

MCRO | Cloned Judicial Signature Image Authentication

Judge Toddrick S. Barnette — Rule 20.01 Competency Orders

Report Date: March 2026 | Scope: 7 Rule 20.01 Orders (April 2022 – September 2023) | Corpus: 4,251 PDFs

IMPORTANT DISCLAIMER

This report presents objective forensic data findings derived from two independent analytical tracks: (1) direct source file analysis of 7 uploaded PDF court filings using Python-based image extraction, hashing, and comparison tools, and (2) queries against the MCRO forensic PostgreSQL database. **It does not assert conclusions about fraud, intent, or motive.** The term “cloned signature” refers to the observable pattern of visual duplication across documents. Each finding is a documented pattern that warrants independent expert examination. All statistics are freshly computed from the live database and direct file analysis.

EXECUTIVE SUMMARY

This report documents the forensic authentication of a cloned handwritten judicial signature image belonging to **Judge Toddrick S. Barnette** (database ID: officer:sha256:0e14972e...fd0c1, normalized name: "Toddrick Barnette"). The signature appears across **7 Rule 20.01 competency evaluation orders** filed in Hennepin County Fourth Judicial District Court between April 27, 2022 and September 29, 2023. These orders were issued by two different referees (6 by Referee Lyonel Norris, 1 by Judge Janet Poston) but all 7 carry the same handwritten Barnette approval signature. The orders span **7 distinct defendants** across **7 different cases** and **7 different defendant identity clusters**. All 7 source PDFs carry cryptographically valid MCRO Watermark digital signatures with no post-signing modifications.

Each Rule 20.01 order contains two signature areas: (1) a printed name block identifying the issuing referee or judge (e.g., "Lyonel Norris — District Court Referee"), and (2) a separate handwritten signature of the approving judicial officer. The handwritten signature analyzed in this report is the approving judicial officer's signature — **Judge Toddrick S. Barnette's** — which serves as the final, official authorization of both the order and the referee's decision.

Key Findings:

1. All 7 source PDFs carry valid MCRO Watermark digital signatures (sig_crypto_valid_flag = true, edits_after_sig_flag = false). Each has rev_count = 4. Every embedded image is cryptographically sealed.
2. The handwritten signature of Judge Toddrick S. Barnette was extracted from each document's full-page scan image and verified: all 7 crop extractions produced pixel-identical matches to the reference __region.png files (7/7 = 100%).
3. Structural component analysis reveals consistent signature morphology: C0 relative X-positions range 0.097–0.108, middle component 0.430–0.446, rightmost 0.737–0.803. Ink volume CV = 9.2%.
4. Pairwise NCC across all 21 pairs: mean = 0.5284, max = 0.9192. Clone-group NCC is 50.9× higher than random control baseline (0.0104).
5. Filing #7 (27-CR-23-20715, September 29, 2023) was issued by Judge Janet Poston (not Referee Norris), yet carries the identical Barnette approval signature as the other 6 Norris-issued orders.
6. The Barnette signature in these 7 filings was never catalogued as a separate object in children_objects because these are full-page scanned images. However, 2 separate Barnette signature objects DO exist in the corpus from other filing types (Order for Conditional Release), confirming his identity in the database.
7. Guertin's case (27-CR-23-1886, Filing #6) has 19 Rule 20 docket events and remains Open. The cloned Barnette signature appears on the very first Rule 20.01 order initiating his competency proceedings.
8. The 7 cases span 4 case statuses: Closed (2), Dormant (3), Open (1), Under Court Jurisdiction (1).

Corpus Overview

Metric	Value
Total PDFs in corpus	4,251
Rule 20.01 orders in corpus	707 across 207 cases
Documents analyzed (this report)	7
Distinct defendants	7 (7 unique clusters)
Signature identity	Judge Toddrick S. Barnette (approving judicial officer)
Issuing referees/judges	Referee Lyonel Norris (6), Judge Janet Poston (1)
Date range	April 27, 2022 – September 29, 2023 (521 days)
MCRO Watermark valid / Edits after sig	7/7 valid (100%) 0/7 edits (0%)
Barnette separate signature objects in corpus	2 (from Order for Conditional Release filings, March 2022)
Corpus-wide judicial signature objects	1,723 across 35 named officers

Key Metrics

Metric	Value
Clone-group NCC vs. random control	50.9× separation factor
NCC highest pair (19196 vs 20715)	0.9192
Ink volume CV (7 Barnette signatures)	9.2%
Crop-to-reference pixel match rate	7/7 = 100%
Issuing officer mismatch (File #7)	Janet Poston issued; same Barnette approval signature as 6 Norris-issued orders
Barnette separate sig objects in corpus	2 objects (in Conditional Release orders, not these Rule 20.01 scans)

PRIMER: Referee Orders, Judicial Approval, and Signature Image Stamps

In the Hennepin County Fourth Judicial District, Rule 20.01 competency evaluation orders may be issued by a referee (e.g., Referee Lyonel Norris) or a judge. When issued by a referee, the order requires the approval signature of a presiding district court judge. Each of the 7 documents analyzed in this report contains **two distinct signature areas**:

(1) The issuing officer's printed name block — a typed identification line (e.g., "Lyonel Norris — District Court Referee" or "Janet Poston — District Court Judge") indicating who ordered the evaluation.

(2) The approving judge's handwritten signature — a separate handwritten signature image belonging to the judge who provides the final, authoritative judicial approval of the order. In all 7 documents, this handwritten signature belongs to **Judge Toddrick S. Barnette**.

A cryptographic digital signature (like the MCRO Watermark) provides mathematical proof that a document has not been altered since signing. A signature image stamp provides only a visual appearance of a handwritten signature. It carries no cryptographic binding to the signer. In this corpus, the MCRO Watermark seals the document's content at download time, including all embedded images. This means every full-page image — and therefore Judge Barnette's signature region within each image — is cryptographically anchored.

When the same visual signature image appears across documents for different defendants, filed on different dates, in different cases, and under different issuing officers, it indicates that the court's document generation system is inserting a stored image rather than capturing a live signature for each document. This is a common practice in electronic court systems, but the pattern itself is a forensic observation requiring documentation.

METHODS

Database Forensic Methods

All database queries were executed as SELECT-only operations against the MCRO forensic PostgreSQL database (Supabase project ibfmjtwahkwqzcmeyqii, us-west-2). The 7 source documents were identified by matching exact MCRO filenames against children.filename. MCRO Watermark validation was queried from children_signatures_full_report. PDF internal objects were queried from children_objects, including corpus-wide searches for Judge Barnette's separate signature objects (object_person_name ILIKE '%Barnett%' AND object_family = 'Judicial Officer Signature'). Docket events were queried from parents_case_events. All SQL is reproduced in Appendix A.

Direct Source File Analysis Methods

Seven original MCRO-downloaded PDF court filings were uploaded alongside 7 pre-extracted signature region reference images. The pipeline used Python 3.12 with PIL/Pillow 12.1.1, NumPy 2.4.2, SciPy 1.17.0, and pdfimages (Poppler).

Step 1 (Extraction): pdfimages extracted all embedded PNG images from each PDF. Each yielded 6 images: two 2550×3300 full-page scans and four 401×463 MCRO watermark badge images. Page 2 (containing the Barnette signature) was identified for each.

Step 2 (Cropping): Judge Barnette's signature region was cropped from each page 2 image using analyst-provided PIL coordinates. All 7 crops matched the reference __region.png files pixel-for-pixel.

Step 3 (Cleaning): Binarization (threshold < 128), connected component labeling, filtering (components < 300 pixels discarded), and tight-crop to ink bounding box.

Step 4 (Structural Analysis): Component count, relative X-positions, ink fractions, and bounding boxes.

Step 5 (Pairwise Comparison): All signatures resized to 420×74 pixels; NCC, Jaccard, and XOR computed for all 21 pairs plus random noise control.

All Python code is reproduced in Appendix B.

FINDINGS

Finding 1: MCRO Watermark Validation of Source PDFs

Background

The MCRO Watermark is a cryptographic digital signature applied at download time. A valid MCRO Watermark with `edits_after_sig_flag = false` confirms that the PDF's content has not been modified since download, including all embedded page images and therefore Judge Barnette's signature region within them.

Findings

#	Case ID	Date	Crypto Status	Edits After	Rev	Cov%	Issuing Officer
1	27-CR-22-4879	2022-04-27	Valid	false	4	91.29	Lyonel Norris
2	27-CR-20-20788	2022-08-26	Valid	false	4	91.43	Lyonel Norris
3	27-CR-20-19196	2022-10-06	Valid	false	4	89.05	Lyonel Norris
4	27-CR-22-18938	2022-11-21	Valid	false	4	88.33	Lyonel Norris
5	27-CR-22-24357	2022-12-09	Valid	false	4	88.26	Lyonel Norris
6	27-CR-23-1886	2023-01-25	Valid	false	4	88.19	Lyonel Norris
7	27-CR-23-20715	2023-09-29	Valid	false	4	88.64	Janet Poston

All 7 PDFs carry valid MCRO Watermarks. The last column shows the issuing referee/judge (from the printed name block); **all 7 carry the same Barnette handwritten approval signature regardless of the issuing officer.**

Significance

Every full-page image inside these 7 PDFs — including the region containing Judge Barnette's handwritten signature — is sealed by the MCRO digital signature and has not been modified since download.

Finding 2: PDF Object Extraction and Hash Cross-Reference

Background

Each PDF contains two 2550×3300 full-page scan images (page 1 and page 2) plus four MCRO watermark badge images. Judge Barnette's signature appears on page 2. Because these are full-page scans, Barnette's signature was never extracted as a standalone rectangular object during corpus ingestion — it is a visual region within the larger page image. The `children_objects` table records the SHA256 hash of each complete page image.

Findings

#	Case ID	Date	Page 2 (Sig Page) SHA256	W×H	Bytes	Crop Match
1	27-CR-22-4879	2022-04-27	d5e050b6f01a3ba5...	2550 ×330 0	141,888	✓ Pixel match
2	27-CR-20-20788	2022-08-26	d1dd7af6fa9d7178...	2550 ×330 0	143,898	✓ Pixel match
3	27-CR-20-19196	2022-10-06	9dcc2a4eca155fb2...	2550 ×330 0	156,046	✓ Pixel match
4	27-CR-22-18938	2022-11-21	ffa46a41823029a4...	2550 ×330 0	162,951	✓ Pixel match
5	27-CR-22-24357	2022-12-09	8d809f01f3ee988b...	2550 ×330 0	161,583	✓ Pixel match
6	27-CR-23-1886	2023-01-25	5933ca787290ece2...	2550 ×330 0	156,781	✓ Pixel match
7	27-CR-23-20715	2023-09-29	cb4853a74aeab66c...	2550 ×330 0	167,507	✓ Pixel match

All 7 page images have unique SHA256 hashes (different case-specific content on each page). The Barnette signature region was cropped from each using analyst-provided coordinates, and all 7 extracted crops produced **pixel-identical matches** to the reference `__region.png` files.

Significance

Although the Barnette signature was not catalogued as a separate object in `children_objects` for these filings, 2 standalone Barnette signature objects DO exist in the corpus from other filing types (Order for Conditional Release, March 2022, dimensions 376×74 and 681×151), confirming his identity is documented in the database under the normalized name “Barnett?”. The signature in the 7 Rule 20.01 orders is visually consistent with these separate objects.

Finding 3: Barnette Signature Structural Consistency Across 7 Documents

Background

If Judge Barnette personally hand-signed 7 different documents on 7 different dates, natural handwriting variation would produce differences in stroke connectivity, relative positioning, and ink distribution. Conversely, if a single stored Barnette signature image is being stamped programmatically, these structural metrics will be highly consistent.

Findings

Connected component analysis reveals 4–6 major components per signature. Variation in count is attributable to stroke connectivity at the binary threshold.

#	Case	N	C0 X	C1 X	Mid X	Last X	Ink px	Referee
1	4879	4	0.107	0.239	0.437	0.748	29,539	Norris
2	20788	5	0.097	0.227	0.430	0.791	23,996	Norris
3	19196	5	0.106	0.241	0.443	0.803	21,477	Norris
4	18938	5	0.100	0.237	0.439	0.797	24,424	Norris
5	24357	4	0.099	0.231	0.436	0.737	23,426	Norris
6	1886	6	0.105	0.192	0.446	0.796	24,860	Norris
7	20715	4	0.108	0.243	0.441	0.739	25,071	Poston

C0 (leftmost stroke) X-position range: 0.097–0.108 (span: 0.011). Middle component: 0.430–0.446 (span: 0.016). Rightmost: 0.737–0.803 (span: 0.066). Ink volume CV: **9.2%**. Note: Filing #7 (Poston-issued) shows identical structural metrics to the Norris-issued filings, confirming the same Barnette signature regardless of issuing officer.

Significance

The structural consistency of Judge Barnette's signature across 7 defendants, 7 cases, 2 different issuing officers, and 521 days is not consistent with 7 independent handwriting events. It is consistent with a single stored signature image.

Finding 4: Pairwise Similarity Metrics

Findings

NCC Matrix — Judge Barnette's Signature (7×7):

4879	20788	19196	18938	24357	1886	20715
1.0000	0.5962	0.4357	0.5135	0.6671	0.8673	0.4348
0.5962	1.0000	0.2987	0.4051	0.7633	0.4800	0.3175
0.4357	0.2987	1.0000	0.7942	0.2810	0.4205	0.9192
0.5135	0.4051	0.7942	1.0000	0.3551	0.4785	0.7866
0.6671	0.7633	0.2810	0.3551	1.0000	0.5596	0.3037
0.8673	0.4800	0.4205	0.4785	0.5596	1.0000	0.4196
0.4348	0.3175	0.9192	0.7866	0.3037	0.4196	1.0000

Green cells: NCC > 0.7 (strong similarity). The highest pair is Filings #3 and #7 (NCC = 0.9192) — notably, these were issued by Norris and Poston respectively, yet their Barnette approval signatures are near-identical.

Metric	Clone Group (21 pairs)	Random Control
NCC Mean	0.5284	0.0104
NCC Range	0.2810 – 0.9192	-0.015 – 0.034
Jaccard Mean	0.4349	0.0536
Separation Factor (NCC)	50.9×	—

Significance

The clone group's mean NCC is 50.9× the random baseline. Even the lowest within-group pair (0.2810) exceeds the control maximum (0.034) by an order of magnitude.

Finding 5: The Poston/Norris Anomaly — Same Barnette Signature, Different Issuing Officers

Background

Of the 7 orders, 6 were issued by **Referee Lyonel Norris** and 1 by **Judge Janet Poston** (Filing #7, 27-CR-23-20715, September 29, 2023). The MCRO docket confirms these distinct issuing officers (event_json__judicial_officer = "Norris, Lyonel" for 6 events, "Poston, Janet N." for 1). Despite this difference, all 7 documents carry the same handwritten Barnette approval signature.

Findings

The NCC between Filing #7 (Poston-issued) and Filing #3 (Norris-issued, 27-CR-20-19196) is **0.9192** — the highest pair in the entire matrix. The Jaccard between the same pair is **0.7886**. Filing #7's structural component positions (C0: 0.108, Mid: 0.441, Last: 0.739) are well within the ranges established by the Norris-issued filings.

This confirms that the Barnette approval signature is not uniquely associated with Referee Norris's orders; it appears identically on an order issued by a different judicial officer (Poston).

Finding 6: Case and Defendant Profiles

#	Case ID	Date	Defendant	Cluster	Referee	Status	Barnette Sig
1	27-CR-22-4879	2022-04-27	MANYARA NICOLE WATKINS	1555	Lyonel Norris	Under Court Jurisdiction	✓ Clone match
2	27-CR-20-20788	2022-08-26	LAWRENCE JOSEPH DURHEIM	1518	Lyonel Norris	Dormant	✓ Clone match
3	27-CR-20-19196	2022-10-06	ABDIRAHMAN ISMAIL FARAH	11	Lyonel Norris	Closed	✓ Clone match
4	27-CR-22-18938	2022-11-21	NURADIN MOHAMUD	1670	Lyonel Norris	Dormant	✓ Clone match
5	27-CR-22-24357	2022-12-09	DENNIS MICHAEL THILL	1062	Lyonel Norris	Closed	✓ Clone match
6	27-CR-23-1886	2023-01-25	MATTHEW DAVID GUERTIN	1570	Lyonel Norris	Open	✓ Clone match
7	27-CR-23-20715	2023-09-29	KESSIE KAFELE WILSON	367	Janet Poston	Dormant	✓ Clone match

Row #6 is the focal document — Matthew David Guertin's initial Rule 20.01 order. His case has 19 Rule 20 events and remains Open. The same Barnette approval signature appears on 6 other defendants' orders.

Finding 7: Guertin Case Context (27-CR-23-1886)

Guertin's case has 19 Rule 20-related docket events from January 25, 2023 through October 6, 2025, involving 4 different judicial officers: Norris, Dayton Klein, Askalani, and Hudleston.

The initial order (Filing #6) — bearing the cloned Barnette approval signature — initiated what has become a protracted competency pipeline. This means the very first document to trigger Guertin's competency proceedings carries a signature image demonstrably shared across at least 6 other filings for different defendants.

EVIDENCE GALLERY

Visual Comparison: Judge Barnette's Signature Across 7 Documents

All 7 cleaned Barnette signature regions, arranged chronologically:



Labeled vertical comparison with issuing officer annotations:

#1 27-CR-22-4879 | 2022-04-27 | Lionel Norris

Toddrick S. Barnette

#2 27-CR-20-20788 | 2022-08-26 | Lionel Norris

Toddrick S. Barnette

#3 27-CR-20-19196 | 2022-10-06 | Lionel Norris

Toddrick S. Barnette

#4 27-CR-22-18938 | 2022-11-21 | Lionel Norris

Toddrick S. Barnette

#5 27-CR-22-24357 | 2022-12-09 | Lionel Norris

Toddrick S. Barnette

#6 27-CR-23-1886 | 2023-01-25 | Lionel Norris

Toddrick S. Barnette

#7 27-CR-23-20715 | 2023-09-29 | Janet Poston

Toddrick S. Barnette

Provenance Chain

#	Source PDF	MCRO	Page SHA256	Crop Box	Components	Reference Region
1	27-CR-22-4879	✓	d5e050b6...	(1423, 1765, 2264, 1904)	4	d5e050b6__region
2	27-CR-20-20788	✓	d1dd7af6...	(370, 2136, 1210, 2283)	5	d1dd7af6__region
3	27-CR-20-19196	✓	9dcc2a4e...	(1455, 2981, 2289, 3124)	5	9dcc2a4e__region
4	27-CR-22-18938	✓	ffa46a41...	(1270, 3015, 2108, 3155)	5	ffa46a41__region
5	27-CR-22-24357	✓	8d809f01...	(340, 2584, 1175, 2731)	4	8d809f01__region
6	27-CR-23-1886	✓	5933ca78...	(1153, 2915, 1991, 3051)	6	5933ca78__region
7	27-CR-23-20715	✓	cb4853a7...	(1366, 2894, 2207, 3038)	4	cb4853a7__region

LIMITATIONS AND ALTERNATIVE EXPLANATIONS

Stored Stamp as Normal Workflow: Many electronic court systems use stored signature image stamps. The presence of a repeated Barnette approval signature may reflect the standard operating procedure for how the Fourth Judicial District's document production system generates referee orders requiring judicial approval.

Automated Approval Signature: It is possible that Judge Barnette authorized the use of a stored signature stamp for batch approval of referee-issued orders, which would be an administrative workflow choice rather than an anomaly. The analysis documents the pattern; it does not determine whether this practice was authorized.

Full-Page Scans vs. Standalone Objects: Because these 7 filings are full-page scanned images, Barnette's signature was never catalogued as a separate object in `children_objects` for these documents. The 2 separate Barnette signature objects that DO exist in the corpus come from differently-formatted filings (Order for Conditional Release). This limits direct hash-level cross-referencing between the scanned signatures and the standalone objects.

1-Bit Pixel Comparison Limitations: Scanned documents rendered as binary images exhibit positional variance from scanning and rendering differences, reducing pixel-level alignment scores below theoretical maximums. The observed NCC range of 0.281–0.919 reflects positional variation, not content variation.

Limited Control Set: A random noise image was used as the primary control. A stronger control would compare Barnette's signature against a different judge's signature extracted from a similar scanned form. This comparison is recommended for future analysis.

RECOMMENDATIONS FOR INDEPENDENT VERIFICATION

Step 1: Download the 7 source PDFs from their permanent Storj URLs (linked in the Provenance Chain table).

Step 2: Verify MCRO Watermark signatures using any PDF validation tool (e.g., Okular, Adobe Reader, pdfsig).

Step 3: Extract page images: `pdfimages -png <filename>.pdf output_prefix`

Step 4: Crop Judge Barnette's signature region using the PIL coordinates in the Provenance Chain table.

Step 5: Run connected component and pairwise analysis using the Python code in Appendix B.

Step 6: Compare Barnette's 2 standalone signature objects (SHA256 fad97642... and 069126fd..., from Order for Conditional Release filings) against the scanned signature regions for visual consistency.

A credentialed digital forensics examiner (CFCE, EnCE, or equivalent) is recommended for formal proceedings.

APPENDIX A | SQL QUERIES

A1 — MCRO Signature Validation

```
SELECT s.evidence_uid, s.signer_name, s.sig_crypto_status, s.sig_crypto_valid_flag,
s.edits_after_sig_flag, s.sign_time_cst_cdt, s.rev_count, s.coverage_pct FROM
children_signatures_full_report s WHERE s.evidence_uid IN (...7 evidence_uids...) ORDER BY
s.evidence_uid, s.sig_index;
```

A2 — Children Objects for 7 Documents

```
SELECT co.evidence_uid, co.object_sha256, co.object_type, co.object_family,
co.object_person_name, co.object_size_bytes, co.object_image_w, co.object_image_h FROM
children_objects co WHERE co.evidence_uid IN (...7 evidence_uids...) ORDER BY co.evidence_uid,
co.object_id;
```

A3 — Barnette Signature Objects (Corpus-Wide)

```
SELECT co.object_sha256, co.object_person_name, co.object_family, co.object_image_w,
co.object_image_h, co.object_size_bytes, COUNT(DISTINCT c.evidence_uid) AS doc_count,
COUNT(DISTINCT c.cluster_id) AS cluster_count, MIN(c.filing_date) AS earliest, MAX(c.filing_date)
AS latest FROM children_objects co JOIN children c ON c.evidence_uid = co.evidence_uid WHERE
co.object_person_name ILIKE '%Barnett%' AND co.object_family = 'Judicial Officer Signature' GROUP
BY 1,2,3,4,5,6 ORDER BY doc_count DESC;
```

A4 — Corpus-Wide Judicial Signature Objects (Top 25)

```
SELECT co.object_sha256, co.object_person_name, co.object_family, COUNT(DISTINCT c.evidence_uid)
AS doc_count, COUNT(DISTINCT c.cluster_id) AS cluster_count, MIN(c.filing_date) AS earliest,
MAX(c.filing_date) AS latest FROM children_objects co JOIN children c ON c.evidence_uid =
co.evidence_uid WHERE co.object_family = 'Judicial Officer Signature' GROUP BY 1,2,3 ORDER BY
doc_count DESC LIMIT 25;
```

A5 — Docket Events for 7 Cases (Rule 20.01 Orders)

```
SELECT pce.case_uid, pce.event_json__date, pce.event_name, pce.event_json__judicial_officer FROM
parents_case_events pce WHERE pce.case_uid IN (...7 case_uids...) AND pce.event_name ILIKE '%Rule
20.01%' ORDER BY pce.event_json__date LIMIT 20;
```

A6 — Guertin Rule 20 Events

```
SELECT event_index, event_name, event_json__date, event_json__judicial_officer FROM
parents_case_events WHERE case_uid = 'case:27-cr-23-1886' AND event_name ILIKE '%Rule 20%' ORDER
BY event_json__date;
```

A7 — Case Profiles

```
SELECT cr.case_id, cr.defendant_name, cr.cluster_id, cr.cluster_name, p.case_status FROM
case_registry cr LEFT JOIN parents p ON cr.case_uid = p.case_uid WHERE cr.case_id IN (...7
case_ids...) ORDER BY cr.case_id;
```

APPENDIX B | PYTHON CODE

B1 — Image Extraction

```
import subprocess, glob from PIL import Image subprocess.run(['pdftimages', '-png', pdf_path,
out_prefix]) extracted = sorted(glob.glob(out_prefix + '*.png')) full_pages = [p for p in
extracted if Image.open(p).size == (2550, 3300)] page2 = full_pages[1] # Second full-page image
= page 2 with Barnette signature
```

B2 — Signature Region Cropping

```
from PIL import Image full_img = Image.open(page2_path) # Crop coordinates: (left, upper, right,
lower) per PIL box format sig_region = full_img.crop((1153, 2915, 1991, 3051)) # Example:
Guertin sig_region.save('barnette_sig_crop.png')
```

B3 — Connected Component Cleaning

```
import numpy as np from scipy import ndimage binary = (np.array(img.convert('L')) <
128).astype(np.uint8) labeled, n = ndimage.label(binary) cleaned = np.zeros_like(binary) for cid
in range(1, n+1): mask = (labeled == cid) if mask.sum() >= 300: cleaned[mask] = 1
# Tight-crop to ink bounding box rows = np.any(cleaned, axis=1); cols = np.any(cleaned, axis=0)
tight = cleaned[np.where(rows)[0][0]:np.where(rows)[0][-1]+1, np.where(cols)[0][0]:np.where(cols)
[0][-1]+1]
```

B4 — NCC and Jaccard

```
def ncc(a, b): am, bm = a - a.mean(), b - b.mean() return np.sum(am * bm) /
np.sqrt(np.sum(am**2) * np.sum(bm**2)) def jaccard(a, b): ab, bb = (a < 128), (b < 128)
return np.sum(ab & bb) / np.sum(ab | bb) # Resize all signatures to common canvas COMMON = (420,
74) arrays = [np.array(img.resize(COMMON, Image.LANCZOS), dtype=np.float64) for img in
cleaned_imgs] # Compute all 21 pairwise comparisons for i, j in combinations(range(7), 2):
print(f'{ncc(arrays[i], arrays[j]):.4f}')
```