

A PRESCIENT ABSTRACT:

In the past 30 years, various ideas have been presented for machines which could recognize spatial patterns. With the **advent of the digital computer** and its use in data processing, there has been a great increase of interest in the automatic conversion of human language to language understandable by a machine. **The translation to machine language of spatial symbols**---pattern recognition---is important to this conversion.

Papers presented at the the March 3-5, **1959**, Western Joint Computer Conference
San Francisco, California Pages: 291-294

W. H. Highleyman (*RPI 1955*), Bell Telephone Labs., Inc., Murray Hill, N.J.

L. A. Kamentsky Bell Telephone Labs., Inc., Murray Hill, N.J.



Document Systems Analysis: Testing, Testing, Testing...

A Short History of Document Test Data

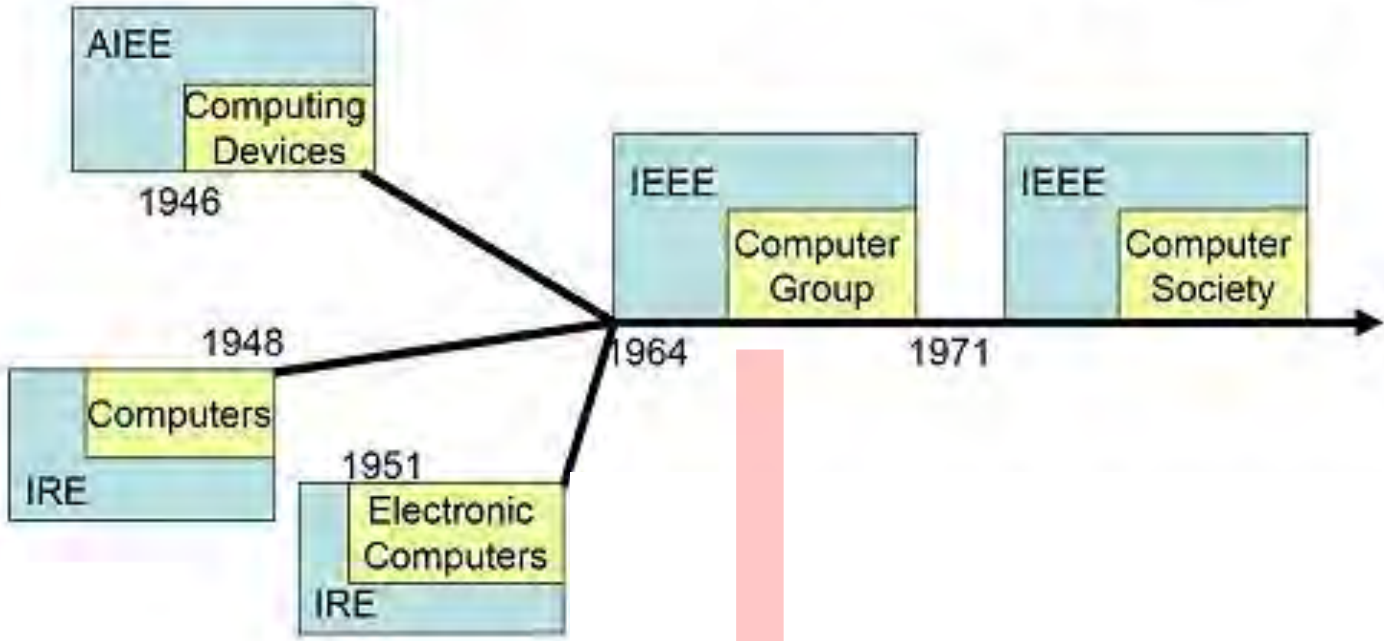
by

George Nagy

DocLab, RPI

PG-50

Organizations & Committees ~ 1967



ICPR	1973
IAPR	1978
PAMI	1979
ICDAR	1991
DAS	1994
IJDAR	1998
DocEng	2001

IEEE-CG TC on Pattern Recognition

Subcommittee on Reference Data Sets



IBM T.J. Watson Research Center 1965

Gardiner Tucker

Don Rosenheim

A. Hoagland

Don Streeter

Glenn Shelton, Jr.

George Nagy & Dick Casey

First Pattern Recognition Meeting Oct. 1966 - chaired by Al Hoagland



About a third of the presentations about das

Abend, Ball, Chow, Cover, Duda, Freeman, Groner, Hall, Julesz, Kanal, Kirch, Minsky, McCormick, Munson, Prewitt, Roberts, Papert, Rabinow, Roberts, Rosenfeld, Sammon, Specht, Stanat, Sheinberg, Sutherland, Specht, Uhr, Widrow, Zadeh... (52, 15 from U's)

COMPUTER GROUP NEWS

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS



Vol. 1 No. 4

January, 1967



A HAPPENING IN PUERTO RICO

Trends in Pattern Recognition A Report on the 1966 IEEE Pattern Recognition Workshop

by
George Nagy

IBM Watson Research Center
Yorktown Heights, New York

Who, What, When, Where

Self-Organizing, Bionic, Heuristically Programmed, Pattern Recognizing, Learning, Neuronal, Cybernetic, Goal-Seeking, Problem-Solving, Microprogrammed, Multiprogrammed, Multi-Input, Redundant, Adaptive, Self-Repairing, Self-Teaching, Time-Sharing, Self-Reproducing, Cluster-Seeking, On-Line, Trainable, Stochastic, Kilomegacycle, Optimal, Artificially Intelligent, Synnoetic Computing Machines – was one speaker's list of the key words necessary to describe the range of topics discussed at the recent "happening" (the chairman's characterization) instigated in Puerto Rico by the Pattern Recognition Subcommittee of the IEEE Computer Group.

the user to make on-the-spot corrections and to adjust style to suit the recognition logic. The one off-line project heard from relies on the context inherent in a program's language such as Fortran to keep the error rate within acceptable limits.

Further contributions in character recognition consisted new algorithms designed to improve maximum likelihood decisions based on features by taking into account the interfeature statistical dependencies and the Markovian properties of natural language.

Other applications-oriented presentations covered holographic techniques for fingerprint recognition, polynomial decision boundaries for electro-cardiograms, automated photometric chromosome analysis, adaptive networks for sonar phased antenna arrays and for aerial photoreconnaissance, a sequential decision model for blackjack, graphic input computers, the superposition of flight paths on contour maps, and the analysis of three-dimensional projections. Among these, the ECG analysis seems closest to practical applicability. Several of the other projects, notably the work on fingerprints, chromosomes, sonar, and graphic input, all make use of realistic data sets.

The outline of a general purpose pattern recognition a

IEEE Computer Group News,
pp. 16-19, January 1967

reprinted in *Spectrum*

June 9, 2010

Excerpts from DocLab Archives (1967-1974)

Minutes of the

IEEE Computer Group

Technical Committee

on Pattern Recognition (*PRC*) and its

**Subcommittee on Reference Data Sets and
Performance Evaluation Standards** (*SCDS*)

Al Hoagland, A. Hamburger, L. Kanal, A. Rosenfeld, B. McCormick, B. Widrow, New: D. Brick, C.K. Chow, H. Freeman, J. Sammon, G. Nagy (+ visitors: H. Ostreicher, M. Watanabe)

- PR Subcommittee upgraded to **full TC**
- Puerto Rico **Workshop proceedings**:
 - **Wiley** would typeset and publish for \$10 per copy
 - **Spartan** would print “as is” for \$ 5-6 per copy
 - **McGraw Hill** not interested, **Addison Wesley** maybe
 - **8000 copies of OPTICAL CHARACTER RECOGNITION (Spartan 1960) sold**
 - IEEE SMC PG-35 interested (also in taking over PG -16)
- *Pattern Recognition Society* established by R. Ledley

April 10, 1967, continued

- Participation at forthcoming meetings:
 - Washington, DC (UMD, ONR, USPS) June 1967- Rosenfeld
 - NCC Chicago September 1967 – C.K. Chow, J. Munson
 - Systems Science **Hawaii** January 1968 – **Watanabe**
 - Specifically, Nagy's controversial short paper on Unsupervised Learning, presented at the Puerto Rico workshop, should be expanded to a full paper (???)
 - IFIPS Edinburgh August 1968 – Herb Freeman
 - **IEEE G-SSC** **TC on Pattern Recognition and Learning Systems**
 - **IEEE G-AC** **TC on Adaptive and Learning Systems**
 - (MMS+SSC→SMC)

After the meeting, Al Hoagland asked me to look into reference data.

MEMORANDUM

To: A. S. Hoagland, Chairman, IEEE Pat Rec Committee
From: G. Nagy
Date: August 28, 1967
Subject: **Reference Data Sets**

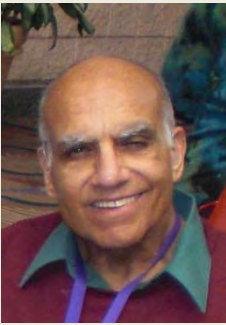
Contacted universities, OCR manufacturers, industrial and non-profit research labs, and the United States Government.

“The consensus of opinion appears to be that the establishment of reference material of this sort is long overdue.”

Alternatives:

1. Establish a small subcommittee to publish a **catalog** of data sets which may be obtained from their respective owners;
2. Co-sponsor with a **government agency** (NIST, then NBS);
3. Endorse a **non-profit research org or a consultant** to make reference data available to the public for a fee;
4. **A means within IEEE to acquire, maintain and distribute the data, in a manner similar to the Computer Group Repository, which in fact already encourages the submission of original data.**

PRC **October 13, 1967 Boston**



- Procs. of Puerto Workshop mailed to Thompson (Kanal).
- Nagy's suggestion for a **subcommittee on reference data sets** adopted. Requests to add pictorial and time-varying signals, as well as multi-dimensional feature data.
[**CK Chow, Munson (SRI), Spooner (CAL), Samson (RDC), Gibbons (PO)**].
- Duda designated Committee's Contributing Editor
 - (to *Computer Group News*).
- PRS is establishing a new journal: *Pattern Recognition*
(editors from PRC invited).
- Explore cooperation in IP with Optical Society of America.
- Delft PR workshop in August 1968 (Verhagen).
- Pisa two-week summer school in September 1968 (Grasselli).
- San Francisco SSC Conf in October 1968.

SCDS March 21, 1968 NYC

- C.K. Chow received enthusiastic IEEE endorsement and offer to cooperate.
- Harry Huskey will accept data tapes as items of his (PGEC) repository:
IEEE Test Data Sets in *Computer Group News*, March 1968, p. 28.
- Harburgen obtained legal advice: IEEE should copyright data, identifying and giving full credit to source. IEEE cannot restrict use of data to researchers.
- **MP:** Spooner has found several MP sources. **REI** has large data base, but reluctant to release it except to researchers. C.K. Chow said **IBM** may release 10,000 chars of MP. **CAL** has 40,000 alphanumeric chars in 24x24 binary form with 64 levels. Expect soon to have 150,000 chars including IBM Executive and Remington Rand Elite.
- **HP:** **Highleyman; Knoll; Munson**
- **Cursive:** **Harmon, Murray Eden, Gibbons**
- **Speech ; EKG, EEG, EMG; Seismic; Radar/Sonar; Fingerprints; X-Rays; Bubble Chamber, Microscope, Aerial, Celestral Photos; Maps; Line Dwgs (none!); Property lists (Medical diagnostics, Taxonomy);**

W.H. Highleyman

- **203 copies of Pattern Recognition sold!**
- Should IEEE repository handle data set distribution (efficiency and cost)?
- No formal efforts will be made to create an umbrella organization to coordinate pattern recognition activities among IEEE committees and other groups
(*the autonomy of the Computer Group with the IEEE is now under discussion.*)
- Delft Workshop report by Chandrasekaran, Kanal and Nagy published by the IEEE.
- **Hoagland thanked and sent up, Chow welcomed as TC chair.**
- Workshop in Honolulu proposed.

SCDS - May 15, 1969

The problem of verifying the description of data on magnetic tape was seen to be a formidable one because of incompatibilities among different computer systems.

Hamburgen will check IEEE Computer Center facilities.

- Four documented data sets submitted to IEEE HQ.
Requires IEEE ADCOM and Tech Ad Board approval:
Chow wrote to McCluskey
- **Twelve facilitators plus two international coordinators appointed for data bases**
- Subcommittee renamed: *Reference Data Bases and Evaluation Procedures*
- Hawaii workshop with SMC should have **no session on OCR** or statistical techniques, **sessions should not be organized by subject**, and most sessions should be devoted to future methods of pattern recognition. (**Objection**: this leaves out most engineers who work in pattern recognition)

PRC **November 18, 1970** Houston

- Spooner to chair SCRD
- **Hamburgen will organize a subcommittee on character recognition**
- Still 672 copies left of Pattern Recognition!
- Still looking for a Service Bureau to copy tapes
- Preparations for 1972 Workshop on PR in Hot Springs (Ed Parrish)

SCDS **May 20, 1971** Atlantic City

1. Data Sets sent from IEEE HQ to Computer Society two months ago, but have not yet arrived
5. Should advertise in *IEEE Spectrum*
6. Publish names of data set users
7. Rabinow to be asked to obtain a set of alphanumeric characters that have been systematically degraded
9. **“It was first agreed that the first order of business was to get the data sets in hand and advertise in Computer so that we can point to a significant milestone in the Committee’s accomplishments.”**

PRC **November 17, 1971** Las Vegas

- Five data sets are ready and will be advertised in the January-February 1972 Issue of *Computer* magazine.
- Production cost estimated at \$100.
- PRC should consider expanding its scope to *image processing* and *artificial intelligence*.
- Al Klinger requested to prepare a Glossary of Pattern Recognition.

Data Sets advertised in IEEE Computer

January 1972 (6 data sets)

January 1973



PATTERN RECOGNITION DATA BASES AVAILABLE

In order to encourage research in the field of pattern recognition, the IEEE Computer Society's Technical Committee on Pattern Recognition has begun collecting data bases from a variety of sources. These data bases, including substantial back-up documentation, may be ordered by using the form at the bottom of the page.

Discounts off the data base list prices are available to IEEE members and members of the American Federation of Information Processing Societies' constituent societies.

When ordering, you may elect to send us your own blank tapes; if you do, be sure they are in good condition and have no other data recorded on them.

1.1.1 Machine Imprinted Alphanumeric Characters – Dr. H. F. Ryan, Cornell Aeronautical Laboratory, Inc./U.S. Postal Service

An alphanumeric character data base of 100,000 samples of 66 character classes. (Also known as the CAL-U.S. Postal Service Alphanumeric Character Data Base.) Thresholded binary images of segmented, centered, mixed-font, machine-imprinted characters. Resolution is 24 x 24. Magnetic tape, 9 track, 2 reels, 1600 BPI.

Price: \$112.50 (\$68.75 with furnished tapes)
Member's discount price: \$90, (\$55, with furnished tapes)

1.2.1 Handprinted Numeric Characters – Dr. A. L. Knoll, Honeywell Information Systems, Data Systems Division

The data base consists of 50 samples of each numeric character generated by 9 different authors. Simple printing rules were specified but not always followed. The samples were selected from those contributed. The images are binary with a resolution of 25 x 21. Punched cards.

Price: \$37.50
Member's discount price: \$30.

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but not always followed. The samples were selected from those contributed. The images are binary with a resolution of 25 x 21. Punched cards.

Price: \$41.25
Member's discount price: \$33.

1.2.2 Handprinted FORTRAN Alphanumeric Characters – Dr. John H. Munson, Stanford Research Institute

The data base consists of two parts, with each part on a reel. The first part contains 3 alphabets of 46 characters, corresponding to the non-blank character set of the basic FORTRAN language, hand-printed by each of 49 authors making a total of 3 x 46 x 49 = 6,762 patterns.

The second part has 2,999 characters printed by a single author. There are 920 characters made up of 20 alphabets of 46 characters each; the remaining 2,079 characters are taken from fragments of actual coding sheets. The images are binary with a 24 x 24 resolution. Magnetic tape, 7 track, 2 reels, 556 BPI.

Price: \$116.75 (\$75.75 with furnished tapes)

alphanumeric characters. The images are binary with a resolution of 12 x 12. Punched cards.

Price: \$55.
Member's discount price: \$44.

1.2.4 Handprinted Numeric Characters – Hiroshi Genchi, Tokyo Shibaura Electric Co., Ltd./Toshiba Research and Development Center

The data base consists of 10,000 hand written numeric characters collected from live as well as experimental mail throughout Japan. The data base is contained on two magnetic tapes with each tape having 5,000 characters. Images are binary with a resolution of 36 x 50. A single pattern consists of 56 words. Magnetic tape, 7 track, 2 reels, 556 BPI, 6 bits per character.

Price: \$115.25 (\$68.75 with furnished tapes)
Member's discount price: \$93. (\$55, with furnished tapes)

1.3.1 Cursive Script – Dr. L. D. Harmon, Bell Telephone Laboratories

Pattern Recognition DATA BASES

1.1.1 Machine Imprinted Alphanumeric Characters – Dr. H. F. Ryan, Calspan Corp./U.S. Postal Service

An alphanumeric character data base (normalized version) of 100,000 samples of 66 character classes. (Also known as the CAL-U.S. Postal Service Alphanumeric Character Data Base.) Thresholded binary images of segmented centered mixed-font, machine-imprinted characters. Resolution is 24 x 24. Magnetic tape, 9 track, 2 reels, 1600 BPI.

Price: \$123.75 (\$75.50 with furnished tapes)
Member's discount price: \$99 (\$60 with furnished tapes)

1.1.1A Machine Imprinted Alphanumeric Characters – Dr. H. F. Ryan, Calspan Corp./U.S. Postal Service

In order to encourage research in the field of pattern recognition, the IEEE Computer Society's Technical Committee on Machine Pattern Analysis has begun collecting data bases from a variety of sources. These data bases, including substantial back-up documentation, may be ordered by using the form at the back of the issue.

Discounts off the data base list prices are available to IEEE members and members of the American Federation of Information Processing Societies' constituent societies.

When ordering, you may elect to send us your own blank tapes; if you do, be sure they are in good condition and have no other data recorded on them.

If you have a data base that you wish to contribute to the Technical Committee on



To order: Use the multipurpose order form at the back of the issue.

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Announcement

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When ordering, you may elect to send us your own blank tapes; if you do, be sure they are in good condition and have no other data recorded on them.

If you have a data base that you wish to contribute to the Technical Committee on Machine Pattern Analysis, please contact Dr. J. B. McFerran, Sperry-Univac, P. . Box 3525, St. Paul, Minnesota 55165.

PRC **June 17, 1972** Atlantic City

- **20 Data Sets purchased!**
- Ed Parrish to chair SCDS
- 41 @ Hot Spring PR Workshop. Income – Expenses = \$705.92.
- S. Yau: Expand scope of PRC and change name, or form another committee :

Pattern Recognition

Complex Information Processing

Pattern Recognition and Machine Intelligence

Heuristic Problems

Pattern Recognition and Artificial Intelligence

Cognitive Technology

Models of Cognition (or Intelligence)

Artificial Intelligence

Machine Pattern Analysis`

SCDS

Suggestion: find a “willing expert “ to verify data sets.

McFerran explained Univac’s computer-generated character data bases.

PRC **Jan 4, 1973** Disneyland

> 100 attendees at 2-DSP Conf at U. Missouri in August 1972

37 Data Sets purchased!

Machine imprinted alphanumeric characters 1.1.1	7
Handprinted numeric characters 1.2.1	7
Handprinted FORTRAN alphanumeric characters 1.2.2	10
Handprinted alphanumeric characters 1.2.3	7
Handprinted numeric characters 1.2.4	3
Cursive script 1.3.1	<u>3</u>
	37

PRC **June 7, 1973** NYC

60 Data Sets purchased!

Will be advertised regularly in *Computer*

Should software (programs) be added?

PRC **February 26, 1974** San Francisco

Lengthy discussion of **acceptability of artificially generated data.**

Collaborate with ACM SIGART?

PRC **May 7, 1974** Palmer House

Task force on publishing mechanisms in PR-oriented journals

PRC **Sept 11, 1974** Mayflower

Copenhagen

IJCPR June 1974 : 400 attendees

Silver Spring

IPR Workshop November 1974

Asilomar

PR Workshop March 1975

El Coronado San Diego

ICPR Fall 1976

First Machine Pattern Analysis TC Newsletter October 1974

1974 PRC

Agrawala, Brick, Butler, Butterfield, Chien, Chow,
Deutsch, Fischler, Frank, Freeman, Fukunaga,
Gibbons, Hamburgers, Harlow, Hoagland, Kanal,
Klinger, Lainiotis, Lambert, Lederer, McFerran,
Mathur, Meisel, Nadler, Nagy, Parrish, Patrick,
Robinson, Rosenfeld, Samit, Sammon, Shapiro,
Sklansky, Spooner, Stoffel, Swonger, Watanabe,
Weinstein, Wilson, Widrow, Yau

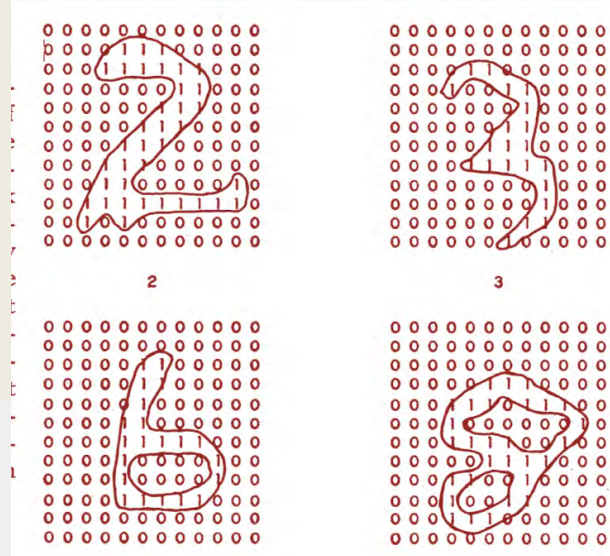
Most often used dataset ever (50 alphabets)

1.2.3 Handprinted Alphanumeric Characters – Dr. W. H. Highleyman, Sombers Associates.

There are approximately 2300 samples of alphanumeric characters. The images are binary with a resolution of 12 x 12. Punched cards.

Price: \$55

Member's discount price: \$44



Data for Character Recognition Studies*

A few years ago during my initial work in the problem of pattern and character recognition, I reduced several samples of hand printing and machine printing to matrix form. I later used this data to obtain experimental results which appeared in two papers.^{1,2} My intent in reducing this data

* Received February 7, 1963.

¹ W. H. Highleyman, "An analog method for character recognition," IRE TRANS. ON ELECTRONIC COMPUTERS, vol. EC-10, pp. 502-512; September, 1961.

² W. H. Highleyman, "Linear decision functions, with application to pattern recognition," PROC. IRE, vol. 50, pp. 1501-1514; June, 1962.

over 50 requests by August 1967

IEEE Computer, April 1976, p. 83

SRI

1.2.2 Handprinted FORTRAN Alphanumeric Characters

Dr. John H. **Munson**, Stanford Research Institute

The data base consists of two parts, with each part on a reel. The first part contains **3 alphabets of 46 characters**, corresponding to the non-blank character set of the basic FORTRAN language, hand-printed by each of **49 authors** making a total of **$3 \times 46 \times 49 = 6,762$ patterns**.

The second part has 2,999 characters printed by a single author. There are 920 characters made up of 20 alphabets of 46 characters each; the remaining 2,079 characters are taken from fragments of **actual coding sheets**. The images are binary with a **24×24** resolution. Magnetic tape, 7 track, 2 reels, 556 BPI.

Price: \$116.75 (\$75.75 with furnished tapes)

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Fig. 14. Handprinted characters on FORTRAN coding sheet. An augmented FORTRAN alphabet is shown by each of twelve different writers. The range of variation is considerable even though the writers were in no particular hurry. These data were collected at the Stanford Research Institute under sponsorship of the U. S. Army Electronics Command.

COLS. 11-20
A,B,C,D,E
F,G,H,I
J,K,L,M,N
O,P,Q,R,S,T
U,V,W,X,Y,Z
[,=,*,/,-,+,-,.,\$,]
A,B,C,D,E
F,G,H,I
J,K,L,M,N
O,P,Q,R,S,T

U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(a)

U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(b)

COLS. 1-10	COLS. 11-20
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(c)

COLS. 1-10	COLS. 11-20
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(d)

COLS. 1-10	COLS. 11-20
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(e)

COLS. 1-10	COLS. 11-20
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]
1,2,3,4,5,6,7,8,9,0	A,B,C,D,E
F,G,H,I,J,K,L,M,N,O,P	Q,R,S,T
U,V,W,X,Y,Z	[,=,*,/,-,+,-,.,\$,]

(f)

Post Office

1.1.2 Machine Imprinted Multilevel Characters

- James S. **Gibbons**, Electronic Sciences Division, U.S. Postal Service.

An alphanumeric character data base of **32,000 (16 level) multi-level characters, extracted from 2100 test mail pieces** each in a **24 x 24** array covering an area of 0.144 x 0.144 square inches. Complete information as to upper/lower case, font style, percent reflectance, color print and background accompanies each character on magnetic tape. Suitable for machine independent research as well as OCR testing. Magnetic tape, 4 reels test characters, 1 reel set up characters, 9 track, 800 BPI.

Price: **\$262.50** (\$150.00 with furnished tapes)

Member's discount price: \$210.00 (\$120.00 with furnished tapes)

Honeywell

1.2.1 Handprinted Numeric Characters -

Dr. A. L. **Knoll**, Honeywell Information

Systems, Data Systems Division

The data base consists of **50 samples of each numeric character generated by 9 different authors**. Simple printing rules were specified but not always followed. The samples were selected from those contributed. The images are binary with a resolution of **25 x 21**. Punched cards.

Price: **\$41.25**

Member's discount price: \$33

Toshiba

1.2.4 Handprinted Numeric Characters - Hiroshi **Genchi**, Tokyo Shibaura Electric Co., Ltd./Toshiba Research and Development Center

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Member's discount price: \$93 (\$55 with furnished tapes)

Bell Labs

1.3.1 Cursive Script - Dr. L. D. **Harmon**, Bell Telephone Laboratories

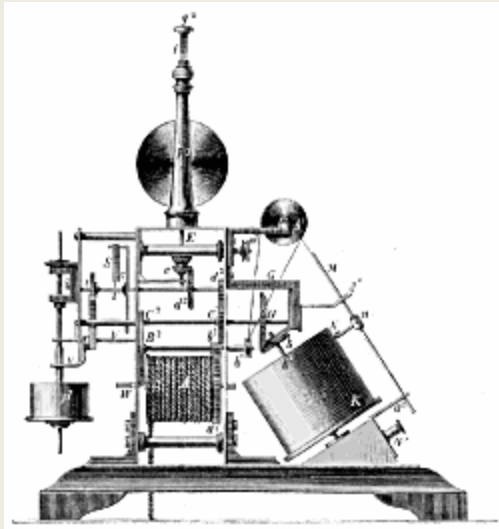
The data consists of **52 cursive script sentences**. The resolution for each sentence is 256 (vertically) x 2048 (horizontally). The images are binary. Magnetic tape, 7 track, 1 reel, 200 BPI.

Price: \$60.50 (\$42.25 with furnished tapes)
Member's discount price: \$50 (\$33 with furnished tape)

To order: Use the multipurpose order form at the back of the issue.

OCR infrastructure: Scanners

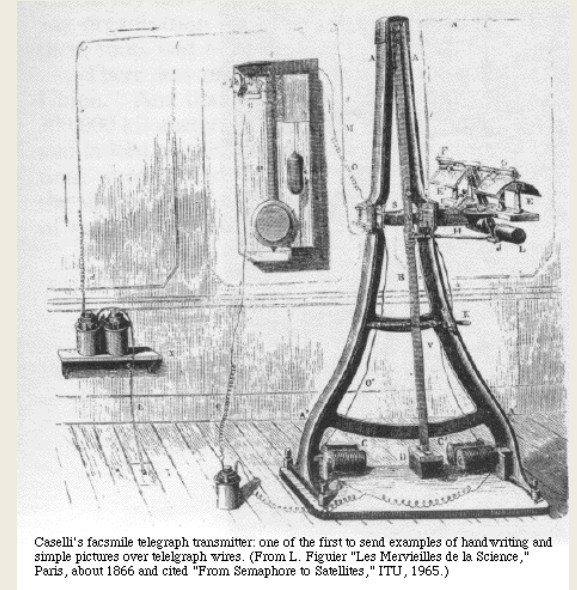
Drum scanners
for telegraphy



Bain 1841

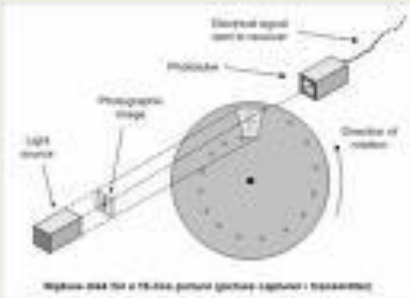


Bakewell 1847



Caselli's facsimile telegraph transmitter: one of the first to send examples of hand writing and simple pictures over telegraph wires. (From L. Figuer "Les Merveilles de la Science," Paris, about 1866 and cited "From Semaphore to Satellites," ITU, 1965.)

Caselli 1861



Nipkow disk
June 9, 2010



Rotating mirror
DAS 2010 (GN)



CRT

OCR GENEALOGY <1960

GUSTAV TAUSEK PATENT 1929

(MECH. TEMPLATES + PHOTODETECTOR)

DAVID SHEPARD 1951

INTELLIGENT MACHINES RESEARCH

READERS DIGEST, STANDARD OIL 1955

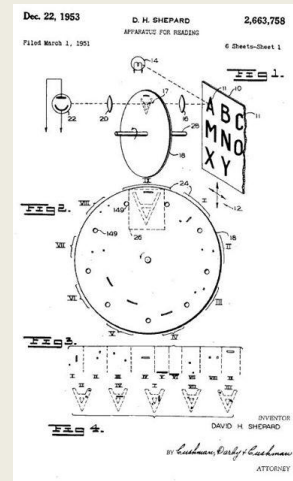
IMR → FARRINGTON → COGNITRONICS

JACOB RABINOW 1952

NATIONAL BUREAU OF STANDARDS 1952

US & CANADA POST 1953

US AIR FORCE (BORROUGHS) 1959



OCR Geneology contrinued

1960 Farrington Philco-Ford NDP Sperry Univac

1962 Rabinow Engineering *HP* → Control Data

> **1960** Fujitsu Hitachi NCR IBM RCA GE Solatron Scan-Data
REI ... > *50 OCR companies in the United States*)

(40 docs & 10,000 chars per second, \$,\$\$\$,\$\$\$)

> **1980** Kurzweil → Xerox → Scansoft → Nuance
↑
Palantir → Calera → Caere ← Recognita

THOCR Expervision Fuji Sanyo RAF IRIS ABBYY...

> **2000** HP → Tesseract → OCRopus GOCR (GNU)

1962 Ray Bonner: A “Logical Pattern” Recognition Program

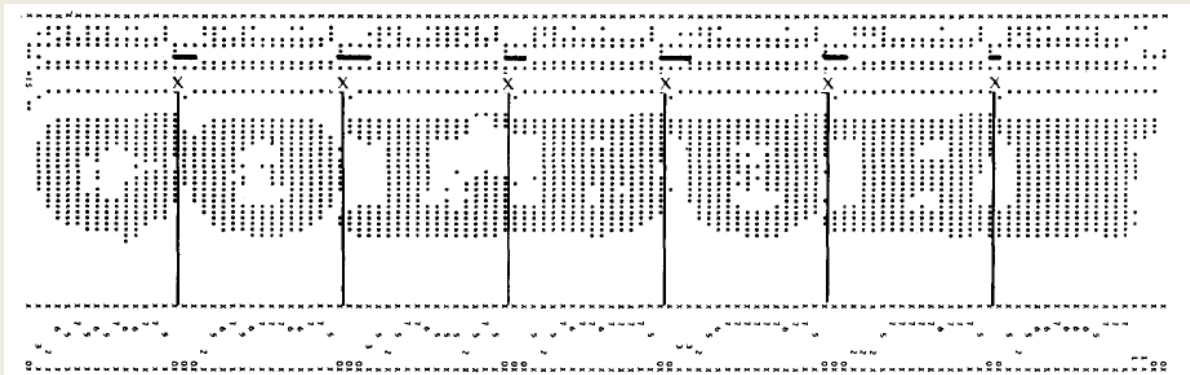
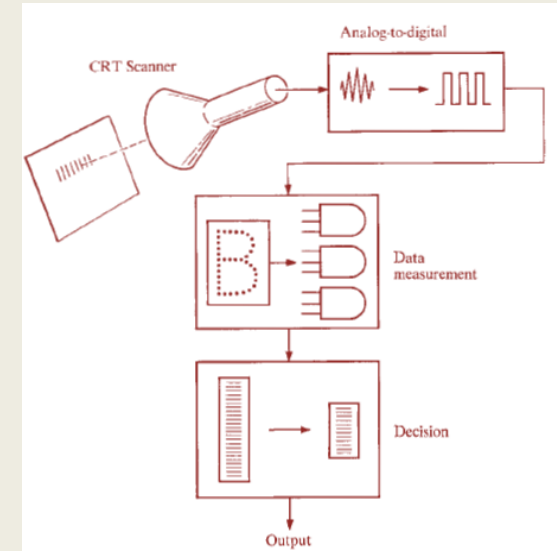


27,519 *unique* 7x10 bitmaps
culled from **1,000,000** samples

2 substitution errors and 14 rejects

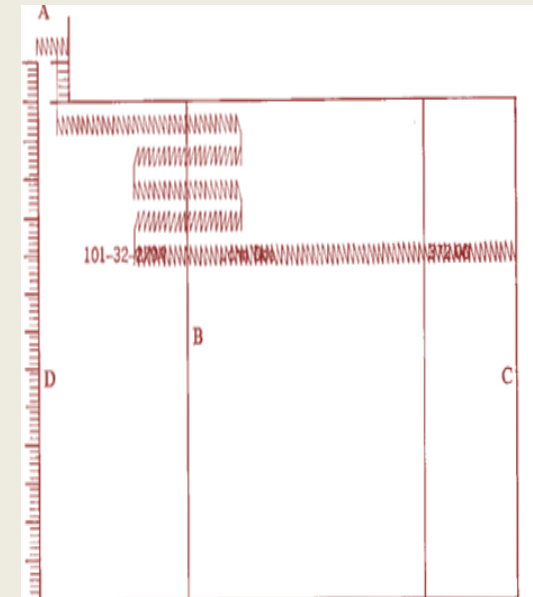
1966: IBM-1975 Social Security Page Reader

- 500 lines per minute ; 200 fonts
- Last Quarter, 1965:
1,300,000 pages = 33 million lines
- 16 million lines recognized
- 4 million lines with one or more rejects
- 12 million lines on rejected pages
- OCR confusion probabilities +
SSA master file of 150 million names
(one million distinct names with frequencies)
(no cross-checking between names and SSN's)



June 9, 2010

DAS 2010 (GN)





1	2	3	4	5	6	7	8	9	10	11	12	13
2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9	9
0	0	0	0	0	0	0	0	0	0	0	0	0

FORM 941a (Rev. 01-1984)
U.S. Treasury Department
Internal Revenue Service

CONTINUATION SHEET FOR SCHEDULE A OF FORMS 941, 941-M, 941SS, OF 942
REPORT OF WAGES TAXABLE UNDER THE FEDERAL INSURANCE CONTRIBUTIONS ACT

Employer's Name: **Smith Industries, Inc.**
Address: **19 West Cedar Place
Rochester, Minnesota**
Employer's Identification Number: **32-4234567**

Pay Period: **3-31-68** Page: **3**

Read INSTRUCTIONS CAREFULLY

EMPLOYEE'S SOCIAL SECURITY NUMBER (or other number used for reporting)	NAME OF EMPLOYEE (Last, first, middle initial)	WAGES PAID TO EMPLOYEE (Include cash bonus)	TOTAL WAGES TO EMPLOYEE FOR YEAR (Include cash bonus)
156 89 3061	Mable Day	900.00	
860 91 2101	Henry Long	45.50	
985 10 3060	John Doe	4.95	
110 00 4782	Pete Oak	372.90	
589 30 2875	Jo Ellen Sand	650.00	
789 29 6689	Chad Wood	90.35	
109 45 8324	Aden Harmes	970.39	
489 32 5031	Ethel Wilson	74.45	
001 78 2543	Ardenn Nelson	4.50	
992 64 3065	Irving Jones	68.00	
821 75 2153	Georgie Swanson	735.80	
287 91 5342	Bonnie Short	45.00	
340 12 4878	Alvin Evans	725.00	
478 38 7838	Carl Hanson	529.65	
240 42 1379	Herman Tree	370.73	
388 94 1201	Mike Cane	2.50	
776 31 6493	John Parken	673.00	
942 21 7833	Tom Hermans	74.00	
229 33 4321	Eugene Togood	829.77	
895 42 1872	Hilma Paul	59.63	
630 11 3582	Ardella Hermans	730.60	
524 73 7532	Greta Olson	89.05	
774 28 4235	Betty Head	112.50	
436 28 2743	Pat Mousebluff	832.75	
357 89 0367	Sharon Ness	643.25	
TOTALS FOR THIS PAGE—Taxable wages and number of employees . . . \$		10,232.46	

NUMBER OF EMPLOYEES:

FEDERAL COPY

PATTERN ANALYSIS AND MACHINE INTELLIGENCE

JANUARY 1979

VOLUME PAMI-1

NUMBER 1

A PUBLICATION OF THE IEEE COMPUTER SOCIETY



Reference data sets
in the modern era



FOREWORD *T. Y. Feng* 1

PAPERS

A Hierarchical Syntactic Shape Analyzer	<i>T. Pavlidis and F. Ali</i>	2
Decomposition of Two-Dimensional Shapes by Graph-Theoretic Clustering	<i>L. G. Shapiro and R. M. Haralick</i>	10
A Description Method of Handprinted Chinese Characters	<i>T. Agui and H. Nagahashi</i>	20
An Intrinsic Dimensionality Estimator from Near-Neighbor Information	<i>K. Pettis, T. Bailey, A. K. Jain, and R. Dubes</i>	25
An Optimal Frequency Domain Filter for Edge Detection in Digital Pictures	<i>K. S. Shanmugam, F. M. Dickey, and J. A. Green</i>	37
Organization and Access of Image Data by Areas	<i>A. Klinger and M. L. Rhodes</i>	50
Shape Matching Using Relaxation Techniques	<i>L. S. Davis</i>	60

Computer Recognition and Human Production of Handwriting
Eds. R. Plamondon, C. Y. Suen & M. L. Simner
© World Scientific Publ. Co., 1989, pp. 131–148

ETL-8 **1979**
~150,000 kyoiku-
kanji characters.

HANDPRINTED CHINESE CHARACTER DATABASE

KAZUO TORAICHI and RYOICHI MORI

Institute of Information Sciences and Electronics, University of Tsukuba, 305 Japan

IWAO SEKITA

Doctoral Program in Engineering, University of Tsukuba, 305 Japan


KAZUHIKO YAMAMOTO and HIROMITSU YAMADA

Information Sciences Division, Electrotechnical Laboratory, 305 Japan

In order to develop and evaluate recognition methods, a common character database is necessary. The authors collected a database of handprinted Chinese characters on a magnetic tape. The database consists of 48,000 characters (4,000 categories \times 12 sets). Each character is quantized to 1 bit and is sampled as 64 (horizontal) \times 63 (vertical) frames. In this paper, the database is introduced and its fundamental topological features are evaluated. In particular, the number of connected components and that of holes are compared with features obtained from the handprinted Japanese Educational *Kanji* character database (ETL-8).

1. INTRODUCTION

Fin-de-siècle sources of western test data

NBS-NIST	1975 -	300K HP alphanumeric 91K phrases of real census data
CENPARMI	1981 -	100K HP 64x32 alphanumeric
ISRI	1993 - 96	Zoned page images
	1992 -	<i>On-line</i> cursive words
CEDAR	1994 -	15K HW “words” from mail
UW I,II,III	1992 - 95	Zoned page images + Synthetics + Graphics
IAM	1999 -	HW sentences

cf. Guyon, Haralick, Hull, Phillips,
Data Sets for OCR and Document Image Understanding Research,
Chapter 30, Handbook of Character Recognition and Image Analysis, Bunke & Wang,
1997

1996

List of Available ISRI Test Datasets (Nartker, Rice, and Lumos *SPIE/IS&T* 2005)

Ground-truth Test Datasets		Number of		Image Resolution						Used in Annual Test
Sample Name	Description	Pages	Characters	200 dpi bin	300 dpi bin	400 dpi bin	300 dpi grey	Fine-mode Fax	Std-mode Fax	
Sample 2	DOE Sample 2	460	817,946		x					1993 & 94
Sample M	Magazine Sample	200	666,134	x	x	x	x			1994 & 95
Sample N	Newspaper Sample	200	492,080	x	x	x	x			1995
Sample B	Business Letter Sample	200	319,756	x	x	x	x	x	x	1995 & 96
Sample L	Legal Document Sample	300	372,098	x	x	x	x	x	x	1996
Sample S	Spanish Newspaper Sample	144	348,091	x	x	x	x			1995 & 96
Sample 3	DOE Sample 3	785	1,463,512	x	x	x	x			1995 & 96
Sample R	Annual Report Sample	300	892,266	x	x	x	x			1996
Sample Z	Magazine Sample 2	300	1,244,171	x	x	x	x			1996
Totals		2889	6,616,054							

NIST OCR DATABASES

NIST Scoring Package

NIST Structured Forms Reference Set of Binary Images

NIST Structured Forms Reference Set of Binary Images II

NIST Machine-Print Database of Gray Scale and Binary Images

NIST Miniform Training Database

NIST Miniform Training Database II

NIST Miniform Test Database

NIST Handprinted Forms and Characters

NIST Scientific and Technical Document

NIST Federal Register Document Image Database

Metadata/Text Retrieval Conference 1997 (METTREC)

A **new project at NIST** (cosponsored by DOD) intended to bring developers of Optical Character Recognition (**OCR**) and Information Retrieval (**IR**) technologies together to study and evaluate the automated production and usability of **large-scale, on-line collections of digital documents**.

1. How should these collections be **constructed in an automated way** using OCR technology?
2. What impact do **OCR errors** have on the accuracy of IR?
3. What types of information should be provided from OCR processing (**in addition to text**) that will facilitate and enhance IR?
4. What types of data (in addition to text) should be **indexed** and retrieved to improve the usability of these collections?
5. What types of "real-world" **OCR/IR integrated applications** can be solved today, solved next year, solved in five years?

To be based on 68,000 scanned pages of a year's worth of the Federal Register plus GPO typesetting files (SGML)

What is METADATA?

Foil 3 Mike Garris 1997

- o Non-text elements (physical or logical) of a document
Fonts, page layout, equations, figures, tables, document type, language, title, author, dates, ...
- o Metadata may be used to construct queries and/or it may be part of the information retrieved.
- o Working definition of metadata will be developed by the planning committee.

PROPOSED SIZE OF DATA SETS

Training Set: 2,000 FR94 page images
2,000 FR94 ground truth files
100 of the 2,000 designated for evaluation
5 known-item queries

Testing Set: 10,000 FR94 page images
10,000 FR94 ground truth files (**IR participants only**)
100 known-item queries

REASONS FOR CLOSING DOWN THE METTREC PROJECT

RECOGNIZING AND USING METADATA

Our primary interest in METTREC has been to pursue the use of automatically recognized metadata and measure its impact on information retrieval.

Based on our experience over the passed year, we have observed:

- a.) **An organized "OCR research community" no longer exists.** There only remains a small number of commercial vendors competing in a "shrinking" market.
- b.) **Very little research** has been developed into technology tools for automatically detecting metadata in legacy paper documents that can be used for IR.

- c.) There is **little motivation for OCR participation.**
- d.) **No one in the IR community is actively researching** the use of metadata. It is acknowledged that metadata is interesting and might be useful, but no one is actually trying to exploit it.

Conclusion: Metadata cannot be readily detected with existing OCR technology, and the IR community is not prepared to address the use of metadata. Therefore, an OCR/IR metadata evaluation conference is not practical.

1998



METTREC resurrected: NIST Special Database 25

Volume 1

Federal Register Document Image Database

....roughly 250 issues, comprised of nearly 69,000 pages, published in the Federal Register in 1994.

....The database includes scanned images, SGML-tagged ground truth text, commercial OCR results, and image quality assessment results.This volume of the database contains

4711 page images scanned binary

at 15.75 pixels per millimeter (**400 pixels per inch**). Cost of the database: \$210.00

Standard Reference Data

National Institute of Standards and Technology

100 Bureau Dr., STOP 2310, Gaithersburg, MD 20899-2310

CASIA Database (~1990)

Chinese Academy of Science Institute of Automation

3,755 level-1 set of GB2312-80, 300 writers = **1,126,500**

Cheng-Lin Liu:

High Accuracy Handwritten Chinese Character Recognition Using Quadratic Classifiers with Discriminative Feature Extraction. ICPR (2) **2006**: 942-945

HCL2000 Database

3,755 level-1 set of GB2312-80, 1000 writers = **3,755,000**

H. Zhang, J. Guo, G. Chen, C Li:

A Large-scale Handwritten Chinese Character Data base for Handwritten Character Recognition, ICDAR 2009

TUAT HANDS on-line Databases

~ **3,000,000** patterns in ~4000 Kanji + Symbol categories

S. Jaeger, K. Nakashima, ICDAR 2001

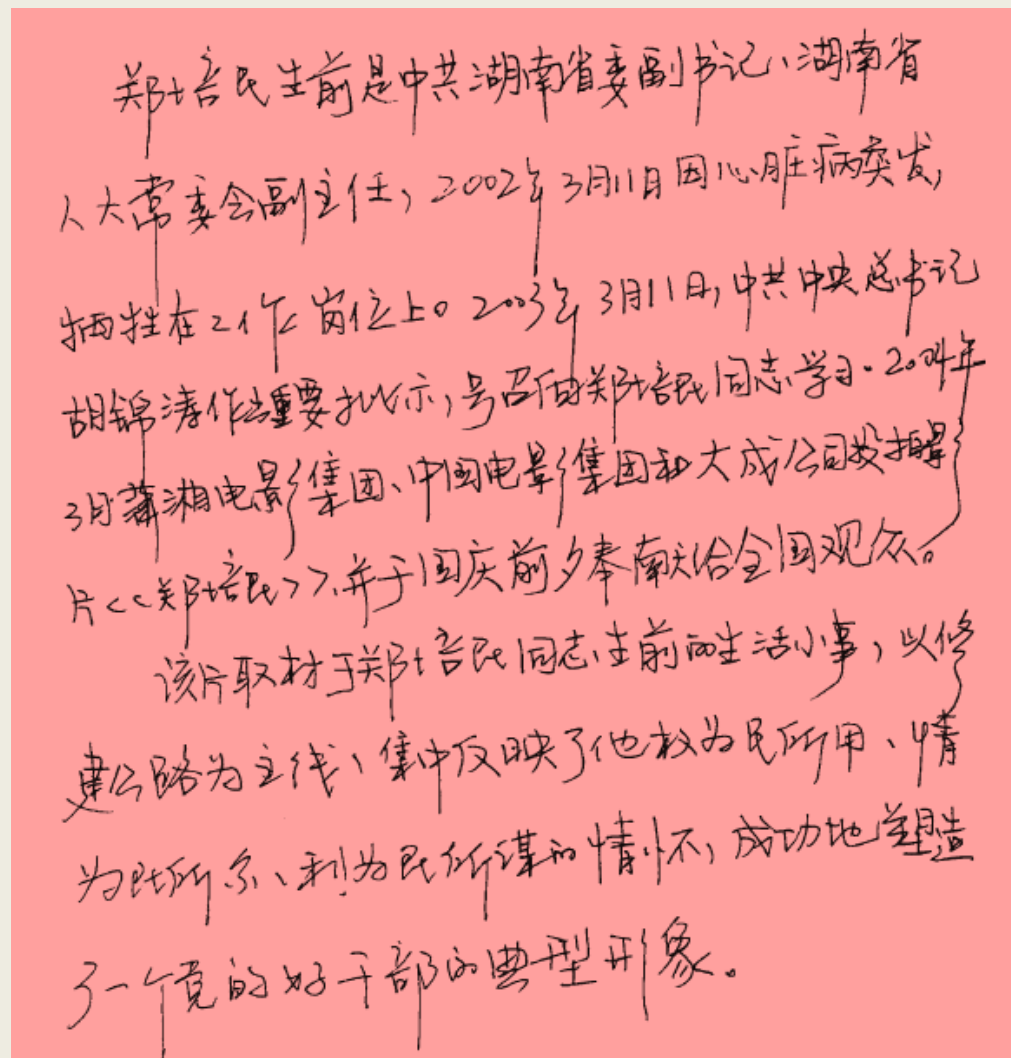
2006: Su, Zhang, Guan: HIT-MW

Unconstrained Chinese
handwritten characters
without preprinted boxes.

853 forms and
186,444 characters

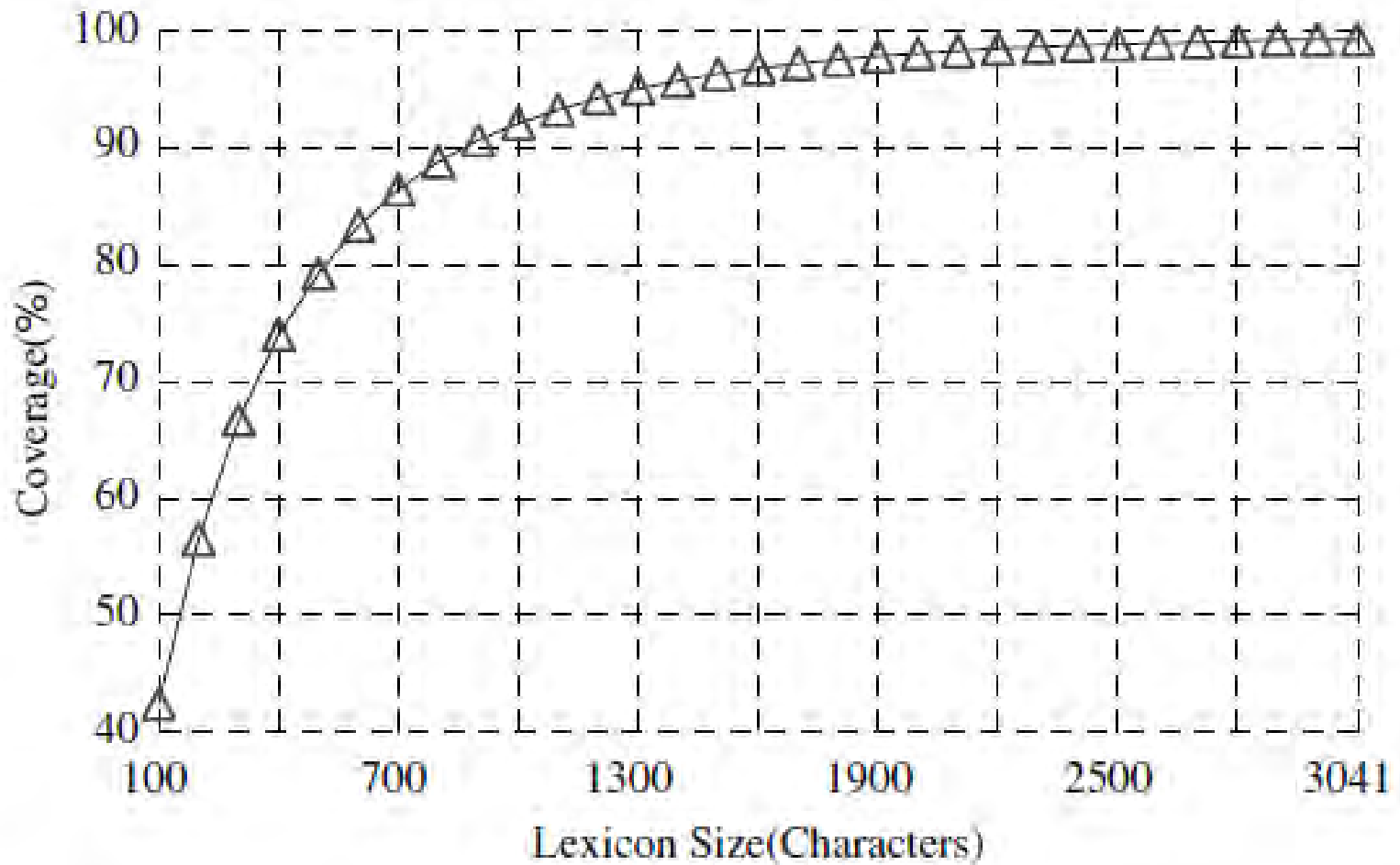
Gray-scale 300dpi BMP

Texts from China Daily



郑培民生前是中共湖南省委副书记、湖南省人大常委会副主任，2002年3月11日因心脏病突发，牺牲在工作岗位上。2003年3月11日，中共中央总书记胡锦涛作出重要批示，号召全党同志学习。2004年3月，潇湘电影集团、中国电影集团和大成公司拍摄了影片《关培民》，并于国庆前夕奉献给全国观众。该片取材于郑培民同志生前的生活小事，以修建公路为主线，集中反映了他权为民所用、情为民所系、利为民所谋的情怀，成功地塑造了一个党的好干部的典型形象。

HIT-MW coverage



**Su & Wang: “Corpus-based HIT-MW database for offline
recognition of general-purpose Chinese handwritten text”**
International Journal on Document Analysis and Recognition

Volume 10, Number 1 / June, **2007**

Database	Language	Unit	Year	Source	
Highleyman	English	Alphanum	1961	[8]	
Munson		Alphanum	1968	[20]	
Suen		Numeral	1972	[28]	
CENPARMI		Postcode	1992	[30]	
CEDAR		City name	1994	[9]	
CAMBRIDGE		Sentence	1994	[26]	
IAM		Sentence	1998	[16]	
IAAS-4M		Chinese	Character	1985	[15]
ITRI			Character	1991	[31]
HCL2000			Character	2000	[36]
HK2002	Character		2002	[5]	
ETL-8	Japanese	Character	1976	[19]	
ETL-9		Character	1985	[24]	
PE92	Korean	Character	1992	[11]	
KU-1		Character	2000	[23]	
IRONOFF	French	Character	1999	[32]	
GRUHD	Greek	Character	2000	[10]	
ISI	Indian	Alphanum	2005	[2]	

A taxonomy of test data sets

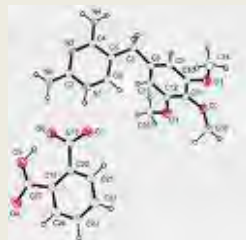
DAS

Engineering drawings |← 40"→|

Schematic diagrams

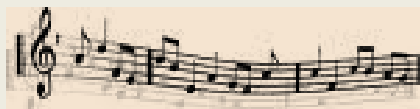
Maps

Formulas + equations



Signatures, letters, diaries

L☺g☺s



Ballots

Illuminated MS, Incunabula,

XVI-XIX C books



T	A	B	L	E	S
---	---	---	---	---	---

Forms	-----

CAPJICAs

NON-DAS

Text (IR, TREK) ?

Cloud, bubble, & spark chambers

Sky (star) pics

Faces

Finger/palm/foot prints

X-rays, CT, MR, PET, ...

Micrographs (cells)

Plants and flowers

Features (U C Irvine)

... ..


Four slides from the NSF-III PI Workshop, April 2010

*The Scholarly Practice of Information
Integration and Informatics*

Haym Hirsh
National Science Foundation

Director, Information and Intelligent Systems (CISE)

UC Irvine Machine Learning Repository

- Over 150 Data Sets for Machine Learning and Data Mining
- Median age: 15 years 
- Should data sets have an expiration date?

Benchmark Data: Reproducible, but Good?

- **Benchmark data allow reproducibility**
- **Reproducibility also depends on software, parameters, etc.**
- **Benchmark data sets must be representative of the sorts of problems our algorithms will see in practice**
- **Benchmark data sets must stay timely as technological and scientific advances allow our ambitions to grow**
- **The pace of data growth makes this difficult**

Proprietary Data/Information

- Many innovative ideas involve proprietary or otherwise restricted data/information
- Do we publish innovations that use generally unavailable data/information?
- What can we learn from the medical community?

2010



IAPR TC 5: Benchmarking & Software

Data

A list of publicly available datasets for benchmarking of pattern recognition algorithms

- A list of datasets on the web by datawrangling.com
- UCI standard database in a unified format
- Hand-Written Symbol Recognition
- CAVIAR video sequences
- Sequence Recognition Dataset
- MNIST data from Yann LeCun
- UCI Machine Learning Repository
- Youtube 22 Concepts
- USPS data from Max Planck Institute for Biological Cybernetics
- Dataset generator

Home	A list of publicly available datasets for benchmarking of pattern recognition algorithms	Links:
Data	Note that publicly available data is published in connection with the contests and competitions .	
Software		
Contests	<ul style="list-style-type: none">• Youtube 22 Concepts• UCI Machine Learning Repository• A list of datasets on the web by datawrangling.com	
Related Activities		
Contact		
Steering Committee		
ICPR 2010 Contest		
ICFHR 2010 Contest		
Latest news:	<ul style="list-style-type: none">• CAVIAR video sequences The EC funded CAVIAR project (Context Aware Vision using Image-based Active Recognition) has collected and hand-labelled ground truth for 81 video sequences comprising about 90K frames.• Sequence Recognition Dataset• MNIST data from Yann LeCun• USPS data from Max Planck Institute for Biological Cybernetics, Tübingen, Germany• Dataset generator	



Machine-print OCR

- **APTI**: Arabic Printed Text Image Database

Handwriting

On-line

- **IAM On-Line** Handwriting Database
- **UNIPEN database**
- **Kuchibue & Nakayosi** Reference: "Collection of on-line handwritten Japanese character pattern databases and their analysis," International Journal on Document Analysis and Recognition, Vol. 7 No. 1, pp.69-81 (2004).

Off-line

- **CEDAR** Off-line Handwriting CDROM1
- **IAM** Database - A full English sentence database for off-line handwriting recognition.
- **MARG**- Medical Article Records Groundtruth ([\[1\]](#)) is a freely-available repository of document page images and their associated textual and layout data. The data has been reviewed and corrected to establish its "ground truth". Please contact Dr. George Thoma (thoma@lhcnlm.nih.gov) at the National Library of Medicine for more information.
- **Hindi** font samples by Andras Kornai, June 5 2003

Miscellaneous Kanji handwritten OCR databases

- **IPTP CD-ROM2**



comments on test data
from www.nagy.virtual.blog

When is N large enough? (Gauss, Chernoff, Guyon, Makhoul, Schwartz, Vapnik)

$$n \approx \left(\frac{z_\alpha}{\beta}\right) \frac{(1-p)}{p} \approx \left(\frac{z_\alpha}{\beta}\right) \frac{1}{p} \approx \frac{2 \ln \alpha}{\beta^2 p} \approx \frac{100}{p}$$

So keep sampling until 100 errors have occurred for a 5% (α) probability that the true error rate is no more than 20% (β) greater than the observed value p .

Which is the better classifier?

Track exclusive errors v_1 and v_2 by each classifier. Then the first classifier is probably better if

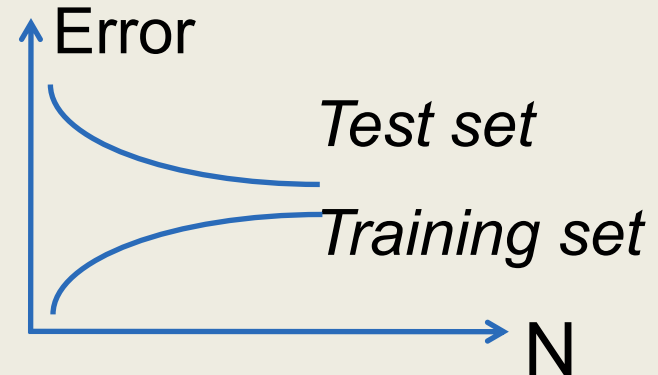
$$\hat{p}_1 - \hat{p}_2 \geq \frac{z_\alpha}{n} \sqrt{v_1 - v_2}$$

Training on Test Data

- Blatant e.g. estimating language model from a *transcript* of the test data.
- Subtle e.g. increasing $P(q_)$ after finding 38 occurrences of *Iraq* in the test data
- Subconscious failing to avert eyes from test data

If you make more than one run on the test set, report the *maximum* error!

Testing on Training Data:



Data Partitioning

- Training – Test (50-50 or 90-10 ?)
- Training – Validation – Test
- Training – Validation 1 – Validation 2 – Validation 3 ... Test
- Leave-one-out, Leave-N-out (cross-validation)
- Non-stationary data
- Sampling with or without replacement

80K samples: 400 sources (writers or fonts), 200 sentences

25% sample: 100 sources, 200 sentences

 200 sources, 100 sentences

 400 sources, 50 sentences

?

Representative of what?

- Real data for HP so far primarily from envelopes and checks. Predicting real-world accuracy requires a **document census** or data from *actual operations*.
- **Copying is different from writing or calculating!**
Vocabulary, spelling, and grammar are as personal as shape: writer demographics are important (cf. NIST SD3/7)
- **In the real world, uniform distributions are rarer than a hen's tooth!** (cf. Benford's Law for *digits*, Zipf's Law for *words*)
- Ground truth depends on *context*.

Reporting classifier “performance”

Two-class Confusion Matrix: *5 independent values!*

Correct, Error, Reject ($C+E+R=1$)

Recognition Rate

Precision & Recall (F-score/measure)

Sensitivity & Specificity

Type I & Type II error

False Alarm & Miss

False Positive & False Negative

(+ is good in war, bad in medicine)

Errors of Omission & Commission

Reject-error curve (C.K. Chow 1970) ROC

N=100		Classified		
		A	B	Reject
True	A	50	3	7
	B	4	30	6



Preprocessing considered harmful

Please don't

binarize,

normalize,

segment,

deskew,

denoise,

thin, fatten,

or otherwise “improve” test data!

**Instead, save your algorithm and parameter settings
in the database.**

Wizard Words mean exactly what you want them to mean:

Concept

Model

Semantics

Context

Ontology

Knowledge

Information

Data

Interpretation

Understanding

as in: *“We situate our semantic concept models
in an ontological context.”*

Un-, non-, semi-supervised;
adaptive, self-adaptive,
teaching, training, learning

Document

Noise

- Real noise is *never* i.i.d.
- Bits don't flip by themselves.
- Random-phase noise is unavoidable but benign.
- Bleed-through and leaky margins are infectious.
- Document noise is different from digitization noise.
- A good scanner is worth three noise filters.
- Adding noise to develop robust algorithms is like ear-training with a gong!
- Every n^{th} document should be a calibration target.

1 INTRODUCTION

DIFFERENCES between documents account for far more of the variation in OCR error rates than do differences between documents. The variation in OCR error rates achieved on a given document by mature OCR systems varies widely. For example, the error rate for a given document within a given application may vary by as much as 100:1 (e.g., from 90% to 99.9% accuracy). The quality of the document is a major factor in determining OCR accuracy. OCR accuracy depends on document composition (typeface, point size, spacing); printing (ink spread, strike-through, paper defects); copying (skew, streaking, shading); and digitization (blurring, sampling, thresholding). Other document manipulations, such as folding, microfilming, and facsimile transmission, may add further degradation.

(In handwritten character recognition, the motivation of a writer is often the dominant factor.) Not even the digitization process is under the complete control of the OCR

handprinted characters simply are not amenable to concise formal description, and the sources of noise and distortion are often unknown. As hope for the future of the process has faded, there has been a marked resurgence of interest in pseudo-random models for generating large synthetic samples of documents. Although some aspects of these models are based on observable physical phenomena, compelling arguments have been made for their use [1].

The use of randomly-generated characters in place of real data was popular twenty years ago for the same reason it is popular today: it is much easier to generate large data sets from a few prototypes under program control than it is to scan, segment, and label real data. The earliest defect models for generating synthetic data for OCR were based on randomly-generated characters and pepper noise. The noise source produced independent and identically distributed (i.i.d.) random variables. Some researchers were amazed at how well even

Proofreading in context is error prone

This is a review, from an intuitive rather than a mathematical perspective, of the statistical foundations of adaptive recognition systems. Key considerations in adaptive classification are priors, sample size and sampling strategy, labels, statistical dependencies, and dimensionality. The small-sample bias and variance of maximum likelihood, maximum *a posteriori* and Bayes estimators are compared in a small concrete case. Iterative expectation maximization for estimating the sufficient statistics of mixtures is illustrated in a simple setting. It is shown that correlation among features is sometimes unjustly maligned. A counterintuitive increase in the error rate after adding a second feature is traced to the curse of dimensionality. Adaptive classification is presented in the context of both parametric and non-parametric (nearest neighbors and neural nets) estimation. Some recent theoretical results and not-so-recent experimental observations on hybrid classification (based on both labeled and unlabeled samples) are summarized.

Ack: X-ing a Paragraph, Edgar Allan Poe, 1850

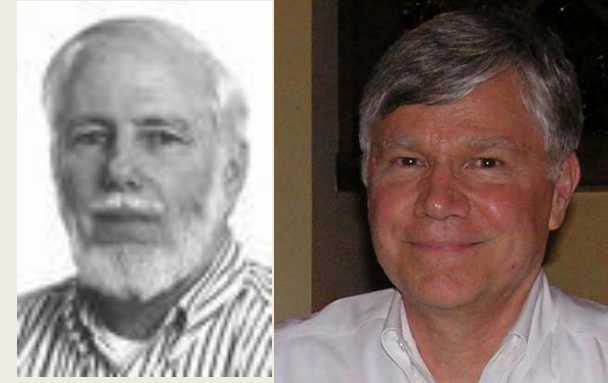
Homogenous class display for OCR



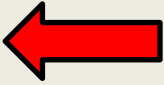
c c c e c c c c c c c c e c c c c c c e c
c c c c c c e c c c e c c c c c c c c c
c c c c c c c c c e c c c c c c c c c c
c e c c c c c c c c c c c c c c c e c c
c c c c e c c c e c c c c c c c e c c c
c c c e c c c c c c e c c c c c c e c c

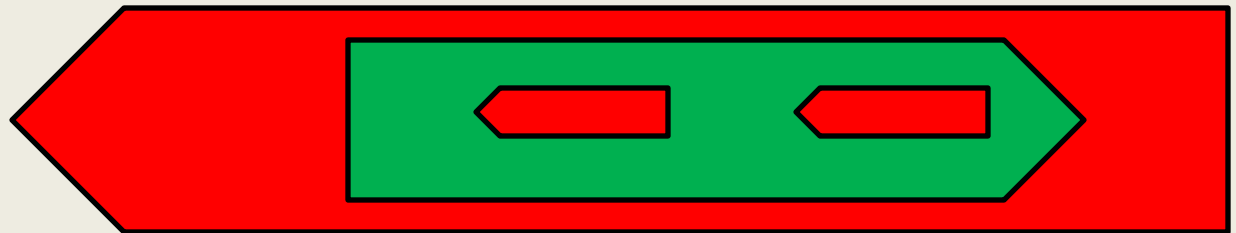
A A R A A A A A A A O A A A A A J A
A A A A A A T A A A A O A A A A A A A
A A A A A A A A U A A A A A A A A A A
A F A A A A A A A A A A A A A A D A A
A A A A A O A A A A Q A A A A A A H A A
A A A A P A A A A A A R A A A A A A A

11%

Foreign is relative



- Language model
- Σχριπτ
- Allographs *a*nd *v*ariants
- Diacritics (English has only *tittles*)
- Numerals, punctuation
-   
- Pure or mixed



Keep on testing, testing, testing:

progress in document analysis has long been driven by sound experiments on carefully prepared test data.

Thank you