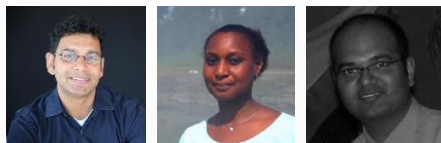


HANDWRITING RECOGNITION

A PERSPECTIVE ON TWO DECADES OF INNOVATIONS

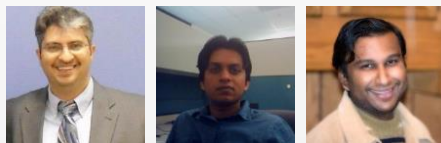


*Venu Govindaraju
University at Buffalo
New York, USA*



PATTERN RECOGNITION

Towards a Globally Optimal Approach for Learning Deep Unsupervised Models
Organizing Multiple Experts for Efficient Pattern Recognition
Active Pattern Recognition Using Genetic Programming
A Complexity Framework for Combination of Classifiers in Verification and Identification Systems
Image Processing using Ontology Concepts for Image Segmentation
Language Motivated Approaches for Human Action Recognition and Spotting
Sequential Pattern Classification without Explicit Feature Extraction



DOCUMENT ANALYSIS

Automatic Recognition of Handwritten Medical Forms for Search
Hierarchical and Dynamic-Relational Models for Handwriting Recognition
Stochastic Modeling of High-level Structures in Handwritten Word Recognition
Statistical Techniques for Efficient Indexing and Retrieval of Document Images
Probabilistic Random Field based Text Identification
Enhancing Cyber Security through the use of Synthetic Handwritten CAPTCHAs
Language Models and Automatic Topic Categorization for Information Retrieval in Handwritten Documents
Methods for Biomedical Image Content Extraction Toward Improved Multimodal Retrieval of Biomedical Articles
Exploiting the Gap between Human and Machine Abilities in Handwriting Recognition for Web Security Applications
Enhancement and Retrieval of Low Quality Handwritten Documents
A Stochastic Framework for Font Independent Devanagari OCR
A Semi Supervised Framework for Handwritten Document Analysis
Bayesian Background Models for Retrieval of Handwritten Documents
Accents in Handwriting: A Hierarchical Bayesian Approach to Handwriting Analysis
Multilingual Word Spotting in Offline Handwritten Documents



BIOMETRICS

Intrusion Detection using Spatial Information and Behavioral Biometrics
A Framework for Fingerprint Enhancement and Feature Detection
Minutia-Based Partial Fingerprint Recognition
Integrating Facial Expressions and Skin Texture in Face Recognition
Integrating Minutiae Based Fingerprint Matching with Local Correlation Methods
A Novel Multi-sample Fusion Methodology for Improving Biometric Recognition
Face Modeling and Biometric Anti-spoofing using Probability Distribution Transfer Learning
A Framework for Efficient Fingerprint Identification using a Minutiae Tree





An Abridged History of Writing Instruments



FINGER
(IN SAND)
(OR CLAY)



QUILL



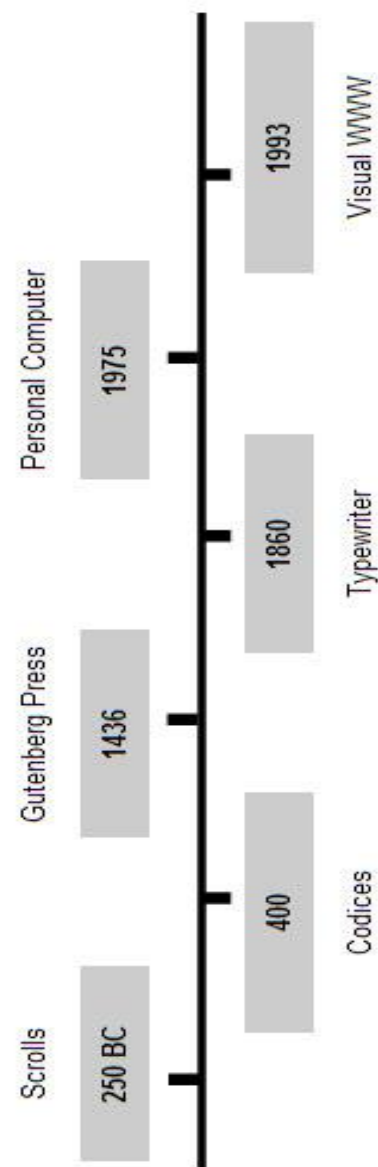
PENCIL



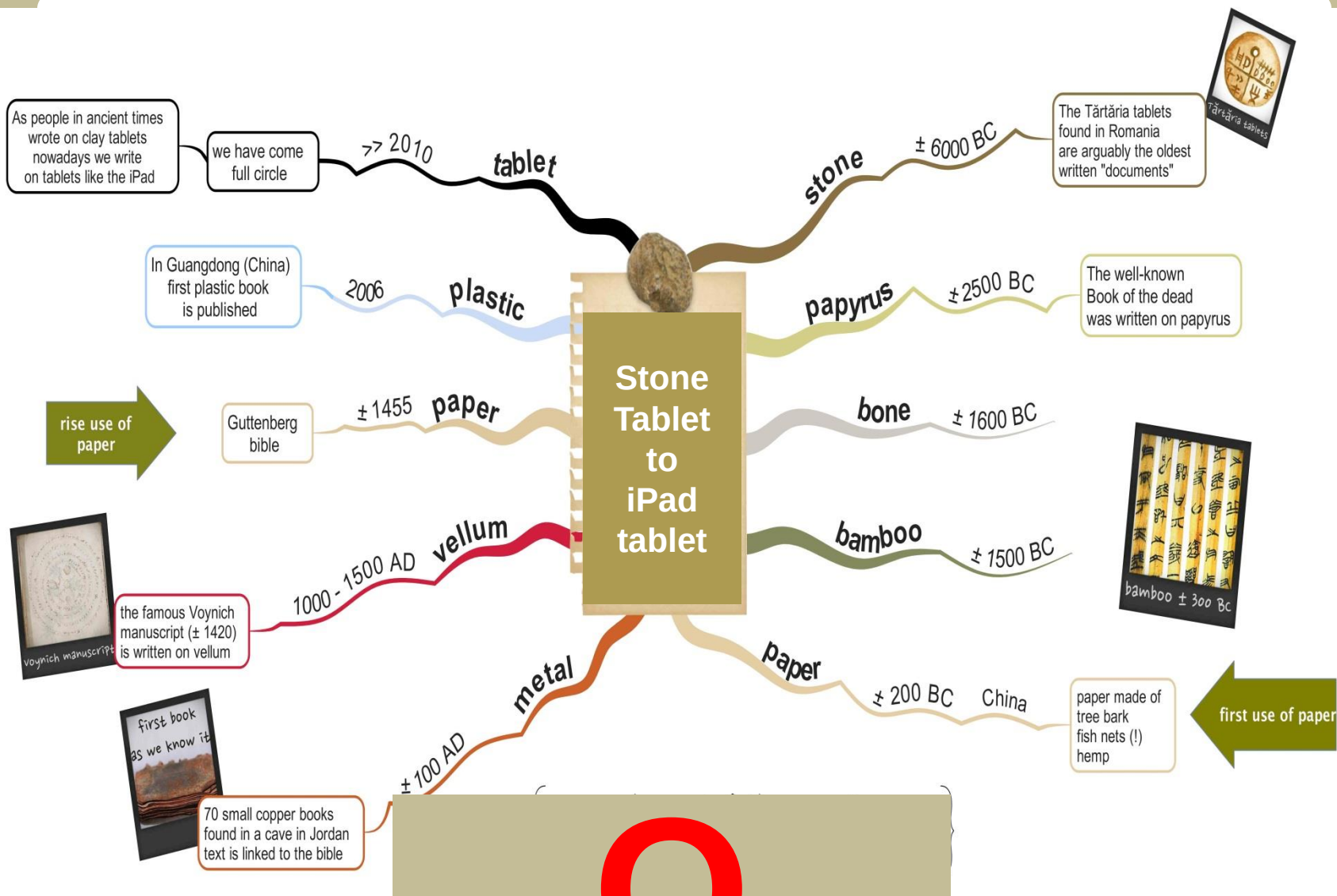
BALL POINT
PEN



FINGER
(ON TOUCHSCREEN)



Full Circle





NATIONAL
MATH + SCIENCE
INITIATIVE

Pencils and Brainwaves

10 Handwriting FACTS



THE WALL STREET JOURNAL.

TUESDAY, OCTOBER 3, 2010 - VOL. CCLVI NO. 81

• • \$2.00

CONCLUSIONS

A NEWS CORPORATION COMPANY

DJIA	10751.27	▼ 78.41	-0.7%	NASDAQ	2344.52	▼ 1.1%	NIKKEI	9381.06	▼ 0.2%	STOXX 600	257.74	▼ 0.5%	10-YR TREAS	▲ 13/32	yield	2.481%	OIL	\$81.47	▼ \$0.11	GOLD	\$1,325.40	▼ \$0.70	EURO	\$1.3689	YEN	83.42
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How Handwriting Trains the Brain

Forming Letters Is Key to Learning, Memory, Ideas

By CHRISTOPHER HUNTER

Ask preschooler Zane Pike to write his name or the alphabet, then watch this 4-year-old's stubborn side kick in. He spurns practice at school and tosses aside workbooks at home. But Angie Pike, Zane's mom, persists, believing that handwriting is a building block to learning.

She's right. Using advanced tools such as magnetic resonance imaging, researchers are finding that writing by hand is more than just a way to communicate. The practice helps with learning to read and to think.



A Dialysis Treatment For The Busy Patient

By Margaret Force

Kidney dialysis is no fun. For most patients, it means sitting in a hospital or clinic hooked up to a machine for three to five hours, three days a week. The rooms are usually decrey and many patients leave feeling washed out. It doesn't have to be that way. In New York's Staten Island, 55 years old, a patient is shown.

Students **WITHOUT** consistent exposure to handwriting **are more likely to have problems** retrieving letters from memory; spelling accurately; extracting meaning from text or lecture; and interpreting the context of words and phrases



Elementary-age students who wrote compositions by hand rather than by keyboarding, one researcher found, wrote **faster**, wrote **longer pieces**, and expressed **more ideas**



Handwriters exhibit **better comprehension** of the content and were **more attentive and involved** during the class discussions versus classmates who took notes by computer



During early childhood, writing letters **improves letter recognition**, as shown in brain imaging studies; and teaching handwriting leads to **improved reading**, as shown in instructional studies



Structured handwriting lessons lead to improved writing performance, academic **success**, and overall student **self-esteem**



a 2012 study concluded that **one in three** participants had not been required to produce something in handwriting for **more than half a year**



A 2012 study found that 33% of people had **difficulty reading their own handwriting**



Research shows that you **remember information better** when you **write** it by hand than when you type it



A psych professor at Dominican University of California found that people who **wrote** down their goals, **shared** them with others, and **maintained accountability** for their goals were **33% more** likely to achieve them, versus those who just formulated goals



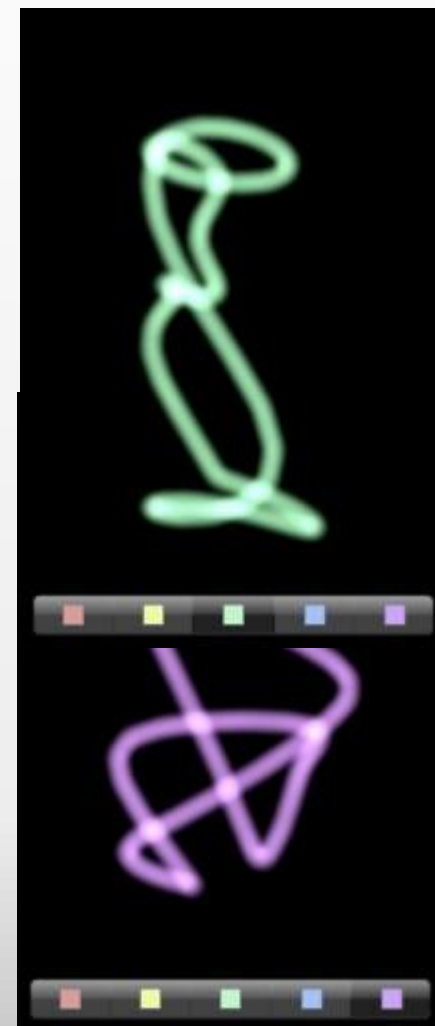
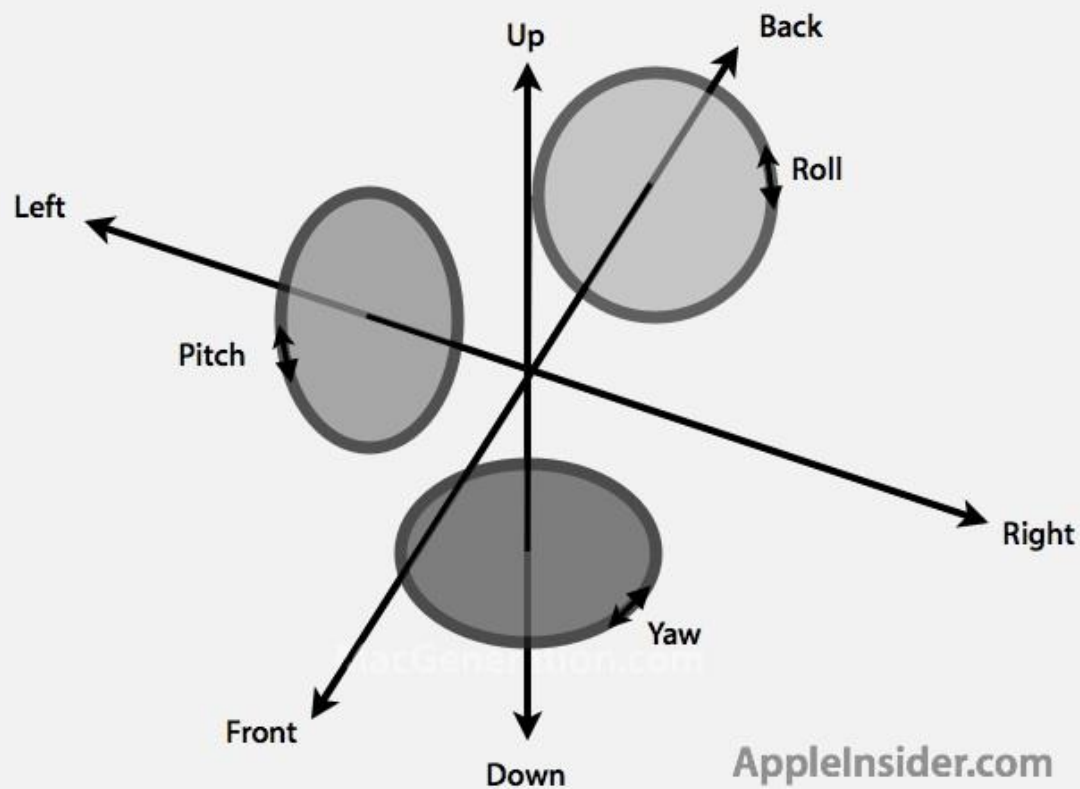
National statistics point to underachievement in writing as a condition that leads to school **dropout, grade retention, and failure to graduate** from high school or college

Air Writing

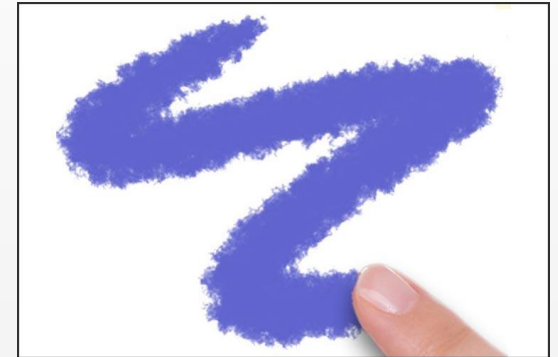
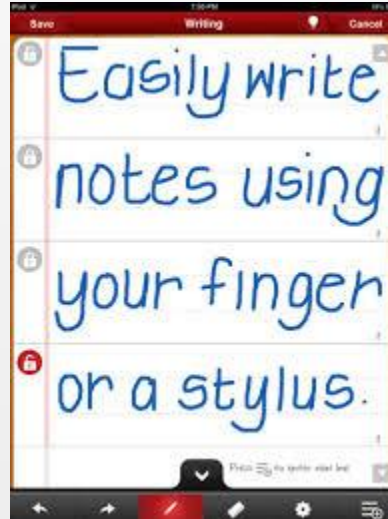


Accelerometers and Gyroscopes

Sense linear and angular acceleration



E-signatures and Finger Doodles



SEND A NEW DOCUMENT



UPLOAD A FILE

GET FROM CLOUD



1

ಕು

ಅ	ಇ	ಉ	ಎ	ಔ
ಕ	ಖ	ಗ	ಙ	ಝ
ಚ	ಠ	ಣ	ತ	ಥ
ನ	ಯ	ಲ	ವ	ಶ

2

ಕು
↓
ಕು

3

ಕು
↓
ಕು

4

ಯ	ಣ	ದ	ನ	ಲ
ಎ	ಉ	ಋ	ೠ	ಌ

↓

ಕು	ಕು
ಕು	ಕು

This AI Algorithm Learns Simple Tasks as Fast as We Do

Software that learns to recognize written characters from just one example may point the way towards more powerful, more humanlike artificial intelligence. *MIT Technology Review, Dec 2015.*

All Things Handwritten

Ich hätte Ihre Bitte gewiss
früher erfüllt, wenn Ihre Briefe
nicht in der Hülle Ihres Geschwister
aus meinem Blickfeld verschwunden
wären. Denn Graphologie hat mich
stets interessiert, wenn ich mich
auch nie systematisch dafür
interessiert habe, ich mache es
mit Schriften wie mit Gesichtern,
ich urteile instinktiv.

Ausdrucksvoll

A. Einstein.

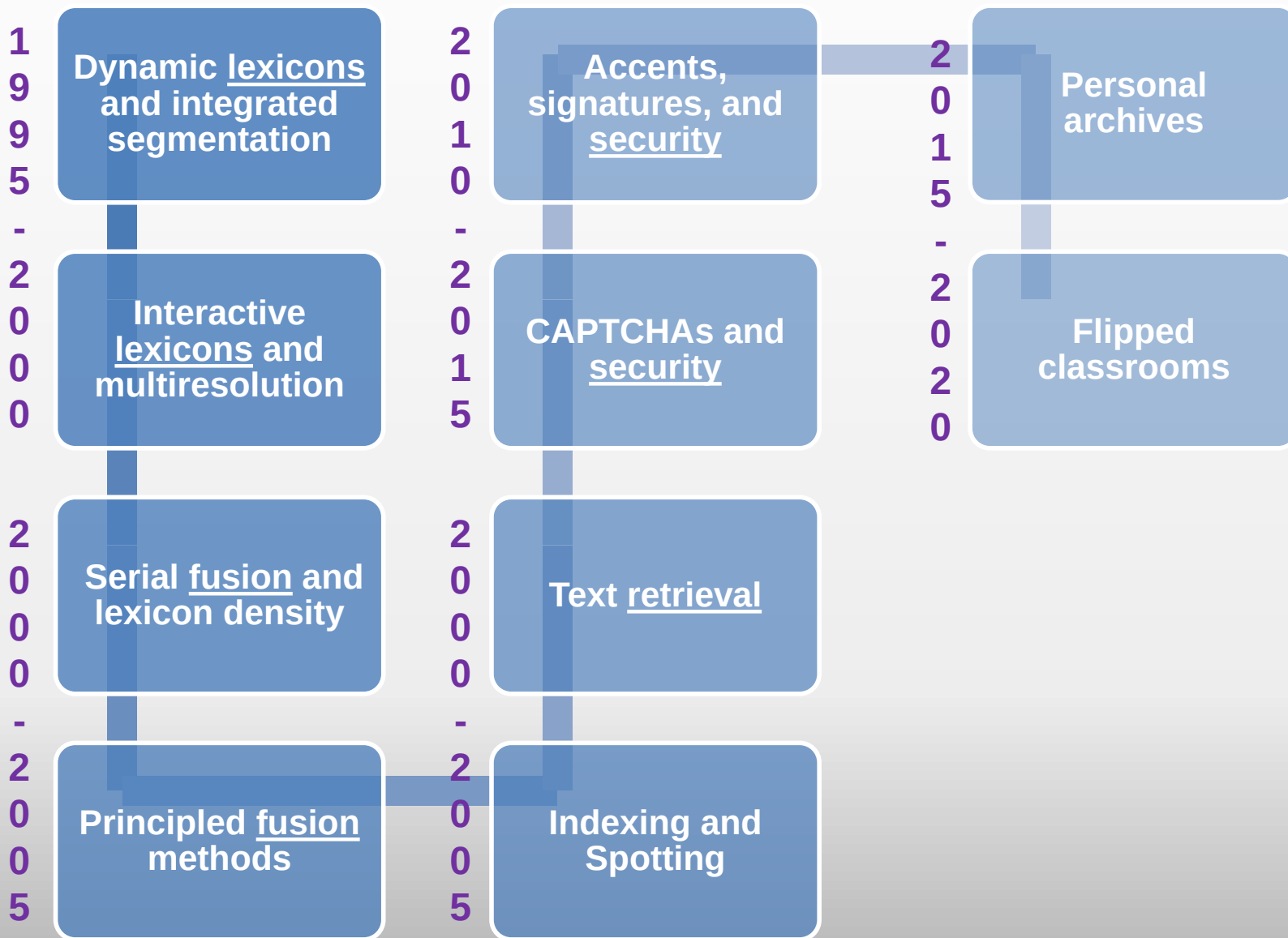
Winchester: October 28th 1755.

Parole Hampton.

The officers who came down
from Fort Cumberland with Colonel
Washington, are immediately to go Recrui-
ting; and they are allowed until the 5th of De-
cember; at which time if they do not
punctually appear at the place of Rendez-
vous assigned them, they will be tried by a
Court Martial, for disobedience of Orders.

FOUND IN WHEELCHAIR, AT
THE LAST FABLE OF DAYS, N
SE WANTED WERE TO BE EQUAL

Key Innovations



LEXICONS

1

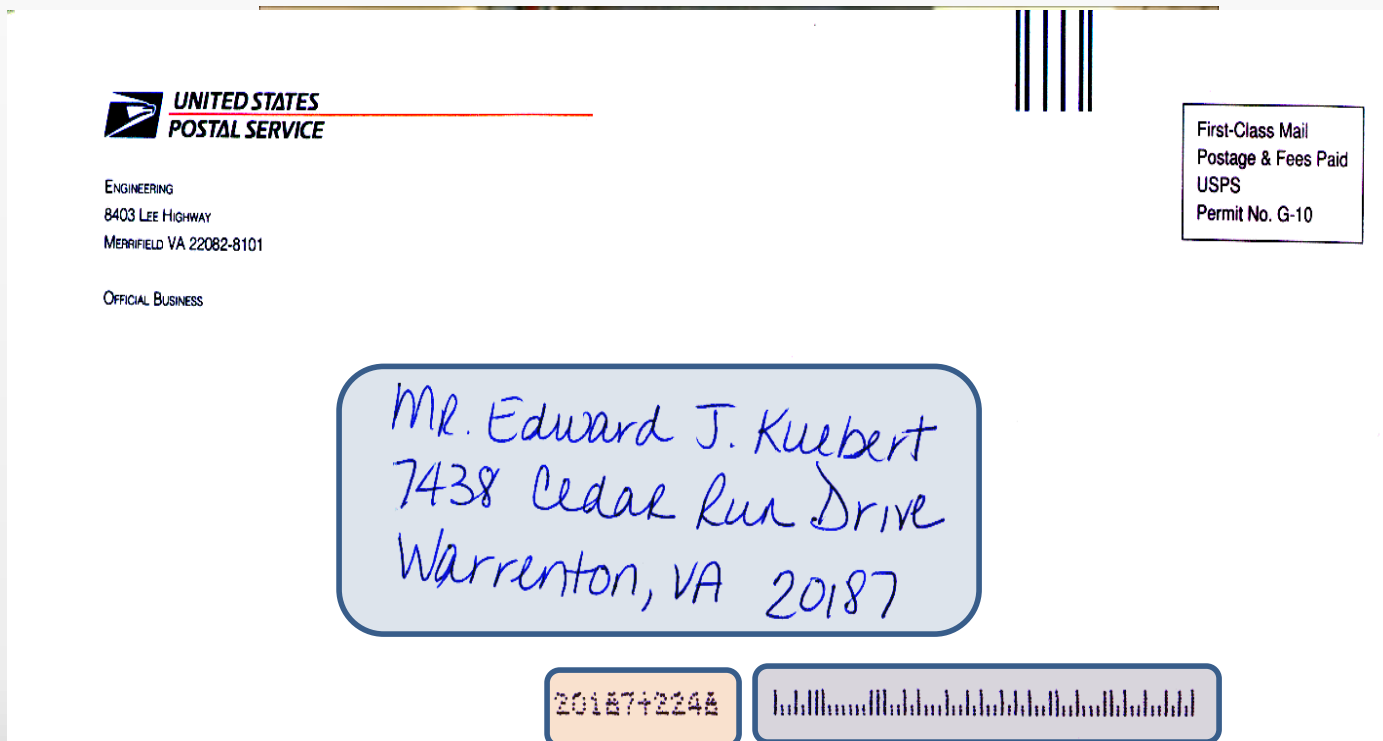


Lexicon



Postal

Lexicon



10-10-20 Rule

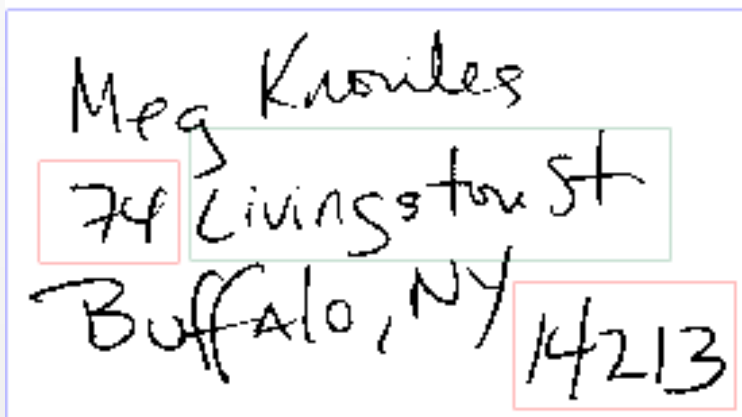
ML Success Story - Highlighted in the CCC Symposium on “Computing Research That Changed the World” (2009); Seminal work of Kim, Govindaraju (PAMI 1997) at the core of the technology

Dynamic Lexicon



Lexicon

Typical Mail-piece Address Block :



ZIP and Primary Number Recognition

ZIP Code: 14213
Primary Number: 74

Database
Query

Lexicon Entry (Street Name)	Addon
BRADLEY ST	1024
COLONIAL CIR	1467
DEWITT ST	1534
GRANT ST	1905
HAMPSHIRE ST	2012
HAWLEY ST	1053
LAFAYETTE AVE	1347
LIVINGSTON ST	1653
MANCHESTER PL	1251
PO BOX	0074
POOLEY PL	1128
POTOMAC AVE	1146
PUTNAM ST	1650

Delivery Point Code: 14213165374

Word Recognition (Street Name)
And Delivery Point Code Derivation

30% ZIPs contain less than 100 street names; Max streets returned is 3,071

Medical

Faxed prescriptions

PATIENT NAME: _____ PHARMACY PHONE: _____

MEDICAL RECORD NUMBER: _____ DATE OF BIRTH: _____

DRUG NAME/ INDICATION	DOSE/FREQ/ QTY/REFILLS	DATES OF SERVICE	
Actos 1500	✓	12/1/11	9/20/12
Glyburide 5	✓	12/1/11	9/20/12
Lisinopril 10	✓	12/1/11	9/20/12
Zetia 100	✓	12/1/11	9/20/12
Simvastatin 40	✓	12/1/11	9/20/12
Metoprolol 25	✓	12/1/11	9/20/12
Fosinopril 10	✓	12/1/11	9/20/12
Aspirin	✓	12/1/11	9/20/12
Calcium citrate 750	✓	12/1/11	9/20/12
Allopurinol	✓	12/1/11	9/20/12

INITIAL IF MEDICATION LIST REVIEWED: _____

COMMENTS: _____

INSTRUCTIONS: CHECK DOSE/FREQUENCY BOX IF MEDICATIONS WERE REVIEWED & CONFIRMED AND NO PRESCRIPTION WAS WRITTEN. IF SAMPLE DRUG(S) DISPENSED, INDICATE BY PUTTING AN "S" IN THE QTY/REFILLS BOX.

Glyburide

- | Rank | Recog result |
|------|--------------|
| 1 | glyburide |
| 2 | bumetanide |
| 3 | indapamide |

Fosinopril

- | Rank | Recog result |
|------|--------------|
| 1 | fosinopril |
| 2 | perindopril |
| 3 | benazepril |

Metoprolol

- | Rank | Recog result |
|------|--------------|
| 1 | metoprolol |
| 2 | metolazone |
| 3 | torsemide |

Lexicons



Lexicon

ONE	TWO	THREE
FOUR	FIVE	SIX
SEVEN	EIGHT	NINE
TEN	ELEVEN	TWELVE
THIRTEEN	FOURTEEN	FIFTEEN
SIXTEEN	SEVENTEEN	EIGHTEEN
NINETEEN	TWENTY	THIRTY
FORTY	FIFTY	SIXTY
SEVENTY	EIGHTY	NINETY
HUNDRED	THOUSAND	LAKH
LAC	LACS	AND
ONLY	CRORE	LAKHS



- Census forms recognition
Lexicon of professions
- Prescription forms
Lexicon of medicines
- Registry of land ownerships
Lexicon of owner

Integrated Segmentation



Lexicon

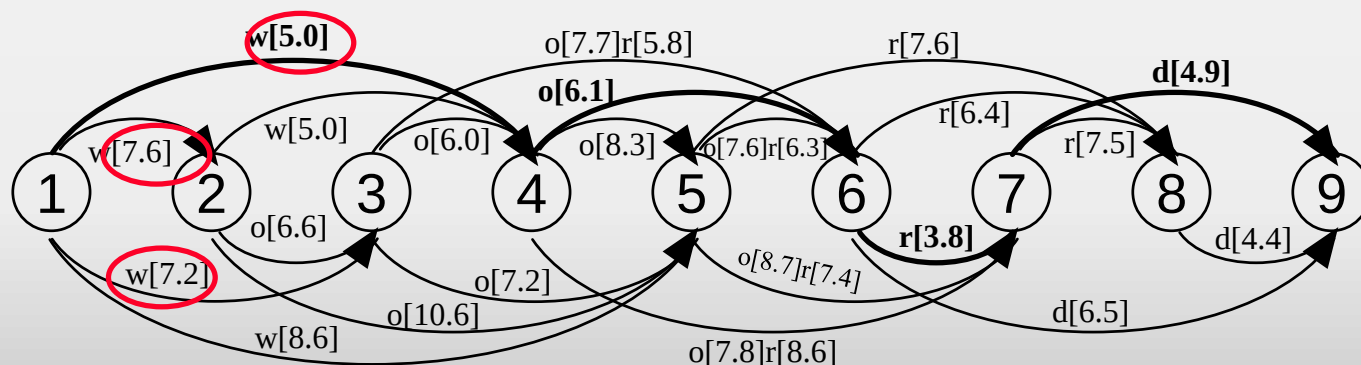
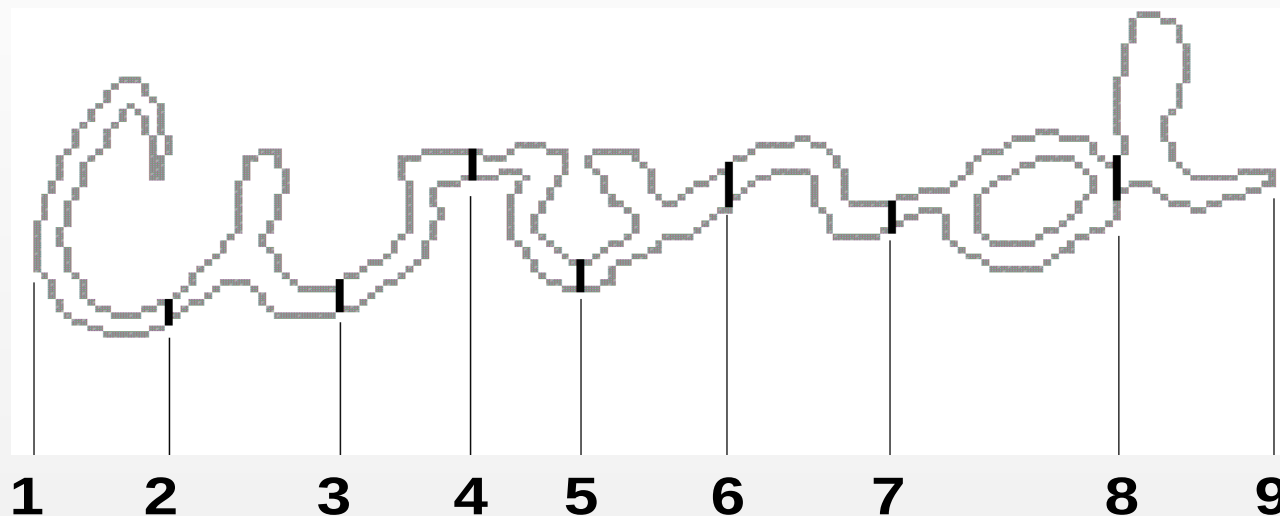
WORD

WELL

WORLD

HOUSE

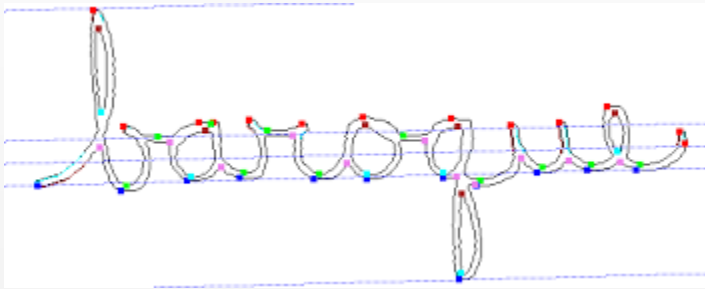
SCHOOL





Interactive Features

Lexicon



A - - - D - -

Hyderabad

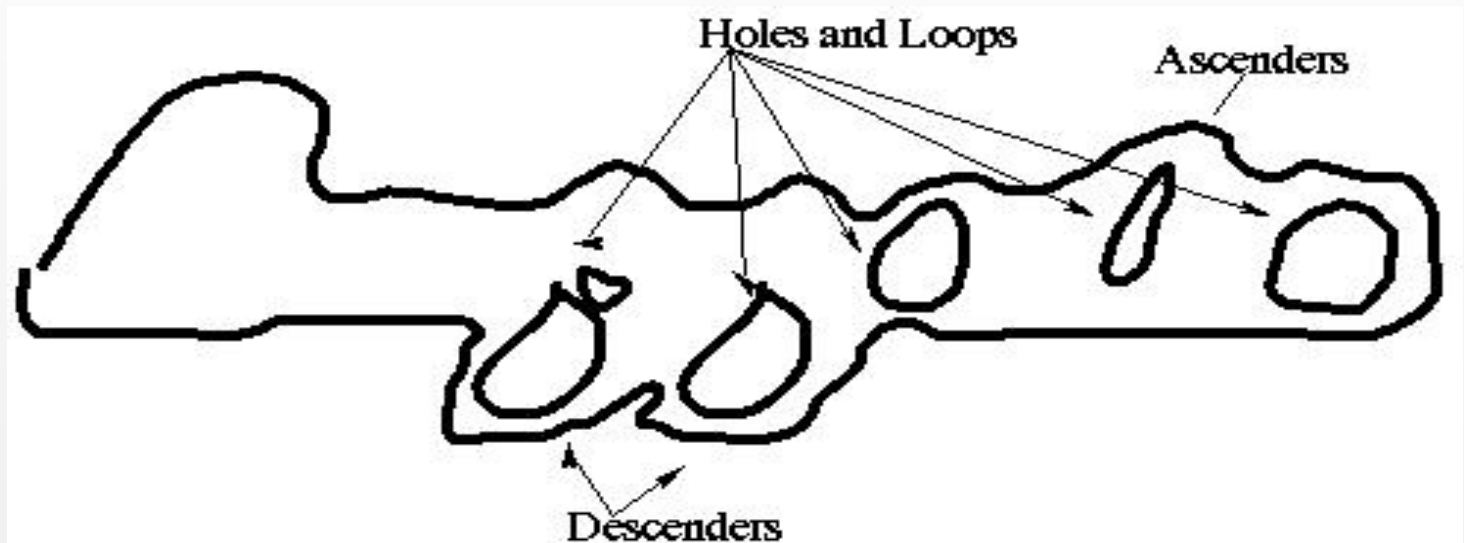
A D A - - - A - A

A - A - - A - -

a. Delhi b. Kolkatta c. Patna d. Dehradun

Interactive Features

Lexicon

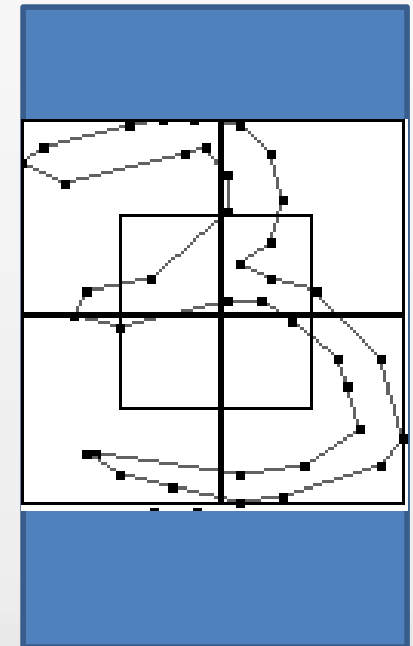
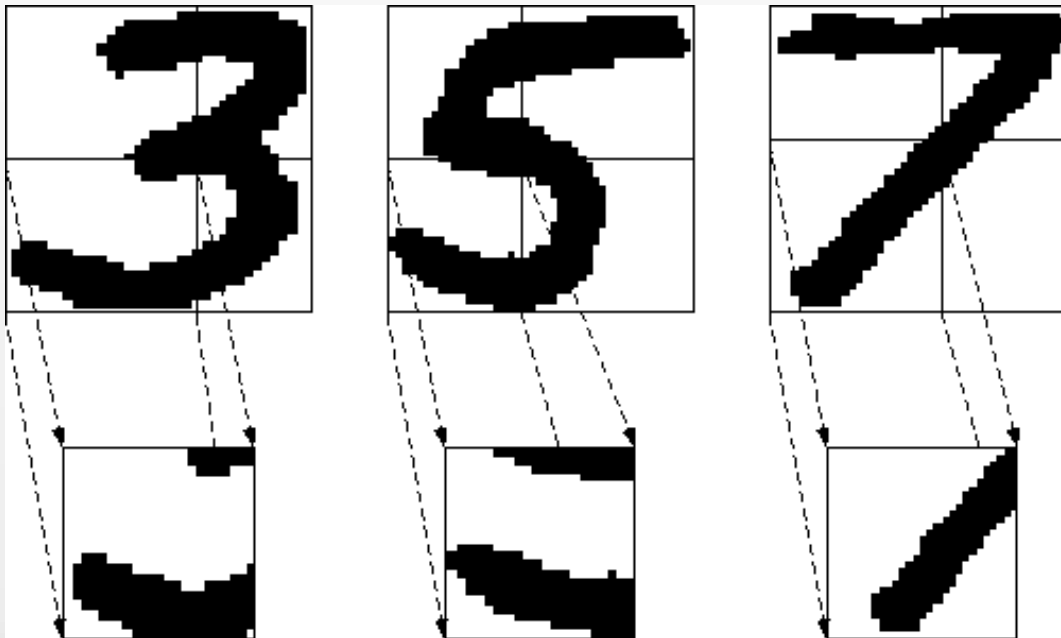


- a) Amherst
- b) Buffalo
- c) Boston
- d) None of the above

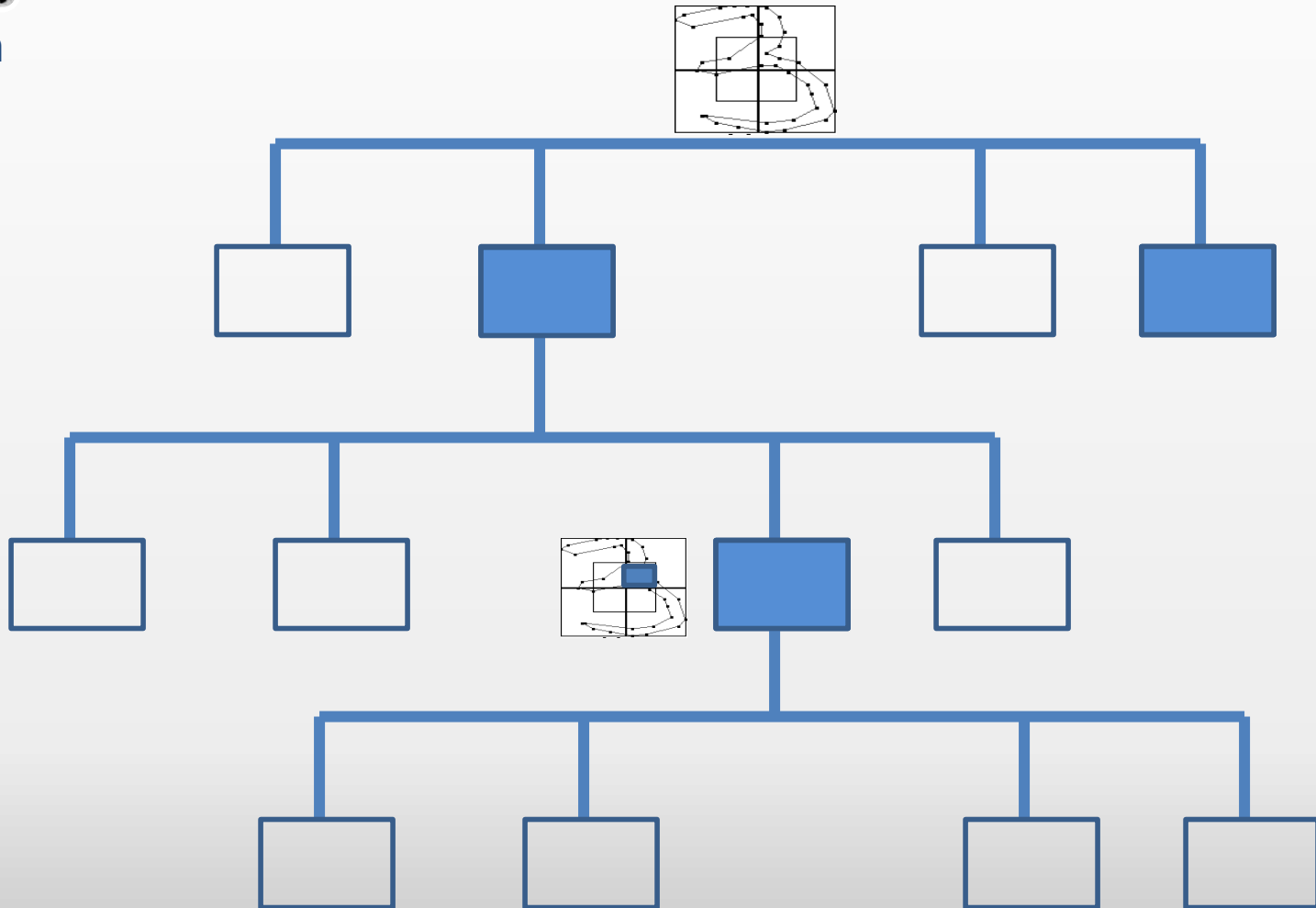
Multiresolution features



Lexicon



A*



Lookup table: $2^9 \times 10 \times 85$ (quad tree, 4 levels)



Interactive Lexicons

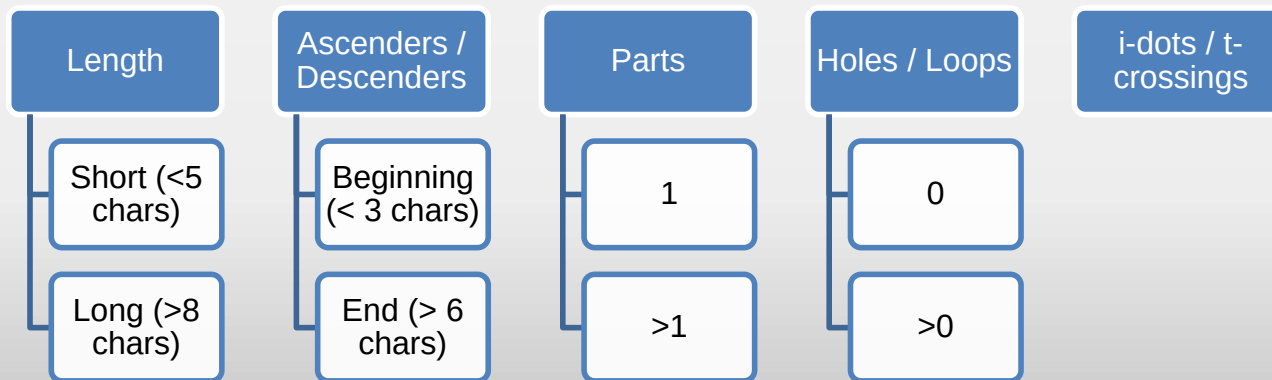
Lexicon

a. *New Delhi*

b. *Kolkatta*

c. *Patna*

d. *Dehradun*





IMPACT

Lexicon

1995-2000

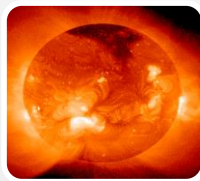
Lex size	%
10	96
100	91
1000 (Top 50)	80 (98)
20000 (Top 100)	62 (94)
Postal Encoding	40

Today

Lex size	%
10	~99
100	~99
1000	~95
Postal Encoding	95

FUSION

2

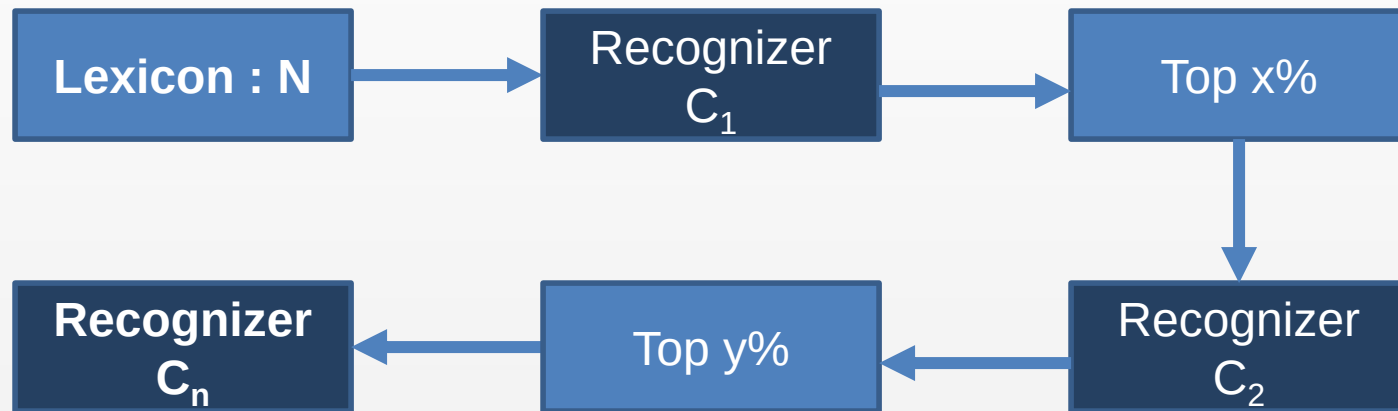


Fusion



Fusion

Serial Fusion



- How does one determine x, y ?
- How does one determine the ordering of $C_1, C_2, \dots C_n$
- Is there a difference based on whether it is an Identification task or Verification task?
- Can it be a generalized principled approach?



Fusion

Lexicon Density

- Lexicon size as feature
 - Different lexicons with the same size have inconsistent results
- Lexicon density as metric
 - Recognizer specific
 - Performance is consistent with the same level of density

Lexicon 1:

1: He
2: Me
3: No
4: So
5: We

Lexicon 2:

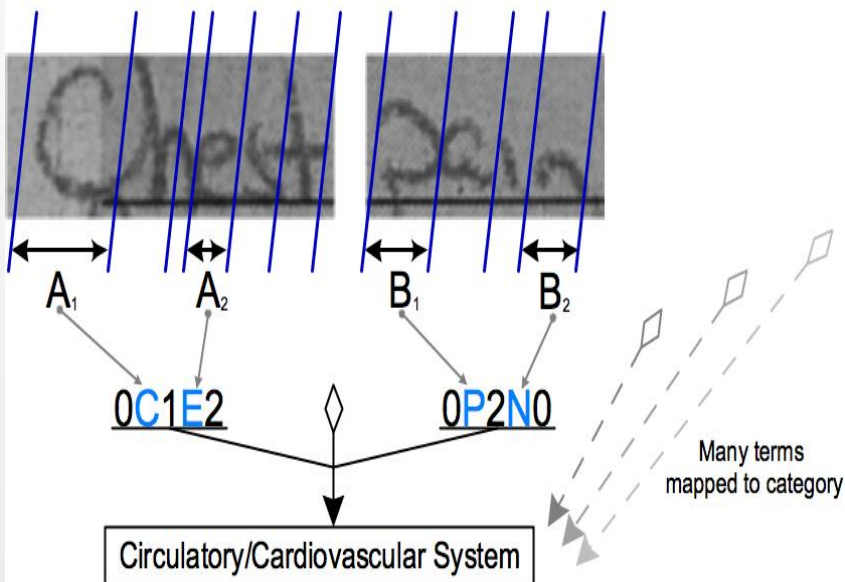
1: Me
2: Memo
3: Memory
4: Memorize
5: Memoryless



Fusion

Bootstrapping for Large Lexicons

Cohesive Phrase: CHEST PAIN

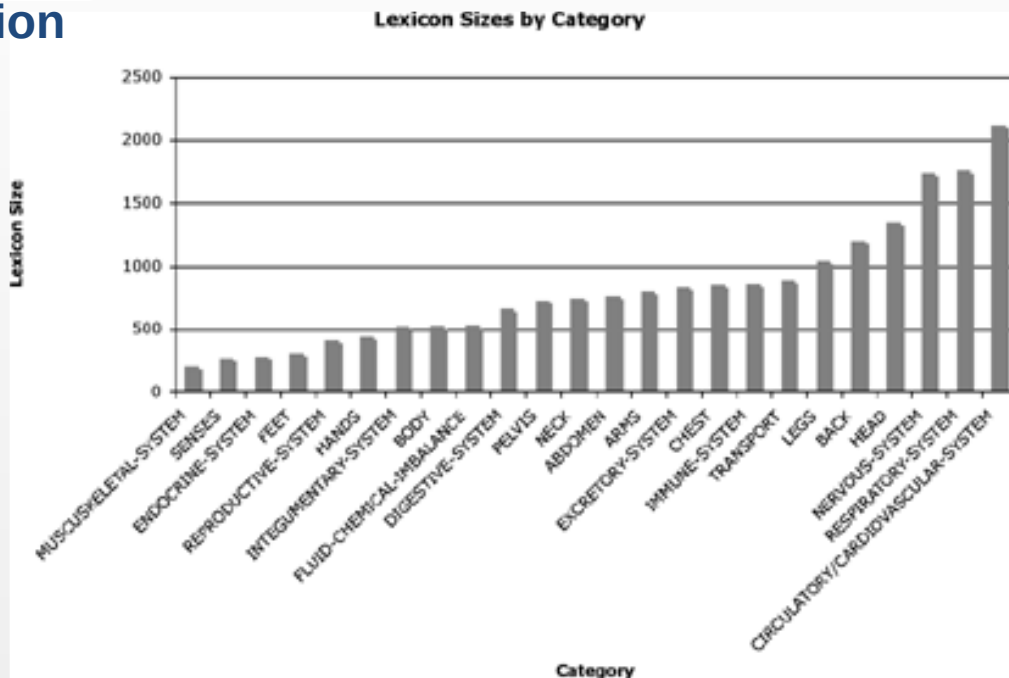


(ID: 342-2)		*C*S* *A*N*
(ID: 407-1)		*C*M* *P*A*
(ID: 407-2)		*H*O* *A*W*
(ID: 473)		*C*F* *L*A*
(ID: 643)		*C*H* *A*W*
(ID: 695-1)		*L*S* *L*R*
(ID: 98)		*C*S* *S*S*
(ID: 606)		*C*W* *D*M*
(ID: 695-2)		*C*F* *W*L*



Pruning Lexicons

Fusion



	Digestive System	Circulatory System	Immune System	Head	Neck	Back	Pelvis	Legs	Arms	Pseudo-Category Vector
(bl, no)	0	0	0	.95	0	0	0	0	0	0
(bl, ns)	.07	0	0	.34	0	.34	0	0	0	2
(bl, nt)	0	0	0	.95	0	0	0	0	0	1
(bl, nr)	0	.06	0	.44	0	0	0	.20	0	1
(bl, mo)	0	0	0	.33	0	.56	0	0	0	1
(bl, mu)	0	0	0	.41	0	0	0	.51	0	0
(bl, mt)	0	.05	0	.44	0	.19	0	0	0	2
(bl, mh)	0	0	0	.95	0	0	0	0	0	0
(bo, no)	.18	0	0	.57	0	.25	0	0	0	3
(bo, ns)	0	0	0	.42	0	.49	0	0	0	1

Vector Q is now added to the original normalized/weighted matrix X

	CLT to RLT	CL to RL	CLT to ALT
HR	↑7.48%	↑7.42%	↑17.58%
Error Rate	↓10.78%	↓10.88%	↓24.53%



Fusion

Principled Approach

Map: M matchers x N classes scores to N combined scores

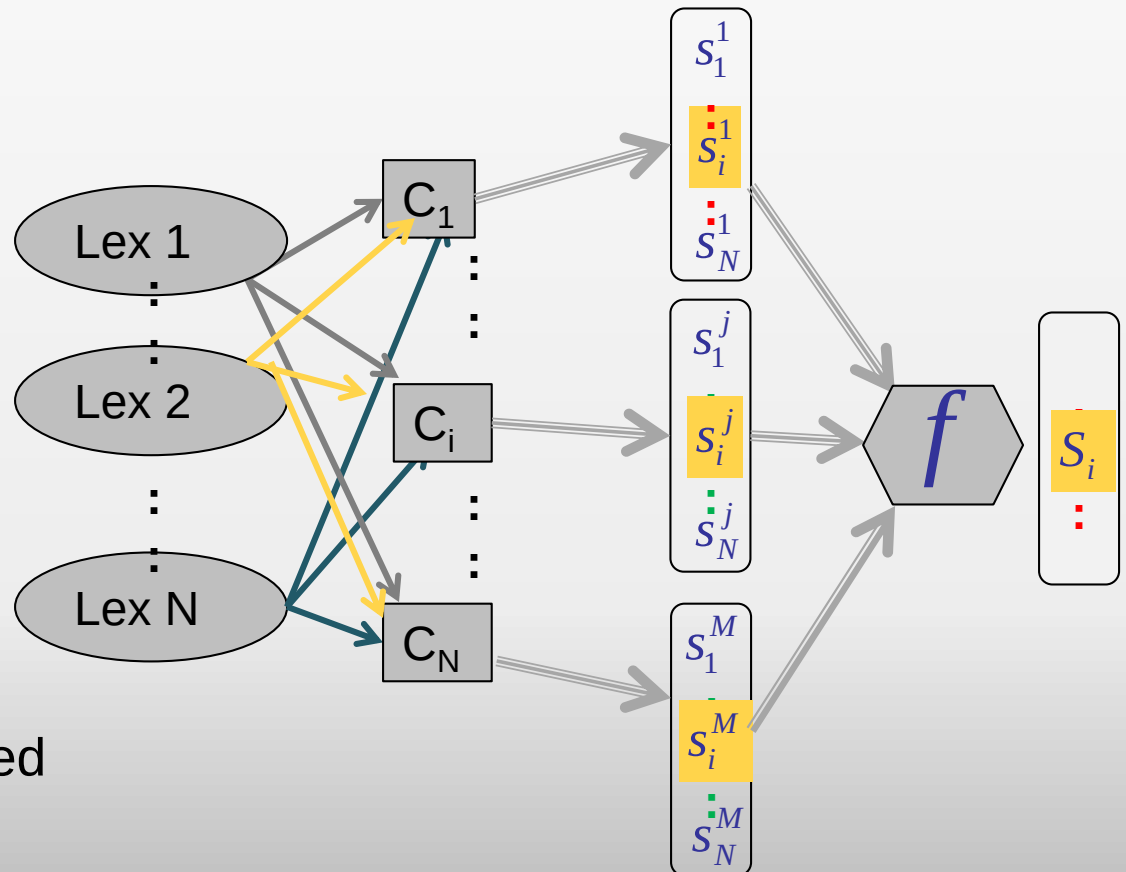
$$S_i = f(s_i^1, s_i^2, \dots, s_i^M)$$

Verification

Verify if combined score of hypothesis $> \theta$

Identification

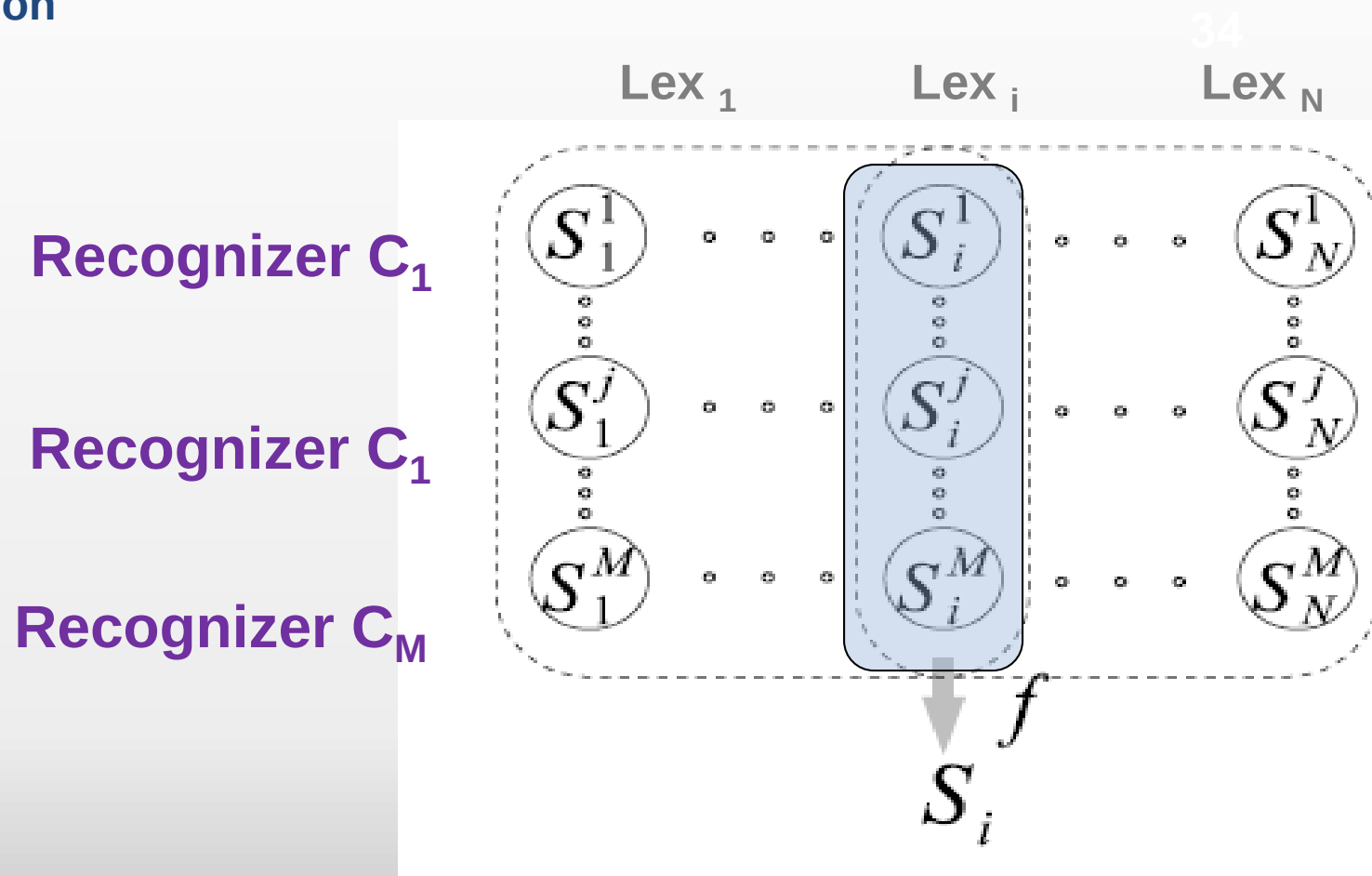
Class of maximum combined score
 $\arg \max_{i=1, \dots, N} S_i$





Fusion

Score Matrix





Fusion

Optimal Methods

$$S_i = f_V \quad S_i > \theta ? \text{ Accept : Reject}$$

$$S_i = f_N \quad S_i \arg \max_{i=1, \dots, N}$$

$$S_i = f_V > \theta ?$$

$$\Theta = \prod_{j=\text{trials}} \frac{p(s_j^k | C^k)}{p(s_j^k | \bar{C}^k)}$$

Likelihood Ratio

$$S_i = f_N ?$$

C1	C2	C1 ^ C2	C1 v C2	LR	Weighted sum	NN
54.8	77.2	48.9	83.0	68.8	81.6	81.7

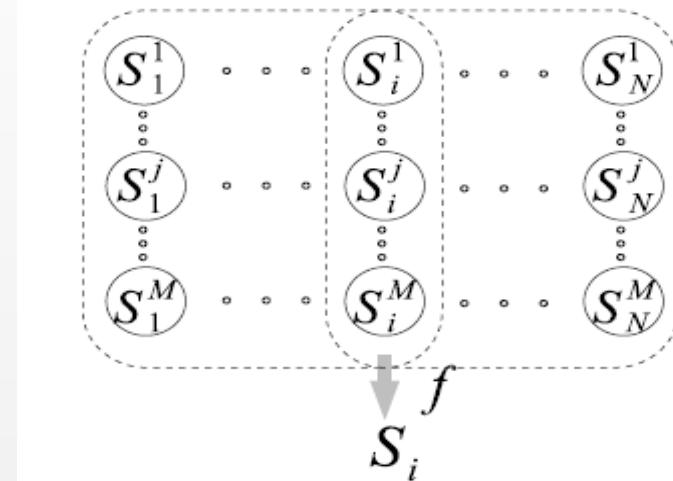


Fusion

IMPACT

Practical

- Dependent Scores
- Independent Matchers



A	B	C	...
.95	.89	.76	...



A	B	C	...
.80	.54	.43	...

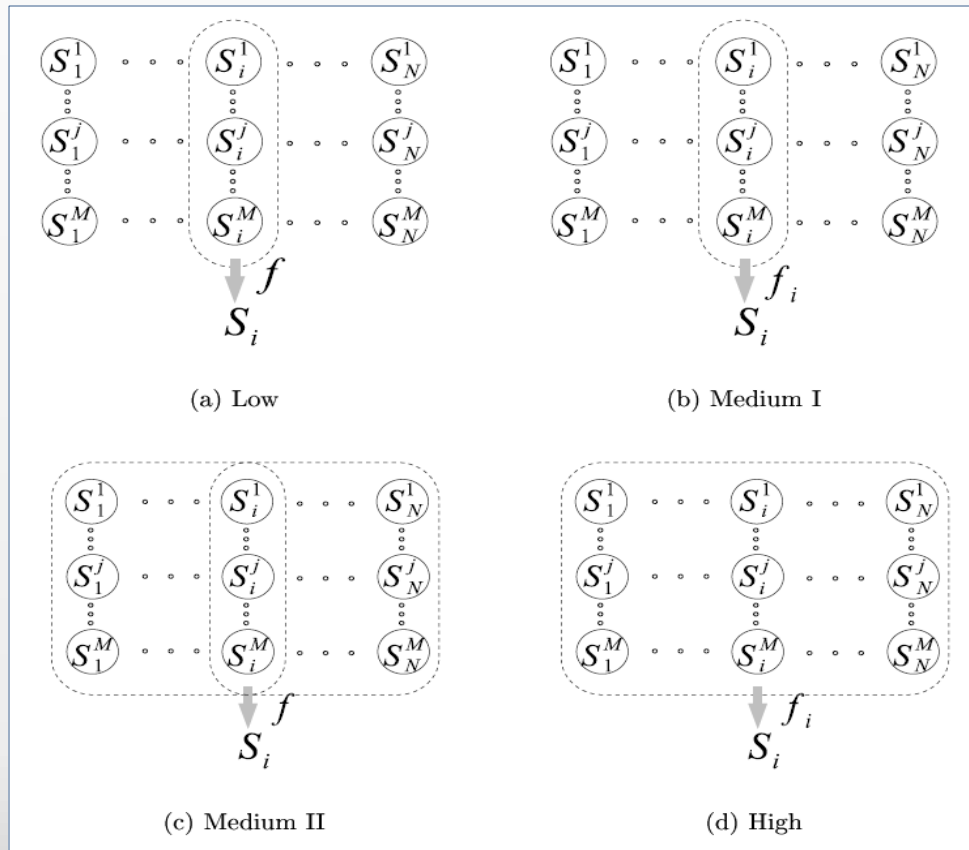
$$C = \arg \max_k \prod_{j=\text{trials}} \frac{p(s_j^k, t_j^k | C^k)}{p(s_j^k, t_j^k | \bar{C}^k)}$$



Fusion

IMPACT

Theoretical



$$S_i = f_i(\{s_i^j\}_{i,j})$$

Low	$C_f(M)$
Medium I	$NC_f(M)$
Medium II	$C_f(NM)$
High	$NC_f(NM)$

INDEXING AND RETRIEVAL

3

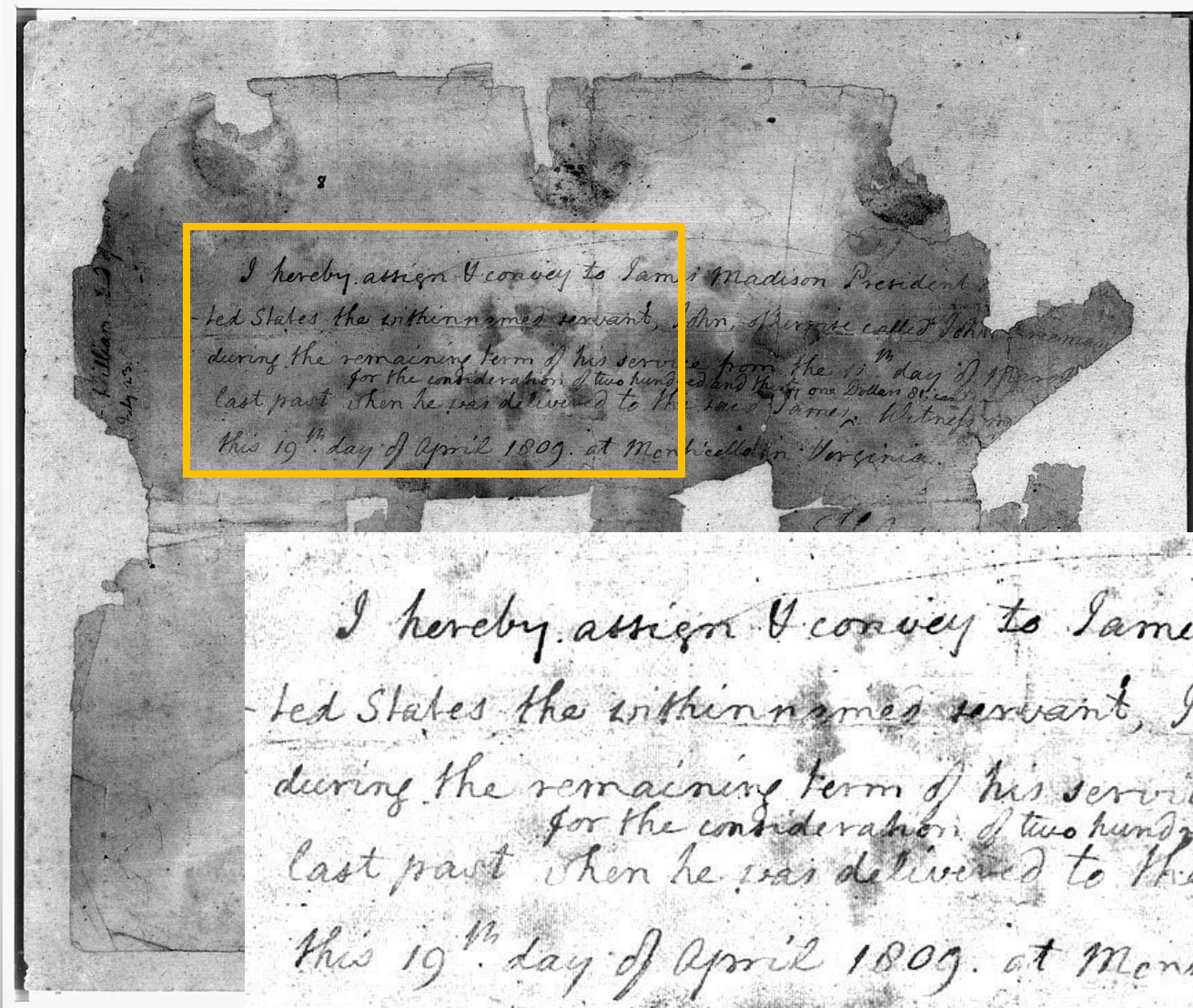


Retrieval

Historical Documents



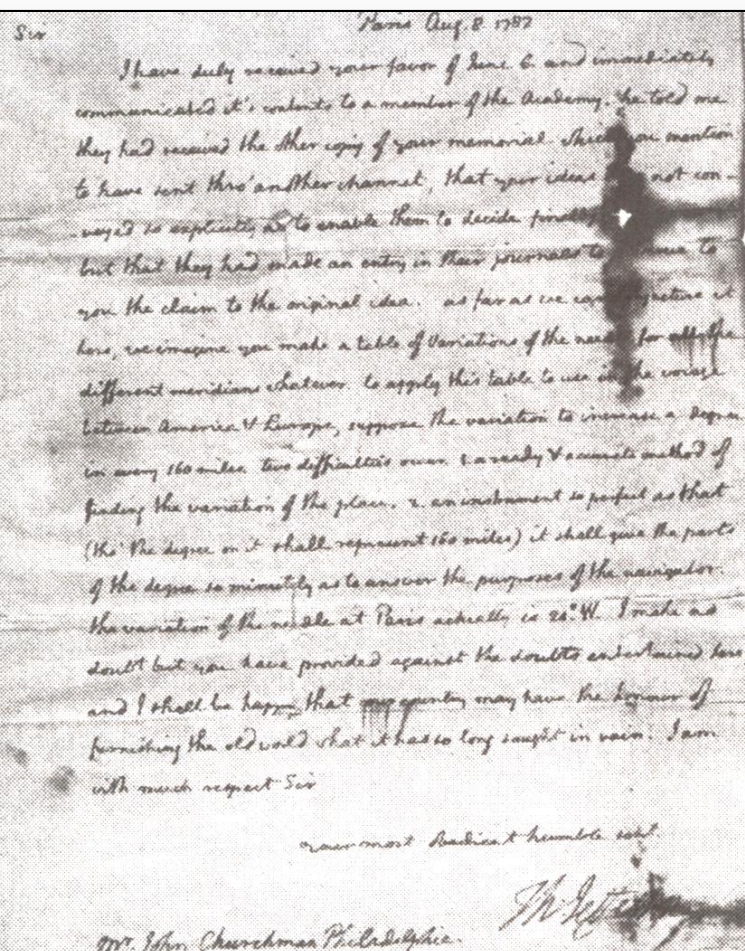
Retrieval



Transcript mapping

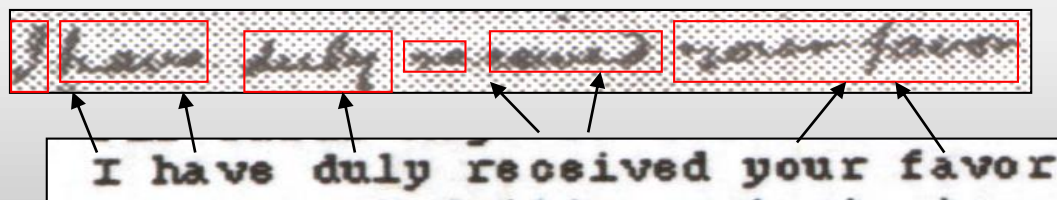


Retrieval



Sir Paris Aug. 8. 1787.

I have duly received your favor of June 6. and immediately communicated it's contents to a member of the Academy. he told me they had received the other copy of your memorial which you mention to have sent thro' another channel, that your ideas were not conveyed so explicitly as to enable them to decide finally on their merit, but that they had made an entry in their journals to preserve you the claim to the original idea. as far as we can conjecture it here, we imagine you make a table of Variations of the needle for all the different meridians whatever. to apply this table to use in the voyage between America & Europe, suppose the variation to increase a degree in every 160 miles. two difficulties occur. 1. a ready & accurate method of

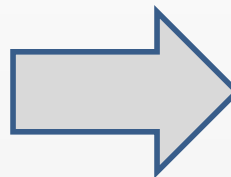
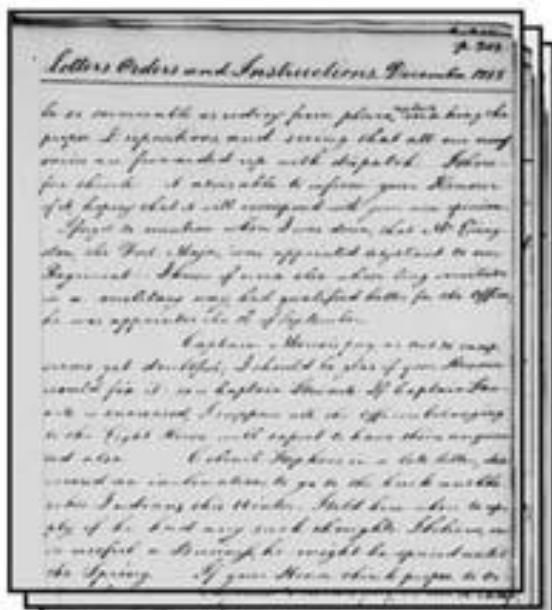


Word Spotting



Retrieval

Documents



1755: p.12, p.22, ...

...

Express: p.12, p.14, ..

...

May: p12, p.45, ..

Clustering

Labeling



Since 1958, 13 **Labour** life Peers and
 Peersesses have been created. Most **Labour**
 sentiment would still favour the abolition
 of the House of Lords, but while it remains
Labour has to have an adequate number of



Impact

Retrieval

- Imperfect Segmentation
- Multiple Writers
- Use recognition scores

$$\hat{freq}_{i,j} = \sum_{\vec{w}} P(\vec{w} | \vec{c}) \cdot \sum_{\vec{\tau}} P(\vec{\tau} | \vec{w}) \cdot \#_{t_i}(\vec{\tau})$$



B14

Lexicon	Controlled		Historical		Medical	Postal	Checks
	10K	1K	10K	1K	4K	100	40
Top 1	57	67	12	28	20	95	99
Top 10	74	75	32	72	42	99	99

CAPTCHAS , ACCENTS AND SECURITY

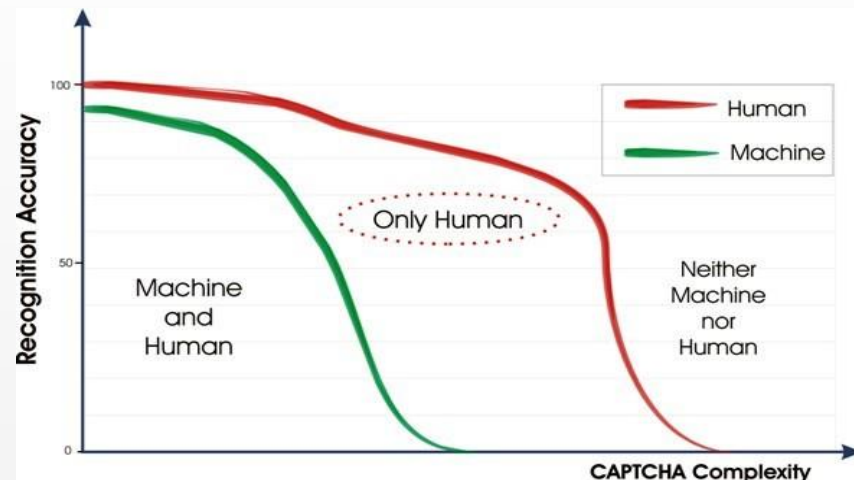
4



Security



Security



New Captchas



Security

☐ I'm not a robot



reCAPTCHA

[Privacy](#) - [Terms](#)

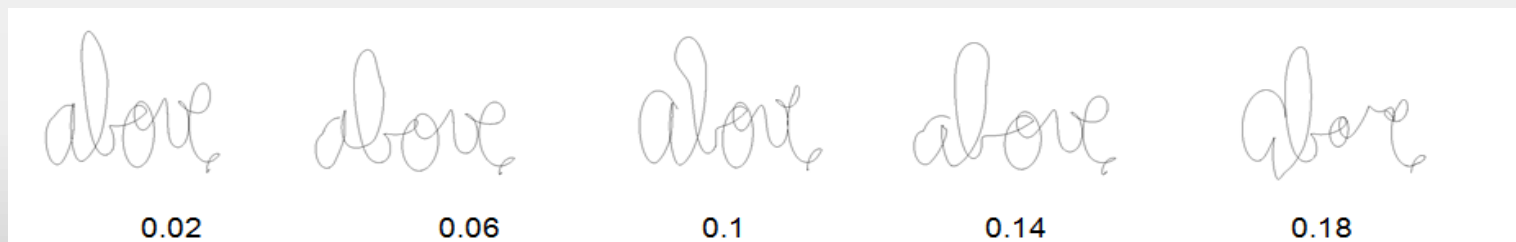
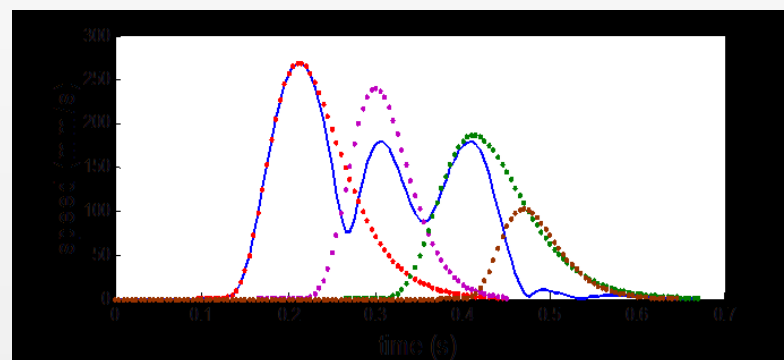
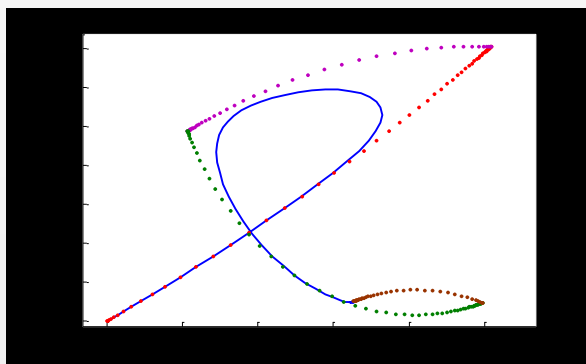
She teaches us English.
What does she teach us?



Security

Neuromotor Model

i^{th} component trajectory :
$$\varphi_i(t) = \theta_{si} + \frac{(\theta_{ei} - \theta_{si})}{D_i} \int_0^t v_{ti}(\tau) d\tau$$





Security

TM may from time to time issue a Variation Order to vary any of the Comprehensive Maintenance Services and the Contractor shall carry out such Variation, and be bound by the same conditions, insofar as they are applicable, as though the Variation is stated in the Contract. If the Variation in the opinion of the contractor will involve an addition to or deduction from the Contract sum, the Contractor shall, as soon as reasonably possible and in any event not later than fourteen (14) days from the date of the Variation Order, advise TM in writing to that effect.

Accents

The farthest distance in the world is not
between life and death but when I stand in
front of you yet don't know that I love

मेरा नाम ऋषि जैन है। मैं कक्षा दार में अध्ययनरत
एक उच्च विचारों वाला छात्र हूँ। मुझे विज्ञान और
खगोलशास्त्र पढ़ने में काफी रुचि है। मैं बड़ा होकर
अलबर्ट आइंस्टाइन की तरह मशहूर होना
चाहता हूँ। घर पर मेरी माँ मुझे कहती है, बेटा,
अथक परिश्रम का फल हमेशा मीठा होता है।
मुझे पूर्ण विश्वास है कि एक दिन मैं महान्
वैज्ञानिक बनूँगा और अपने माता-पिता का
नाम विश्वभर में रौशन करूँगा।

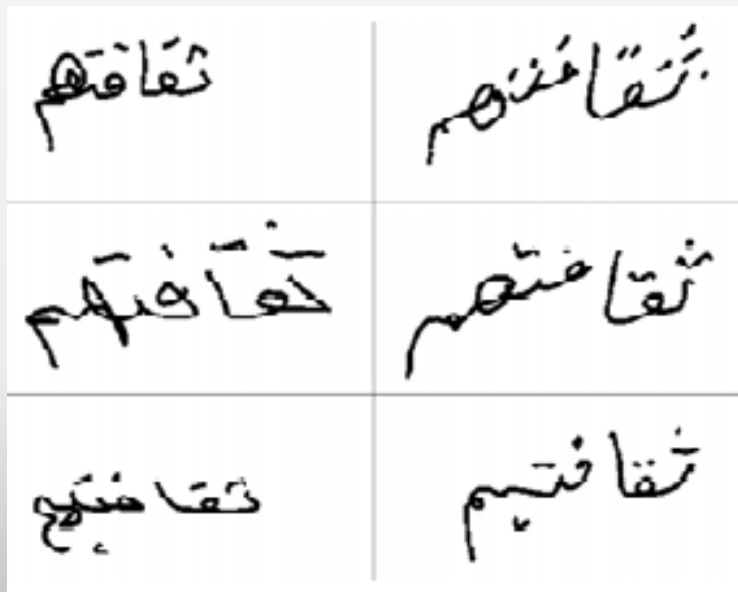
我欲醉眠芳草，
泥未解玉骢。 可怜一溪风月， 莫教踏碎琼瑶。
解鞍青枕绿杨桥， 杜宇一声春晓



Security

trape trape trape trape trape

Increasing perturbations



IMPACT

Complete the challenge:

To continue, please click on the **ORANGE SQUARE**, then the **ORANGE TRIANGLE**

About this Ad

Volkswagen Tiguan

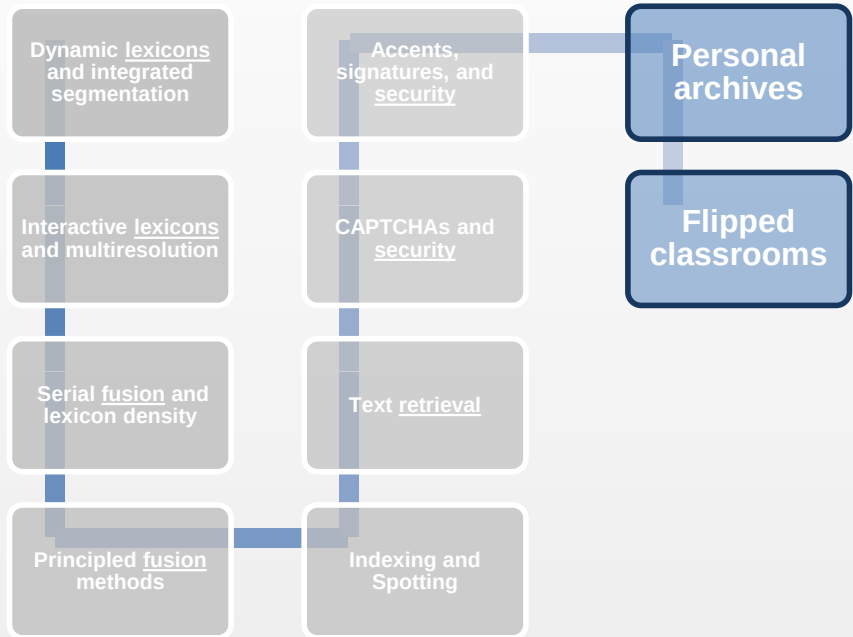
\$22,840 STARTING MSRP / **26** MPG HWY

*LEGAL

Get a Quote

Das Auto.

Navigation and control icons at the bottom of the ad interface.



[illegible]

Marianne Craig Moore was an American Modernist poet, critic, translator, and editor. Her poetry is noted for formal innovation, precise diction, irony, and wit

Marianne Moore Archive: Notebooks Projects Prototype Viewer



File Description
 Notebook 07.03.11
 Notebook Editor: Cristanne Miller

Notebook Description
 Repository: Marianne Moore Collection, Rosenbach Museum and Library, Philadelphia PA
 Dates: 1929-1940
 Note: Yearbook 1921, red leather binding. Includes 8 pages of pre-printed information of various kinds, e.g. Time Differences, Thermometers; Greatest Altitude in Each State; followed by lined calendar pages divided in half so that each leaf contains two dates. First image with MM's writing is the inside front cover. RML number written in pencil: 1250-27

Figure ☐ TextLink

07-03-11 0036-recto

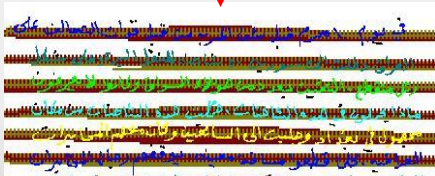
Chapter headings—
 The quiet of the written page
 Few balances no debts
 Salve next to last
 A valuable clipping The Leopard
 Crickets Chapter I . . . Critical
 Protestations of Integrity. Edinburgh Job's
 Permanent Salutation
 Beware of Pickpockets (circus)
 A Pretty Name
 Bravo, Bravado
 A good Eye
 Pleasure is less than Happiness
 It was the month of April, the Bumpkins
 call it May (Cooper)
 He who rides on a tiger can never dismount
 Billiard table green
 mites of creation—cf Baboon Man P
 Dr Popey
 forgive us for flaws
 The Baffled Rat Squeaks
 Phrases from the Bible
 No hunter is a good woodsman unless he
 knows how to prevent fire
 officially noted (Pratt Library book)n

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 The quiet of the written page
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 The one aggravation is war)
 (He who rides on a tiger can never dismount
 Dean Inge n
 Billiard table green
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 Dr Popey
 forgive us for flaws
 The Baffled Rat Squeaks
 Phrases from the Bible
 No hunter is a good woodsman unless he
 knows how to prevent fire
 officially noted (Pratt Library book)n

Multilingual MADCAT

Transform based method works
for both gray scale and binary
images

في يوم ١٠ صفر قبل سن الحشر من قبل قوات التحالف على
العراق دخلت الى سوريا ٥٠ شاهنة للقتل البري على شكل
رطل متقطع. التعتيت بعدد ص هولاو السواق وكانوا لا يعرفون
ماذا يحصلون في هذه الشاهنات. فكلت هذه الشاهنات من مكان
مجهول في بغداد وجلبت الى الساحة وكان معهم المناشير
والبنادق...



في يوم ١٠ صفر قبل سن الحشر من قبل قوات التحالف على
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مجهول في بغداد وجلبت الى الساحة وكان معهم المناشير
والبنادق...

سيرة ذاتية
اسمى عبد الله، ولدت في أبوظبي في السادس عشر من
أكتوبر عام ١٩٦٩م، لدي اهتمام كبير بعالم التقنيات
والحاسوب، وهذا موقعي الشخصي، أكتب فيه أرائي عن
مختلف القضايا ما عدا السياسة. التي ألتفتت بحكم بعض الكتابة
عنها لا خوف من شيء بل لا شيء لا أحب الحديث عن أمور
السياسة التي تلو حقائق في كل مكان، لدي اهتمام كبير بعالم
الحواسيب، وخصوصاً تطوير المواقع، البرمجة وأنظمة
التشغيل.

نقاط سريعة
لا أحب الاختلاط مع الناس كثيراً وأفضل العزلة والبقاء
وحيداً مع كتبى والحواسيب.
بعض أخطائي التي ارتكبتها في الماضي لا زالت تجعلني
أشعر بهم. بالذم والتكبر. أكره نفسي عندما أتذكرها.
كنت أذهب إلى المدرسة وأنا لا أهتم لماذا يجب علي أن
أفعل ذلك كل يوم، أدركت السبب عندما انتقلت إلى
المرحلة الإعدادية.
لا أعتقد أنني سأكره شيئاً في حياتي طالما كرهت المدارس
والانظام التعليمي.
كنت أهرب من المدرسة في المرحلة الابتدائية لأذهب إلى
البحر فقط لأأكل البجرب.
أكره التخزين بكل أنواعه، أفلام الرعب، ألعاب الفيديو
العنيفة والزحام.
لا أحب يسعدني مثل طعم كتب جديدة.
أحب القراءة كثيراً وأقرأ كل شيء تقريباً.
أهوى التصوير الفوتوغرافي مع أنني لم أمارس هذه
الهواية منذ سنوات.
أحب رياضة المشي أمارسها كل يوم تقريباً.
أحب كرة السلة. أيضاً. وإن لم أمارسها منذ وقت طويل.
شاركت عدة مقالات في صفحة رأي الناس في جريدة
الاعتدال، قبل أربع أو خمس سنوات.
أحب السفر والتعرف على البلدان، مع ذلك لم أضع إلا
فلسطين نادراً.
أصدقائي يصفوني بالبارد والعنيد، وأنا كذلك فعلاً.
أحب العثور مع الآخرين حتى لو اختلفت الآراء والأفكار.

Hand vs Machine vs Graphics

Neighboring patches likely to have the same class label

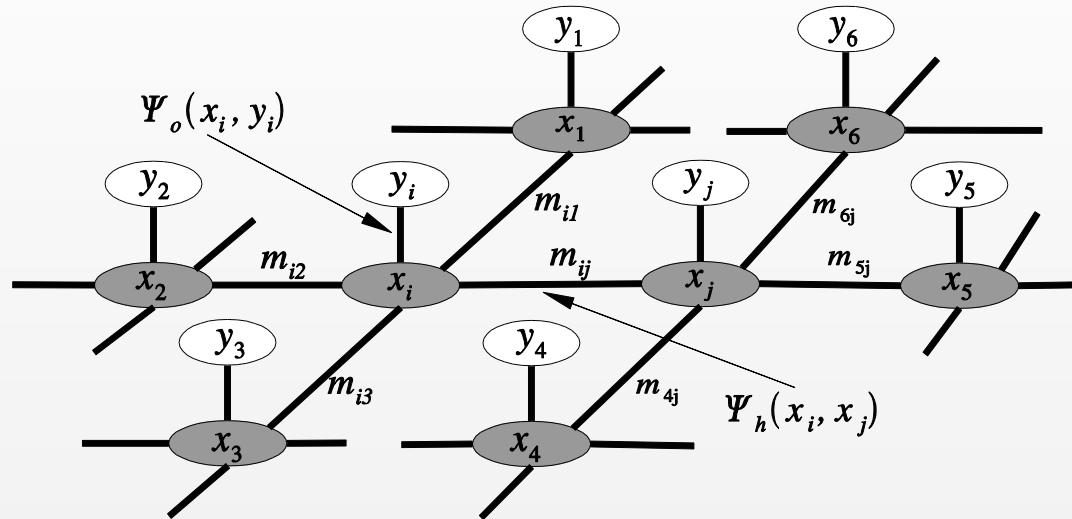
IES AROUND THE WORLD AND
 WAS **BROUGHT AGAINST** THI
 WAS ALSO **CONFIRMED** THAT
 AND **INDEED**, **JUDGE** BOGAE
 LES STATED THAT IF BARCL

Since 1958, 13 **Labour** life Peers and
 Peers have been created. Most **Labour**
 sentiment would ~~it~~ still favour the abolition
 of the House of Lords, but while it remains
Labour has to have an adequate number of

$$\prod_{(i,j)} \psi_h(x_i, x_j) \prod_i \psi_o(x_i, y_i)$$

ψ_h : Nbd similarity; ψ_o : Observ dependency

MRF



$$\psi_o(x_i, y_i) = e^{1/(\lambda D_m(x_i, y_i))}$$

D_m : Distance in Feature Space

$$\psi_h(x_i, x_j) = 1 + \alpha e^{-D_n(i, j)} + \beta e^{-D_e(x_i, x_j)}$$

Distance in Spatial Space (D_n) and Feature Space (D_e):

$$D_n(i, j) = \frac{(dx_{i,j} - \hat{x})^2}{2\hat{x}^2} + \frac{(dy_{i,j} - \hat{y})^2}{2\hat{y}^2}$$

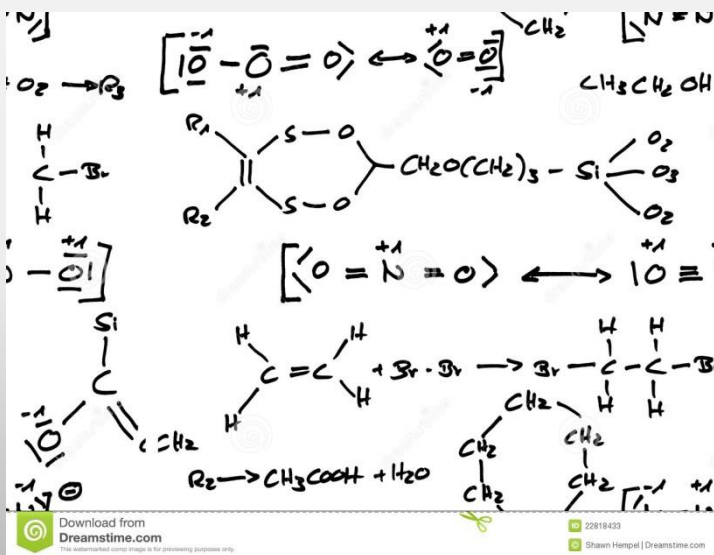
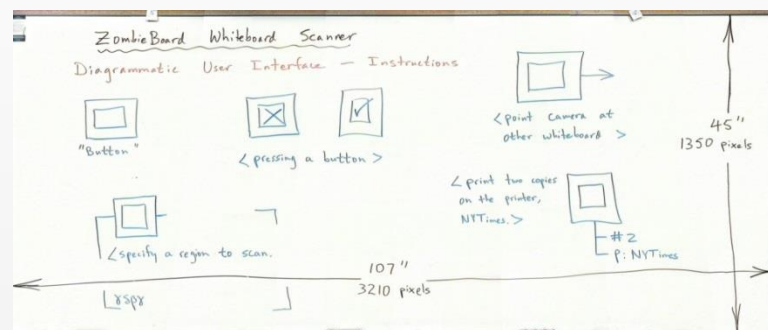
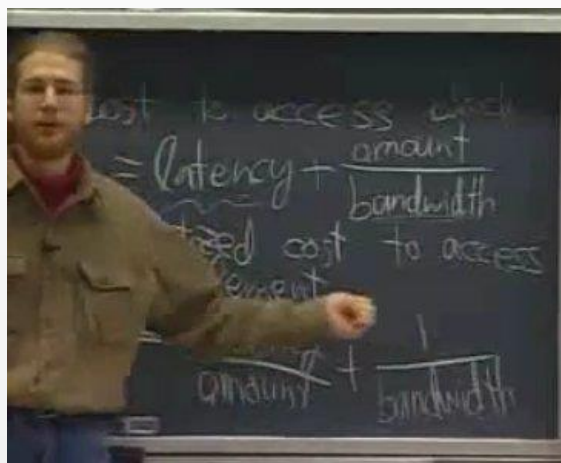
$\hat{x}$
 $\hat{y}$

: dominant gap between words

. dominant gap between lines



Flipped Class



Handwritten physics and mathematics notes:

- Top: $E(\omega T) \propto \omega \cdot \sin(\omega T)$, $I = H \left(\frac{R^2}{2}\right) + H \left(\frac{R^2}{2}\right) = \frac{MR^2}{2}$
- Left: A diagram of a circle with radius r_k and a point $\psi_{k+1} = \frac{1}{2}(\psi_{k+1} + \psi_{k+1})$
- Center: A diagram of a vector field with a central point and surrounding vectors.
- Right: A diagram of a sphere with a point $\mu_0 = \mu_0 \cos \theta$ and a point $B = \text{const } r^2$
- Bottom left: A graph of $U_{\text{ext}}(z) = \frac{q}{r} e^{-iz}$ vs z
- Bottom center: A diagram of a molecule with a central point and surrounding atoms.
- Bottom right: A diagram of a molecule with a central point and surrounding atoms.

Summary

Handwriting...

that action of emotion, of thought, and of decision that has recorded the history of mankind, revealed the genius of invention, and disclosed the inmost depths of the soulful heart. It gives ideas tangible form through written letters, pictographs, symbols and signs. Handwriting forms a bond across millennia and generations that not only ties us to the thoughts and deeds of our forebears, but also serves as an irrevocable link to our humanity. Neither machines nor technology can replace the contribution or continuing importance of this inexpensive portable skill. Necessary in every age, handwriting remains just as vital to the enduring saga of civilization as our next breath.

Michael R. Sullivan



Thank You

vena@cubs.buffalo.edu