HOW TO DEVELOP A TOP-TEN ALGORITHM IN THE 21ST CENTURY

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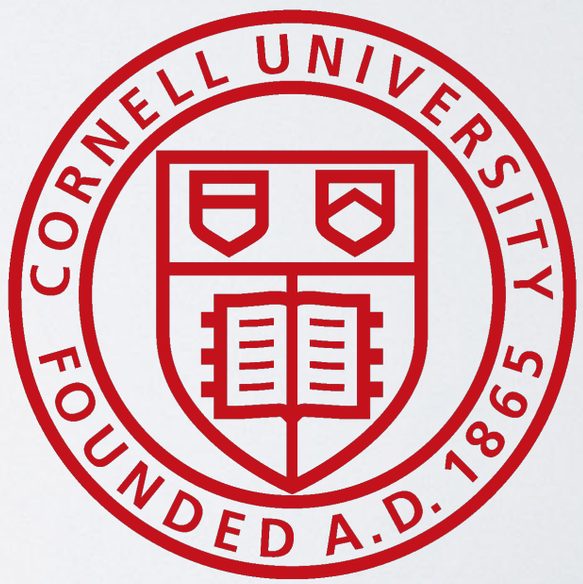
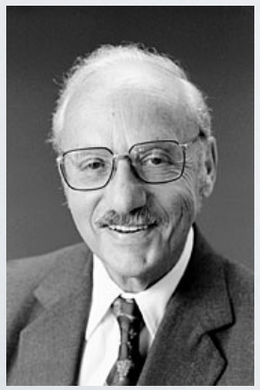


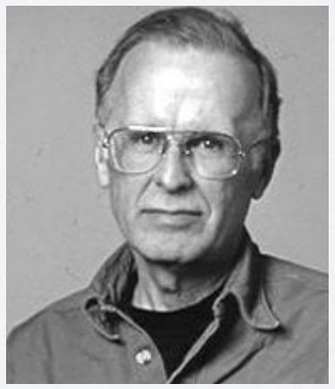
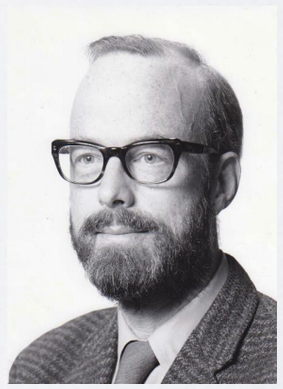
(A talk for fun. Audience participation encouraged.)

DONGARRA'S TOP10 LIST FROM 20TH CENTURY

1946: The Metropolis Algorithm
1947: Simplex Method
1950: Krylov Subspace Method
1951: The Decompositional Approach to Matrix Computations
1957: The Fortran Optimizing Compiler
1959: QR Algorithm
1962: Quicksort
1965: Fast Fourier Transform
1977: Integer Relation Detection
1987: Fast Multipole Method

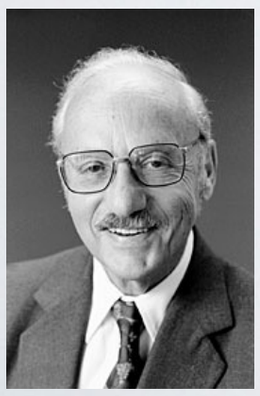




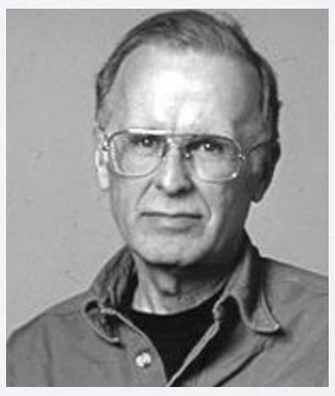
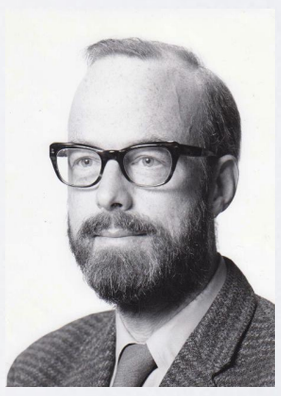




HIGHAM'S TOP10 LIST FROM 20TH CENTURY

1946: The Metropolis Algorithm
1947: Simplex Method
1950: Krylov Subspace Method
1951: The Decompositional Approach to Matrix Computations
1965: Quasi-Newton methods
~~1957: The Fortran Optimizing Compiler~~
1959: QR Algorithm
1992: JPEG compression
~~1962: Quicksort~~
1965: Fast Fourier Transform
1998: PageRank
~~1977: Integer Relation Detection~~
1955: Kalman filter
~~1987: Fast Multipole Method~~

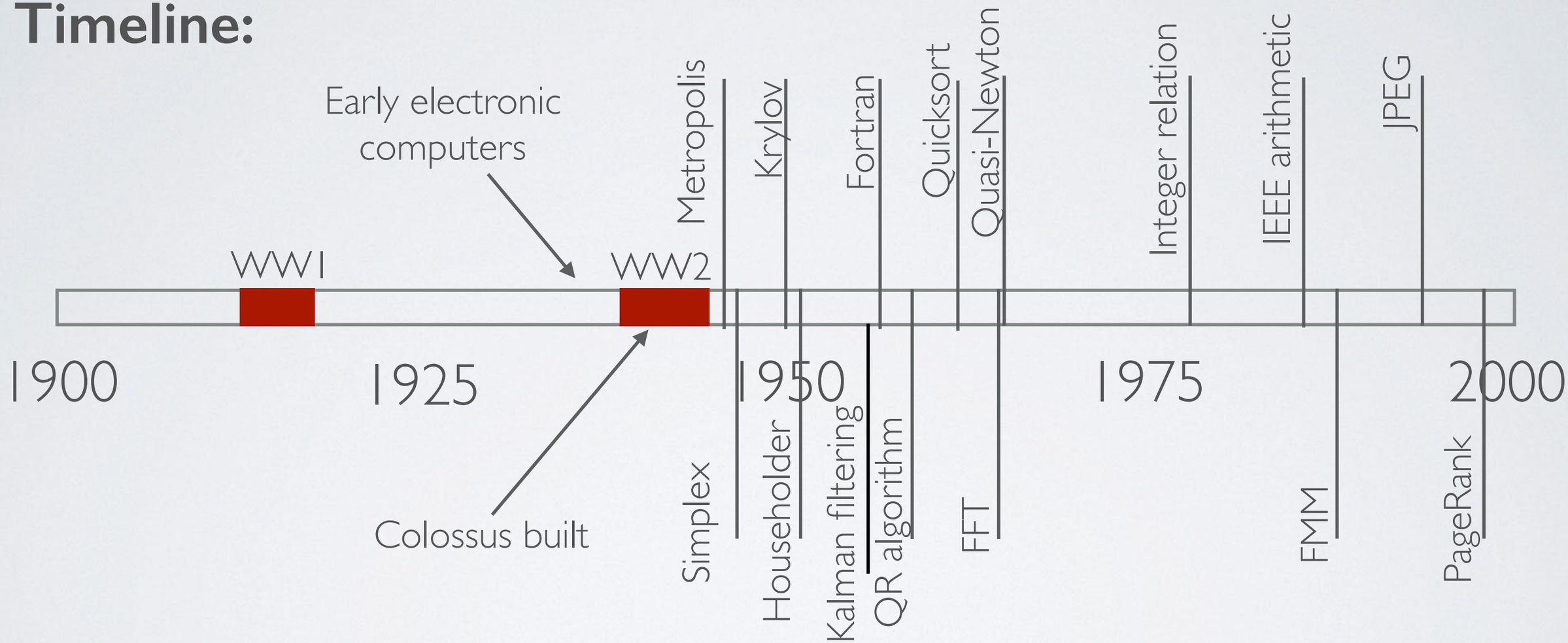





A LIST OF TOP ALGORITHMIC DEVELOPMENTS 1900-2000

Timeline:



``Most influential numerical algorithms of 20th century''

(Complied list from Dongarra's and Higham's list + a few others)

HOW TO DEVELOP A TOP-TEN ALGORITHM IN THE 21ST CENTURY

Q1: What kind of person should I be?

Highly collaborative or lone ranger. Young or old

Q2: What kind of research environment should I be in?

Academia or industry or government.

Q3: What kind of ``products'' should I create?

Papers or conferences or industry/applications.

WHAT KIND OF PRODUCTS SHOULD I CREATE?

- Almost all the algorithms were published in traditional journal-style publications. (Exception: FORTRAN's programming manual.)

- Almost none of the algorithms were patented. (Exception: PageRank.)

- Not all were widely advertised by the ``inventors''. (Krylov & QR algorithm.)

- Some were instantly influential (e.g. FFT & FMM), others took decades (Metropolis-Hastings & Krylov).

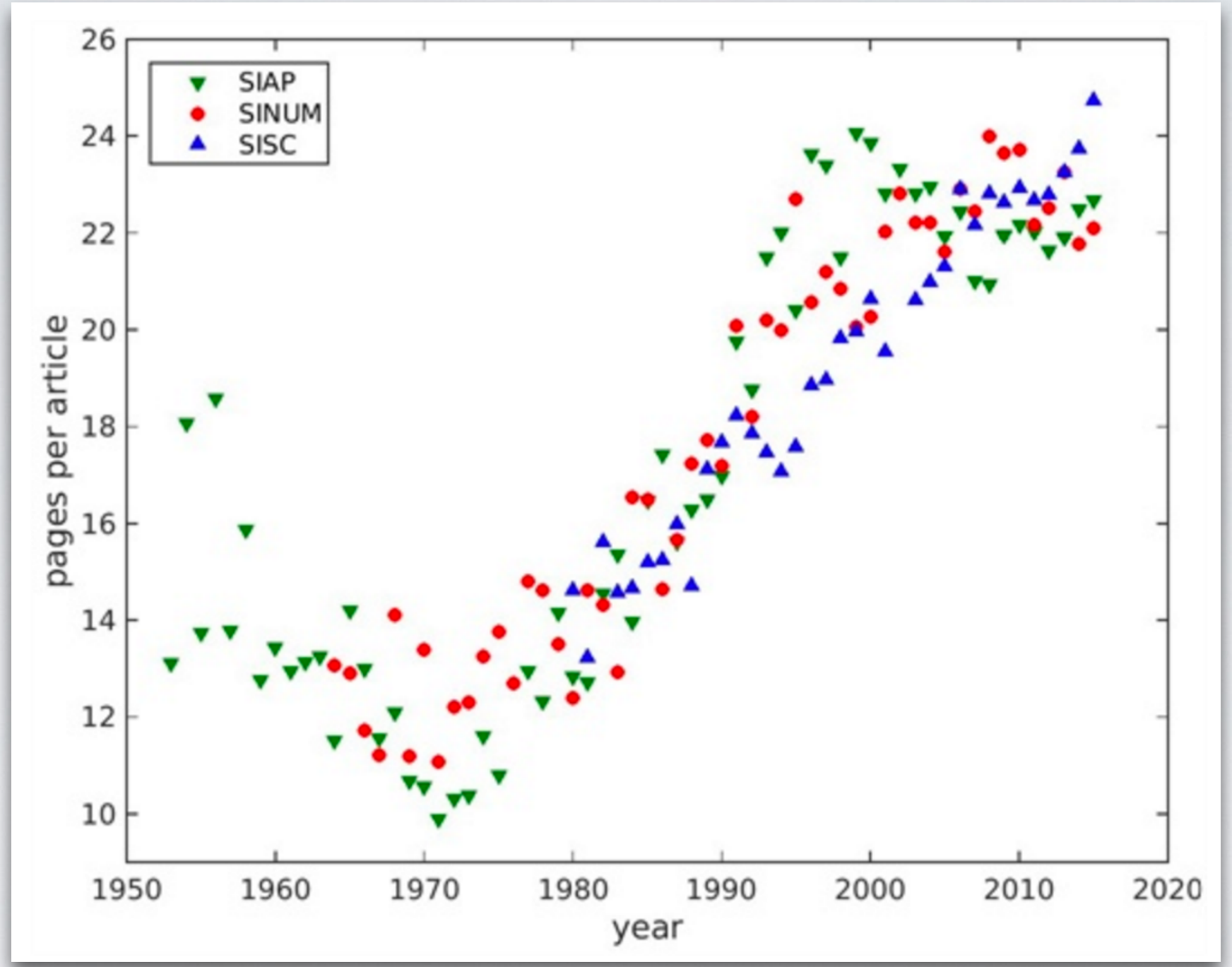
INFLUENTIAL PAPER: SHORT OR LONG

Algorithm	**Paper length**
Metropolis-Hastings algorithm	5
Simplex method	3
Krylov subspace method	28
Householder reflections	3
Kalman filter	10
Fortran complier	37
QR algorithm	6
Quicksort	2
Quasi-Newton	16
Fast Fourier transform	4
Integer relation detection	2
Fast multipole method	23
JPEG compression	17
PageRank	17

Average: 12

Median: 8

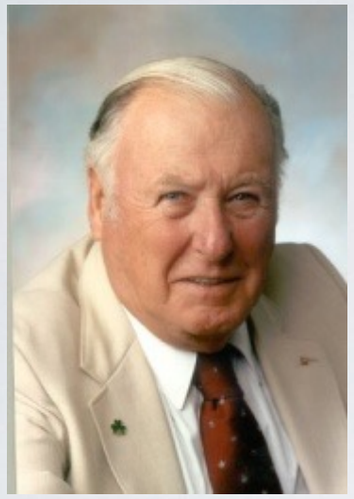
LENGTH OF SIAM PUBLICATIONS



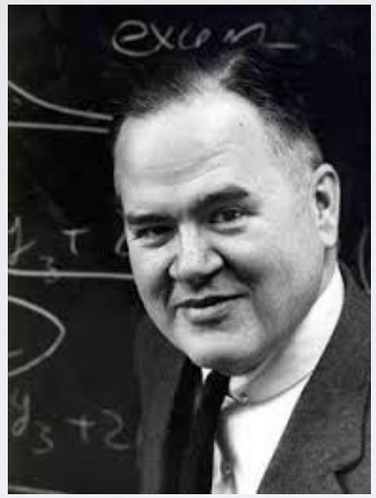
The mean number of pages > maximum allowed number of pages

INFLUENTIAL PAPER: INSTANT SUCCESS?

Fast Fourier transform:

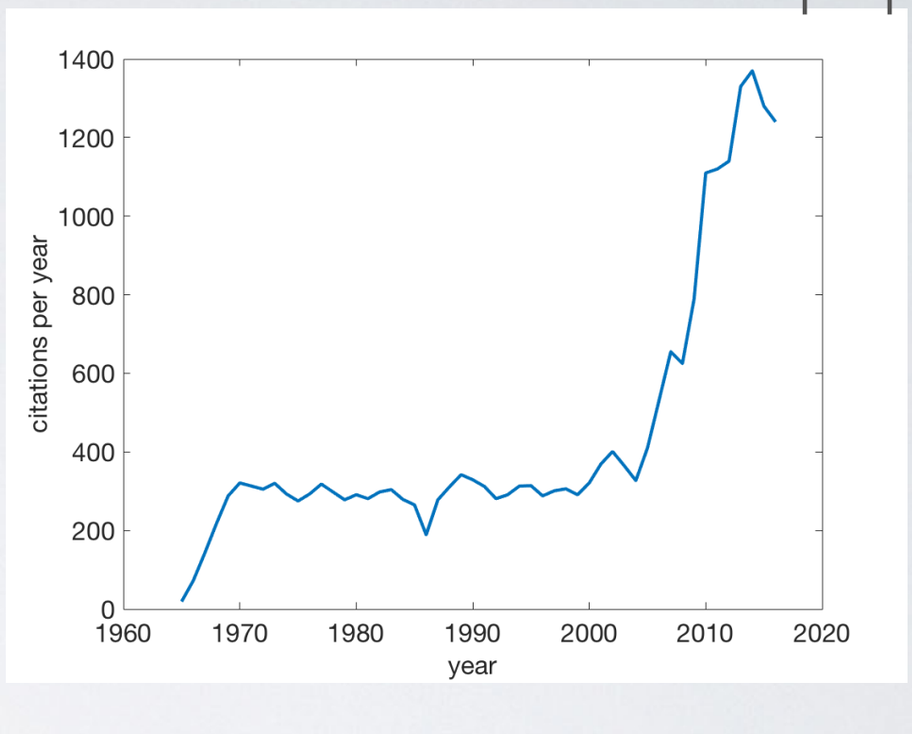


James Cooley



John Tukey

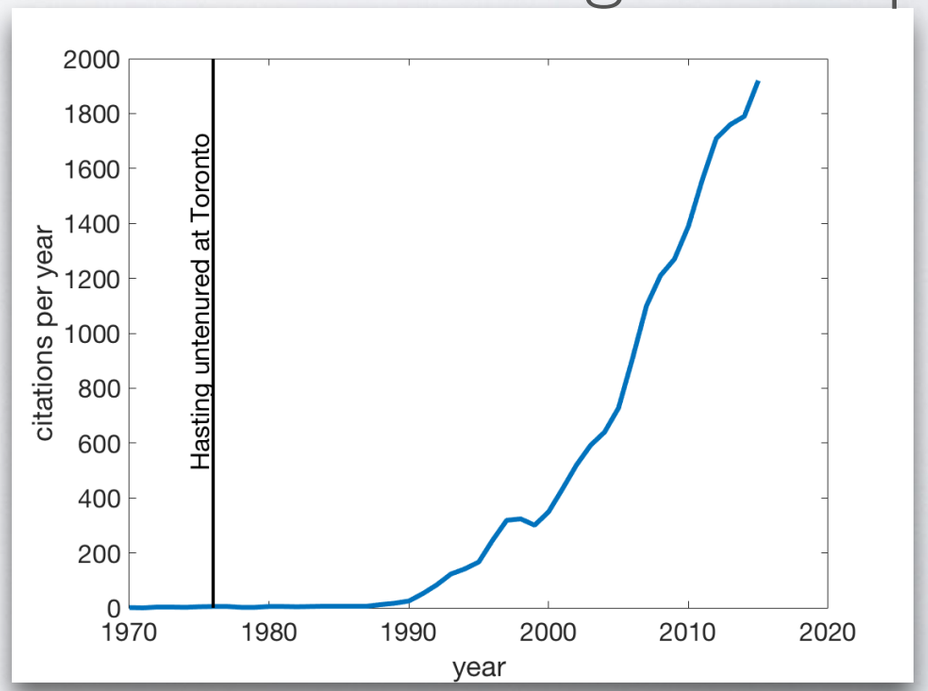
Citation count of FFT 1965 paper



Metropolis-Hastings algorithm:

Wilfred Hastings

Citation count of Hastings 1970 paper



WHAT KIND OF RESEARCH ENVIRONMENT?

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub

Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis

von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

RESEARCH ENVIRONMENT: INDUSTRY/GOVERNMENT

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub
Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis
von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

Most had some involvement with industry and/or government.

RESEARCH ENVIRONMENT: ACADEMIA

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub
Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis
von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

Most were academic professors.

RESEARCH ENVIRONMENT: MATH-RELATED PROFESSOR

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub
Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis
von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

Most were professors in math, CS, and related fields.

RESEARCH ENVIRONMENT: ENGINEERS

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub

Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis

von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

The others were mostly engineers.

RESEARCH ENVIRONMENT: IN USA

A selection of key individuals:

Backus
Broyden
Cooley
Dantzig
Fletcher
Francis
Givens
Golub
Greengard
Hastings
Hestenes
Householder
Kahan
Tukey
Kantorovich
Lanczos
Metropolis
von Neumann
Page
Powell
Rokhlin
Rutishauser
Saad
Wilkinson

A good proportion worked in the USA.

WHAT KIND OF PERSON?

Lone ranger

versus

Collaborative

Young

versus

Old

ORIGINAL PAPER: CO-AUTHORS

Algorithm	Number of authors
Metropolis algorithm	4
Simplex method	1
Krylov subspace method	2
Householder reflections	1
Kalman filter	1
Fortran compiler	0
QR algorithm	1
Quicksort	1
Quasi-Newton	1
Fast Fourier transform	2
Integer relation detection	2
Fast multipole method	2
JPEG compression	1
PageRank	4

Average: 1.64

Median: 1

HOW OLD IS TOO OLD?

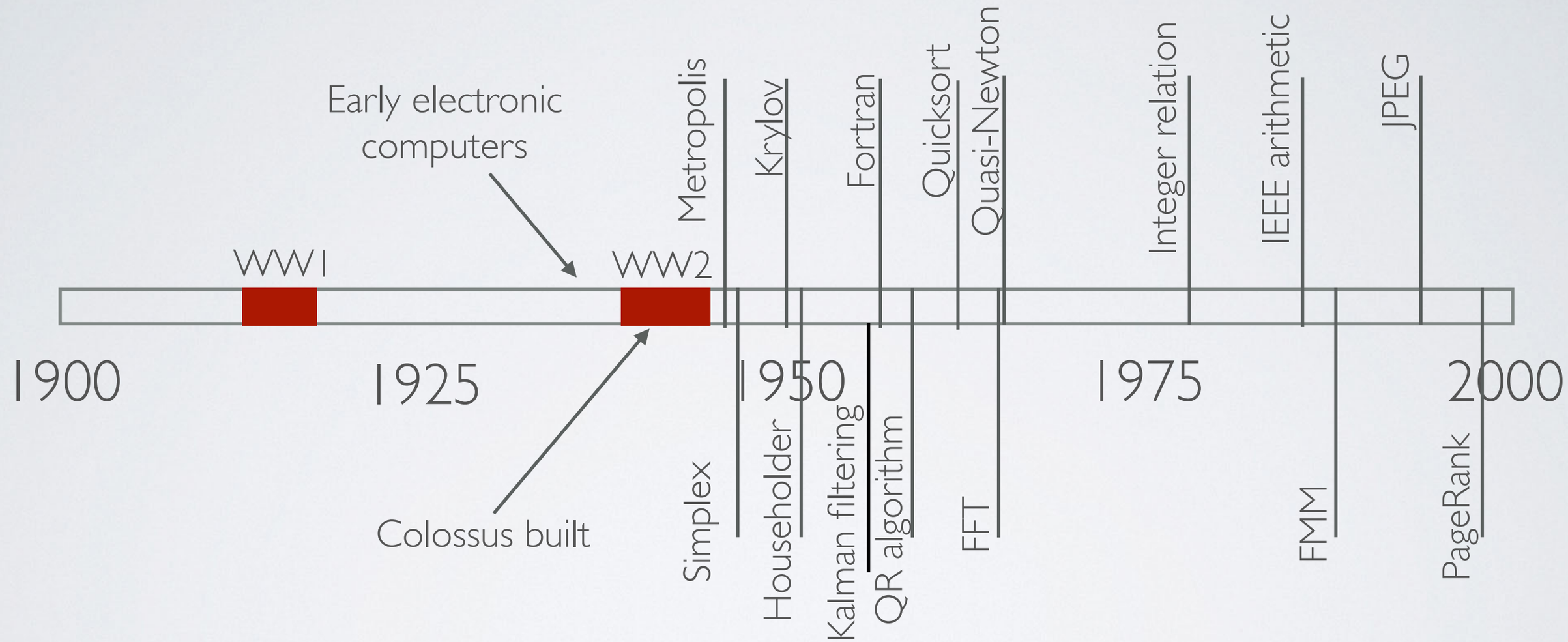
A selection of key individuals:

Backus, 30
Broyden, 32
Cooley, 39
Dantzig, 33
Fletcher, 24
Francis, 27
Givens, 47
Golub, 33
Greengard, 29
Hastings, 40
Hestenes, 46
Householder, 54
Kahan, 44
Tukey, 50
Kantorovich, 27
Lanczos, 59
Metropolis, 33
von Neumann, 44
Page, 28
Powell, 27
Rokhlin, 33
Rutishauser, 28
Saad, 36
Wilkinson, 46

Average: 37
Median: 33

I SAID NOTHING ABOUT THE TOPIC

The last 100 hundred years



In 1917, no-one knew the influential role of electronic computers…

… if an analogous event happens in the 2040s. We will all be too old.

SUMMARY

What kind of work?

- Write short papers (<10 pages).
- Publish in traditional journals.

What kind of research environment?

- Work closely with industry or government.
- In math-related academic field (favorably in the US).

What kind of person?

- Write papers alone or with one other.
- Better to be young, i.e., <45 years old

WHAT KIND OF WORK SHOULD I DO?

Simplified answer:

- Write short papers (<10 pages)
- Publish in traditional journals
- Many of the original papers seem to be motivated by applications. (Not always explicitly described.)

WHAT KIND OF RESEARCH ENVIRONMENT?

Simplified answer:

- Work closely with industry or government
- Become a professor in a math-related field
- It may help to work in the United States