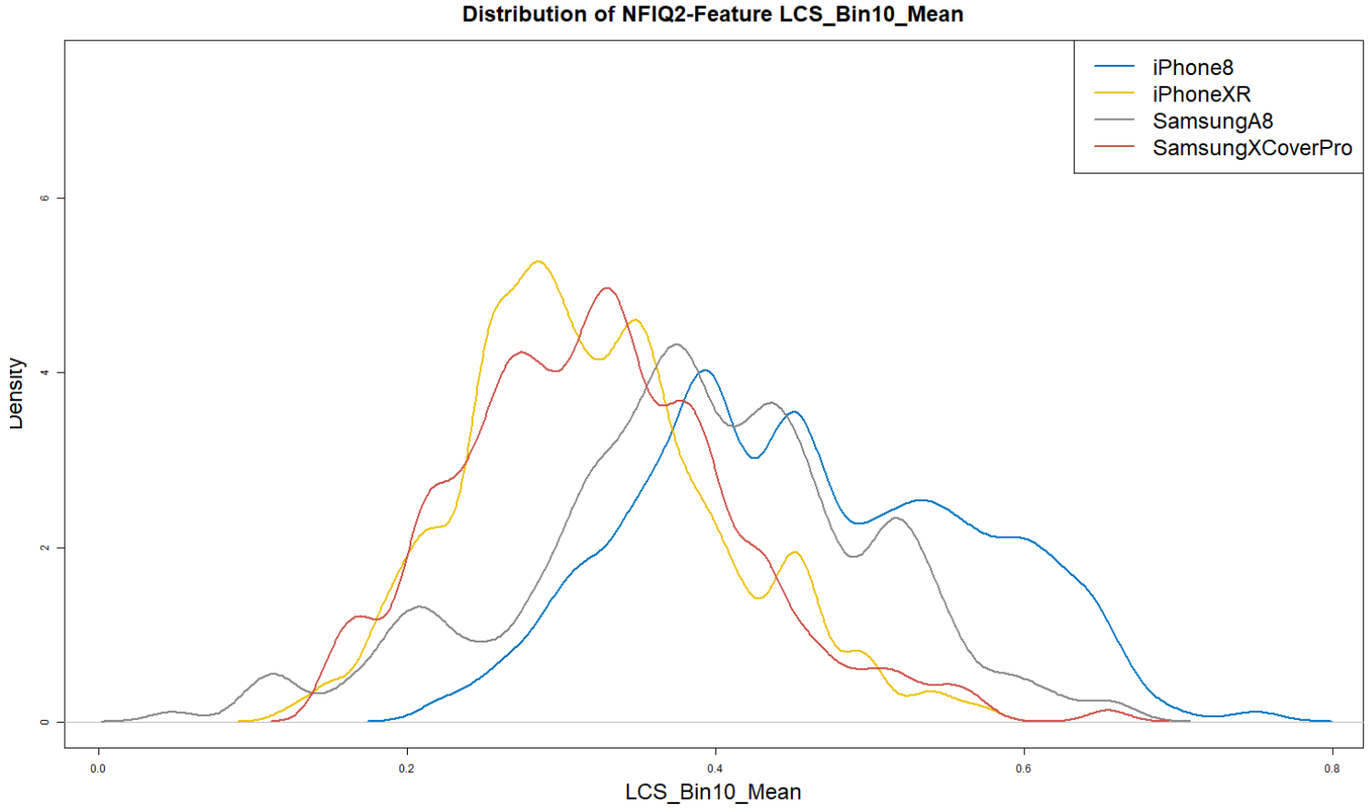
Case Study – Local Clarity Score (LCS_Mean) – Inter-Devices-Variance

- Smaller differences between different capture devices





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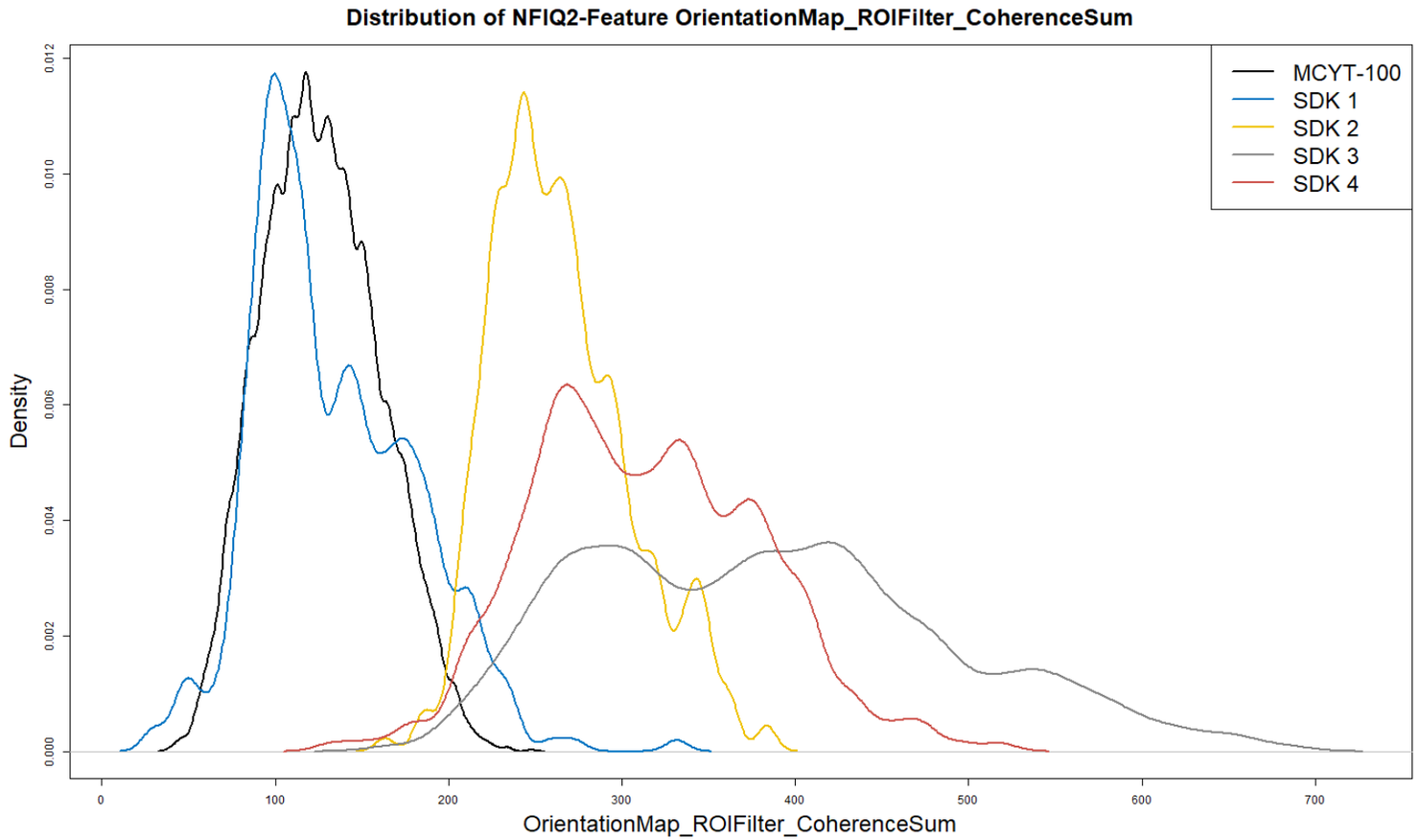
Case Study - OrientationMap_ROIFilter_Coherence_Sum

- 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.

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