

Printer Characterization and Signature Embedding for Security and Forensic Applications

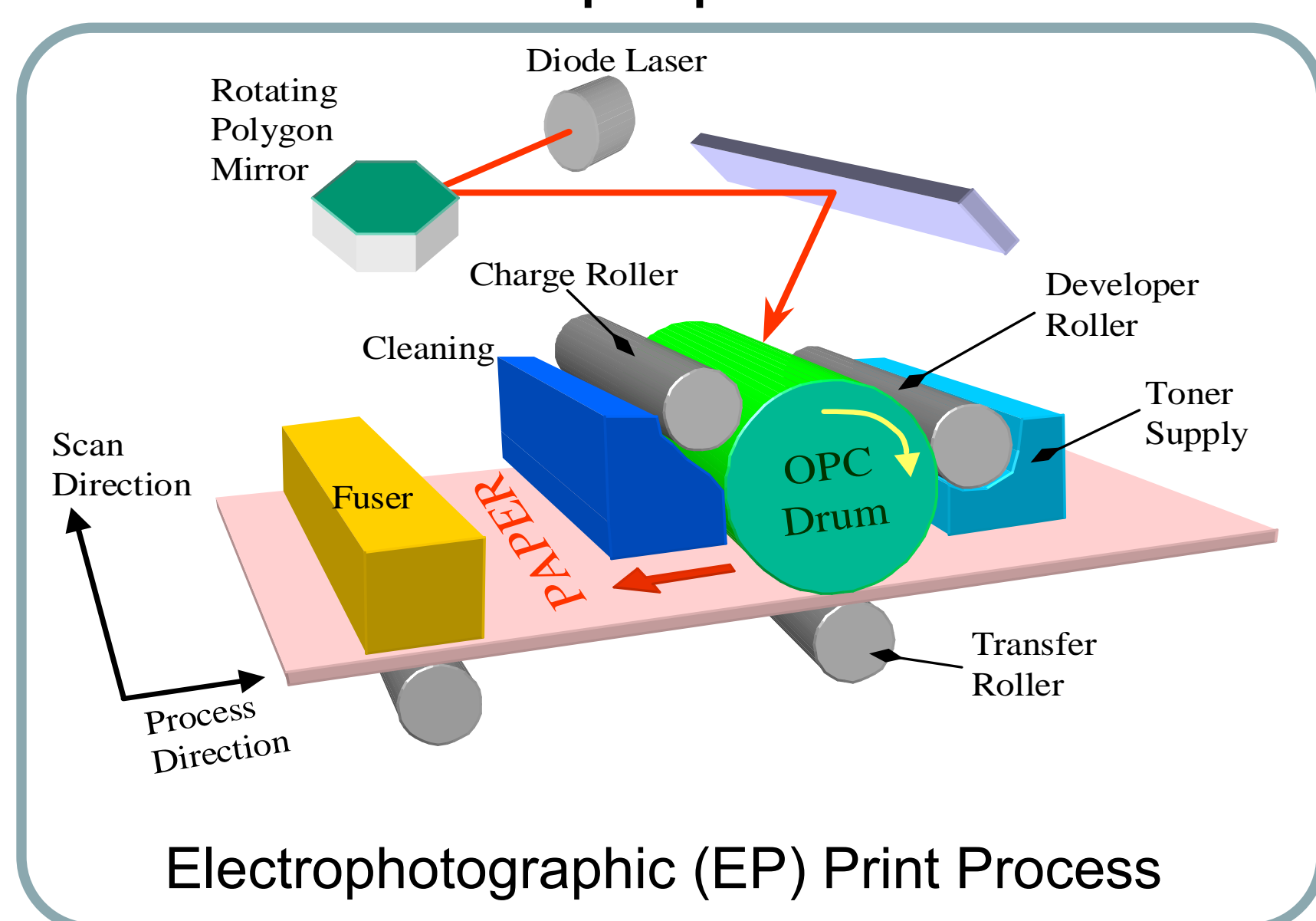
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<http://shay.ecn.purdue.edu/~prints>

Document Protection & Forensic Analysis

- Investigate methods that will allow one to determine if a given document was printed on a particular digital printer, model, manufacturer
- Use our experience in characterizing and improving print quality of ink-jet and electrophotography (laser printing) to develop techniques to authenticate a printer and a document

Protect & Prevent

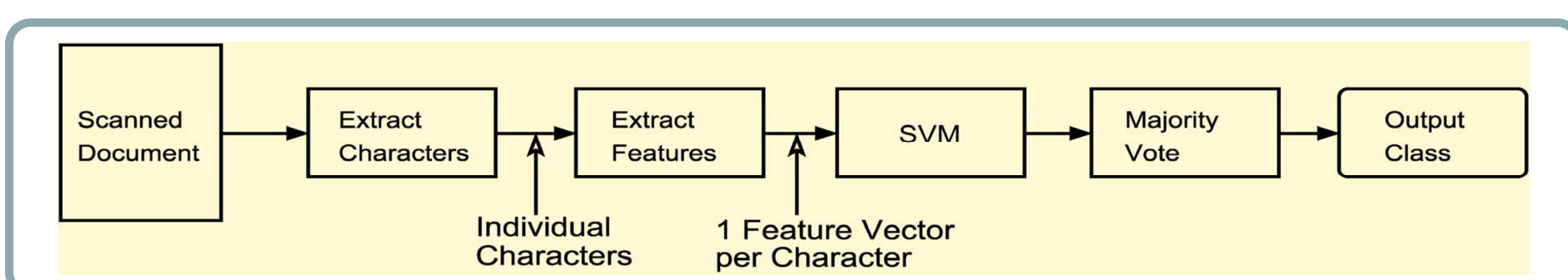
- Copying – scan and print
- Forgery - Alterations – additions and deletions
- Fingerprint and Trace
- Authentication – is this a proper document?



Goals

- Develop methods to embed security features in printed documents by exploiting how the printer actually places marks on the paper to form the printed document
- Can be very robust and/or can be very fragile and tamperproof
- Use *intrinsic signature* of printer to identify as much information as possible from printed document about printer that produced it
- Embed auxiliary information in document at time of printing via *extrinsic signature*
- Intrinsic and extrinsic signatures are based on extraction and modulation of features generated by the physical characteristics of the printer mechanism

Intrinsic Printer Identification

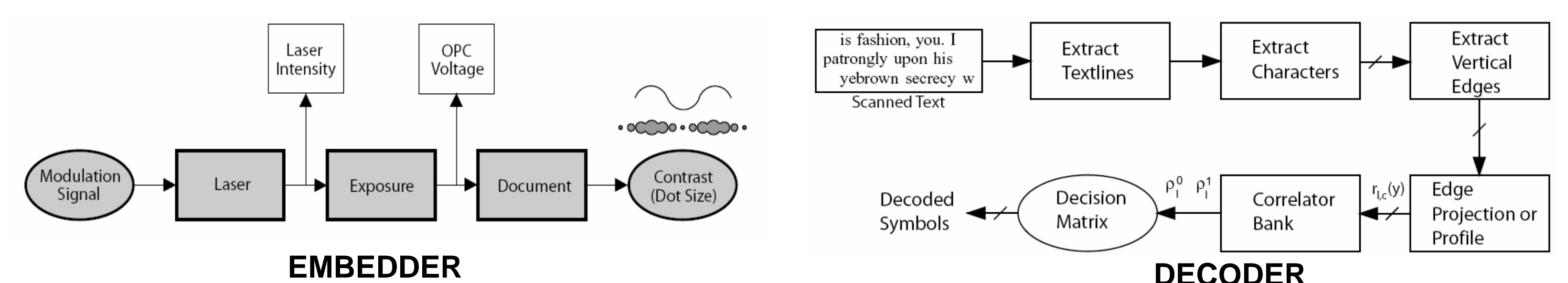


- Graylevel co-occurrence texture features estimated from printed regions within individual text characters
- System works across various font types and sizes, paper types, and consumable age when trained with same font and paper type
- 90% classification accuracy when training on new data and testing on old data
- Similar technique is promising for forensic identification of inkjet printers

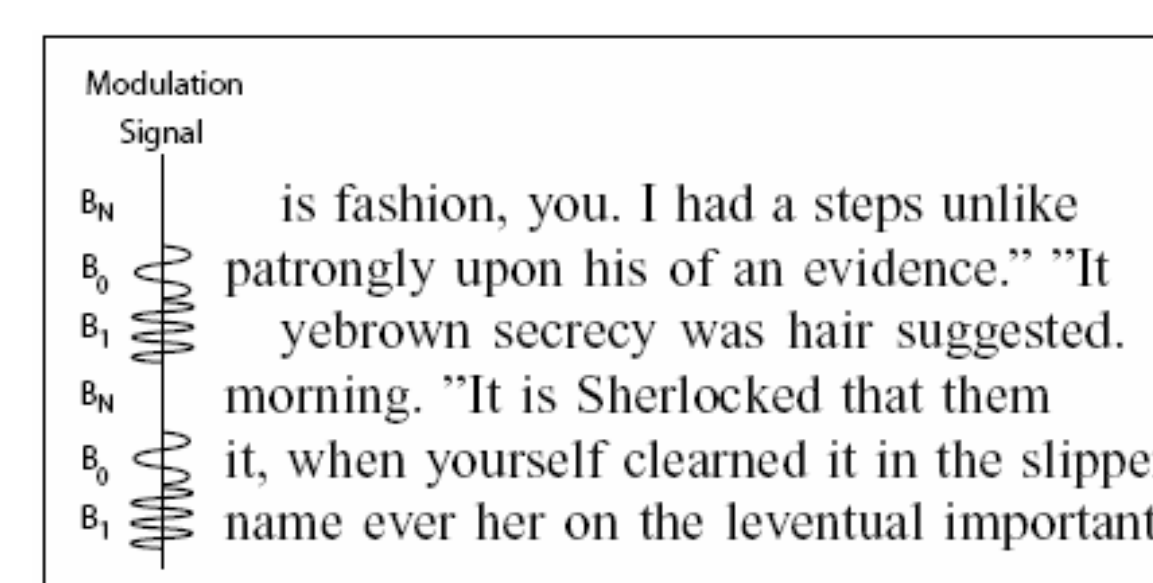
train/test	lj5m	lj6mp	lj1000	lj1200	E320	ml1430	ml1450	hl1440	1250w	14e	Output class
lj5m	296	2	0	1	0	1	0	0	0	0	lj5m
lj6mp	1	256	6	0	17	0	0	15	5	0	lj6mp
lj1000	2	2	284	12	0	0	0	0	0	0	lj1000
lj1200	7	2	2	289	0	0	0	0	0	0	lj1200
E320	0	0	0	0	300	0	0	0	0	0	E320
ml1430	1	0	0	0	0	299	0	0	0	0	ml1430
ml1450	0	0	0	0	0	0	300	0	0	0	ml1450
hl1440	0	28	0	0	0	5	2	259	6	0	hl1440
1250w	0	0	0	0	0	0	0	3	292	5	1250w
14e	0	0	0	0	0	0	0	17	67	216	14e

Classification results using 22 features. Test and training documents consist of 300 'e's printed with 12pt Times Roman font.

Extrinsic Signature Embedding



- Generate extrinsic signature by modulating laser intensity
- Ability to synchronize with individual text lines and embed different signals on a per line basis
- Embedded signature does not affect perceived image/text quality, but is still detectable from the scanned document



$$B_N(y) = 0$$

$$B_0(y) = A * \text{sign} \left(\sin \left(\frac{2\pi f_0 y}{R_p} \right) \right)$$

$$B_1(y) = A * \text{sign} \left(\sin \left(\frac{2\pi f_1 y}{R_p} \right) \right)$$

Character Level Decoding Error			
$(f_0/f_1) \setminus A$	0.1V	0.2V	0.3V
15/30	3.6	0.2	0.0
30/60	7.9	2.1	0.2
60/120	14.5	8.2	3.0

Line Level Decoding Error			
$(f_0/f_1) \setminus A$	0.1V	0.2V	0.3V
15/30	12.1	3.0	0.0
30/60	3.0	0.0	0.0
60/120	36.4	6.1	3.0

- Test document generated using our Forensic Monkey Text Generator (FMTG) with 12pt Times Roman font (50 lines per page)
- 2 bits embedded every three lines (33 bits in 50 lines of text)
- All bits can be correctly detected with well chosen embedding parameters
- Tradeoff between embedding frequency/amplitude and detection error

References available at <http://shay.ecn.purdue.edu/~prints>