

“Logici” e Informatici:
Corrado Böhm
Alfonso Caracciolo di Forino

Simone Martini

Alma mater studiorum • Università di Bologna
and
INRIA FoCUS – Sophia / Bologna

Pisa, 13 novembre 2021



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
DIPARTIMENTO DI INFORMATICA - SCIENZA E INGEGNERIA

Inria
informatiques mathématiques



Part of a larger project:

Trace the interaction between logic
and (*the practice and science of*) computing,
in Italy in the 50s and 60s

The myth

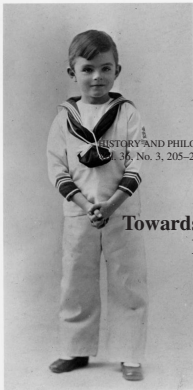


Computing from Logic

Is Alan Turing the *father* of
computer science?



Is Alan Turing the *father* of computer science?



HISTORY AND PHILOSOPHY OF LOGIC, 2015

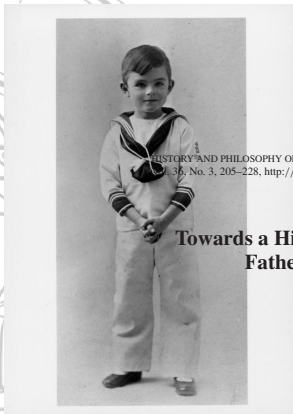
35, No. 3, 205–228, <http://dx.doi.org/10.1080/01445340.2015.1082050>



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**Towards a Historical Notion of ‘Turing—the
Father of Computer Science’**

Is Alan Turing the *father* of computer science?



HISTORY AND PHILOSOPHY OF LOGIC, 2015

36, No. 3, 205–228, <http://dx.doi.org/10.1080/01445340.2015.1082050>



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Towards a Historical Notion of ‘Turing—the Father of Computer Science’

viewpoints

DOI:10.1145/2658985

Viewpoint
Why Did Computer Science Make a Hero Out of Turing?
Comparing the legacy of Alan Turing in computer science with that of Carl Friedrich Gauss in mathematics.

Maarten Bullynck, Edgar

Is Alan Turing the *father* of computer science?



DOI:10.1145/2542504

Thomas Haigh

Historical Reflections

Actually, Turing Did Not Invent the Computer

Separating the origins of computer science and technology.

HISTORY AND PHILOSOPHY OF LOGIC, 2015

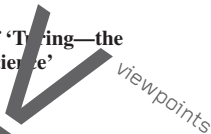
Vol. 36, No. 3, 205–228, <http://dx.doi.org/10.1080/01445340.2015.1082050>



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Towards a Historical Notion of ‘Turing—the Father of Computer Science’



DOI:10.1145/2658985

Maarten Bullynck, Edgar

Viewpoint Why Did Computer Science Make a Hero Out of Turing? *Comparing the legacy of Alan Turing in computer science with that of Carl Friedrich Gauss in mathematics.*

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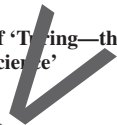


DOI:10.1145/2659499

Viewpoint

A Turing Tale

Assessing the accuracy of popular descriptions of Alan Turing's influences and legacy.



DOI:10.1145/2659985

Viewpoint

Why Did Computer Science Make a Hero Out of Turing?

Comparing the legacy of Alan Turing in computer science with that of Carl Friedrich Gauss in mathematics.

Maarten Bullynck, Edgar

Turing the father of CS?

- Little influence on actual computers
EDVAC, and not Turing's ACE is the ancestor of Manchester Mark I
- The mathematical theory of computation
is the result of an agenda of the late 50s
- Of course **someone knew**. . .
von Neumann, Goldstine, Curry, Bernays, Gorn, . . .

The Italian context (1): philosophy

- No “real” logic after Peano until the end the WW II (Father Bocheński professor of Logic at *Angelicum*, in Rome)
- Reconstructing the philosophical landscape:
Antonio Banfi, Ludovico Geymonat, Giulio Preti

Ludovico Geymonat



Born, 1908

Died, 1991

Laurea, Turin:

Philosophy (1930) and Mathematics (1932)

Vienna, 1934

Turin: **Centro di studi metodologici**, 1947

Prof in Cagliari, then Pavia, 1949-1956: Theoretics

Prof in Milan, 1956-1978: Philosophy of science

The Italian context (2): computing

1953-55: Buy vs Build

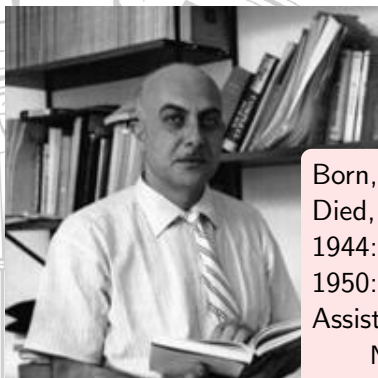
- Buy: Rome, Milan, later Naples
- Build: Pisa (and Olivetti)

The Italian context (3): cybernetics

Naples: Istituto di Fisica Teorica

- 1954: Eduardo Caianiello meets Norbert Wiener in Rome seminars on automatic computing and cybernetics promoted by Fermi
- 1958:
 - Valentino Braitenberg arrives in Naples
 - Gruppo di Cibernetica officially established in Naples
 - Wiener lectures in Naples
 - SIF school in Varenna on Theory of Information
Caianiello director; Wiener honorary president
- 1960: Wiener lectures again in Naples
- 1961: cybernetics curriculum in the Laurea in Physics

Eduardo R. Caianiello



Born, 1921

Died, 1993

1944: L in Physics, Naples

1950: PhD in Physics, Rochester, NY

Assistant prof in Maths and Physics:

Naples, Rochester, Turin, Rome

1955: Higgins visiting professor, Princeton

1956: Professor, Naples

Quantum Field theory, Renormalization theory

Cybernetics

The Italian context (3): cybernetics

Blurred boundaries: cybernetics and computing science

- Physics: interest on automatic computing
- Cybernetics: Caianiello, Borsellino, Ceccato, Gamba
- Ravello, 1964: First Course on Automata Theory as part of International School of Physics, Caianiello director:

Yuri Matiyasevich, Michael Rabin, Claude Berge, Marco Schützenberger, Maurice Nivat, John Holland, J. Richard Büchi, Michael Arbib, Corrado Böhm and Wolf Gross, Jack Cowan, Warren McCulloch



The Italian context (4): a galaxy of scattered interests

Vittorio Somenzi (1918 – 2003) Meteorology (military), phil. of science

Giuseppe Vaccarino (1919 – 2016) Chemistry

Silvio Ceccato (1914 – 1997) Law, music, etc.

Delfino Insolera (1920 – 1987) Engineering

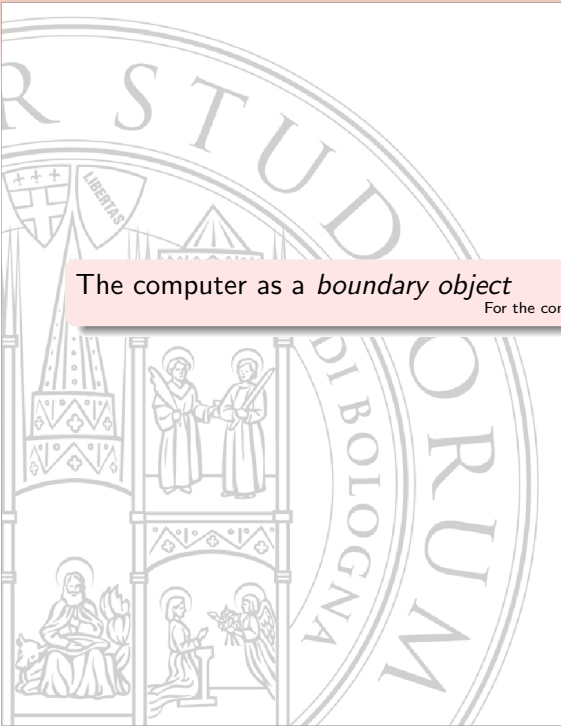
...

Journals:

Archimede 1948–

Methodos 1949–1969 (Vaccarino, Ceccato, Somenzi)

Civiltà delle macchine 1953–1979



The computer as a *boundary object*

For the concept of b.o.: [Leigh Star and Griesemer, 1989]

Calcolatrice Elettronica Pisana

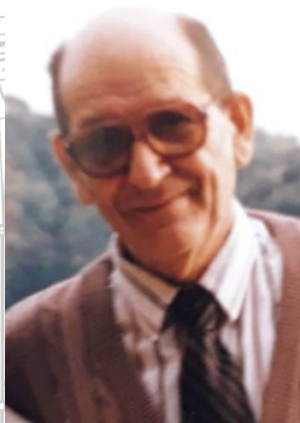
- 1954: Fermi writes to the Rector of Pisa
- 1955: creation of CSCE (Centro Studi Calcolatrici Elettroniche) young (< 30 year old) physicists recruited from Rome:
Alfonso Caracciolo di Forino, Elio Fabri and Sergio Sibani
- Caracciolo is head of the *mathematical-logical section*:
 - *logical* project of the machine
 - machine language
 - programming techniques

Alfonso Caracciolo 16° principe di Forino



[Photo ©Università di Pisa e CNR]

Alfonso Caracciolo 16° principe di Forino



Born, 1925

Died, 1996

1943: enrolled in Physics, Rome

Deeply unsatisfied

1950: correspondence with **Geymonat**

1951: correspondence with **Somenzi**

1952: move to Turin; Laurea in Physics (July)

Onde di superficie per bacini di profondità variabile

1952ff: contacts with the “scattered galaxy”

1953: Sur la construction du langage de la physique

(XIe Congr. Inter. Philosophie, Bruxelles)

1955: in Pisa, recruited by CSCE

[Photo: private Caracciolo archive, by courtesy]

Caracciolo: Universal machines

RAPPORTO SULLE MODERNE CALCOLATRICI ELETTRONICHE.

(dott. A. Caracciolo)

dicembre 1954

na in vista di certe applicazioni, si può ben dire che quasi tutte le macchine sono 'universali' nel senso che ciascuna di esse é in grado di risolvere qualunque problema che possa essere risolto da ogni altra calcolatrice elettronica a cifre. La

C.S.C.E.
BIBLIOTECA
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N.1 I - N.28

Böhm: Universal machines

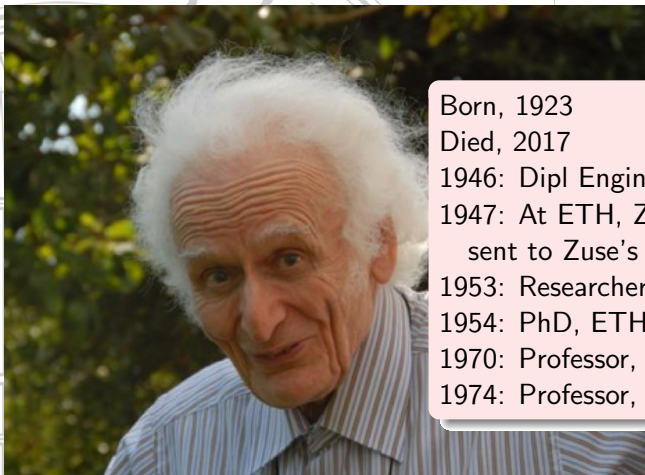
Calculatrices digitales.
Du déchiffrement de formules logico-mathématiques par la
machine même dans la conception du programme.

Mémoire de CORRADO BÖHM (à Roma) (*).

Nous voulons admettre — ce qui est assez plausible — que les calculatrices les plus évoluées sont universelles, au sens spécifié par M. TURING.

(*) *Ricercatore* à l'*Istituto Naz. per le Applicazioni del Calcolo*. Thèse présentée à l'Ecole Polytechnique Fédérale, Zurich, pour l'obtention du grade de Docteur ès Sciences mathématiques. Rapporteur: Prof. Dr. E. Stiefel; corapporteur: Prof. Dr. P. Bernays (1952).

Corrado Böhm



Born, 1923

Died, 2017

1946: Dipl Engineering, Lausanne

1947: At ETH, Zürich

sent to Zuse's lab to evaluate the Z4

1953: Researcher at IAC, Rome

1954: PhD, ETH Zürich (Stiefel, Bernays)

1970: Professor, Turin

1974: Professor, Rome La Sapienza

Corrado's lectures in Pisa

Mon. A-14



UNIVERSITÀ DEGLI STUDI DI PISA

Facoltà di SCIENZE MAT., FIS. E NAT.

REGISTRO DELLE LEZIONI

di CALCOLI NUMERICI E GRAFICI

dettate dal Sig. Prof. C. BÖHM

nell'Anno Scolastico 19⁵⁸ - 19⁵⁹

Handwritten: 2/45

Argomento della lezione N. <u>45</u> Paragone della derivata dell'esempio al rapporto dell' ipotesi; e fine.	Argomento della lezione N. <u>47</u> Traduzione sequenziale ad un numero finito di stati. Esempio di Turing a Turing. Teoremi di Turing. Axiomi di Turing. Analisi di un algoritmo sul campo reale; ruolo di Turing.
Addì 3-2-1959 ore 17	Addì 4-2-1959 ore 16
Firma dell'insegnante Corrado Böhm	Firma dell'insegnante Corrado Böhm

Argomento della lezione N. <u>46</u> Definizione di una macchina di Turing. Definizione di calcolo incostante su macchine di Turing.	Argomento della lezione N. <u>49</u> Esempio di macchina di Turing. Rappresentazione dei numeri interi. Definizione di funzioni calcolabili e funzioni non calcolabili.
Addì 17-2-1959 ore 17	Addì 18-2-1959 ore 16
Firma dell'insegnante Corrado Böhm	Firma dell'insegnante Corrado Böhm

[©Archivio Storico Università di Pisa]

Böhm's lectures in Pisa, 1958

- ... some numerical analysis ...
- TMs; computation by a TM
- Partial and total computable functions
- Universal TM
- Some algorithms do not exist
- ... some numerical analysis ...
- Structure of a digital computer
- Programming of a digital computer
- ... some numerical analysis ...

Alfonso's lectures in Pisa

Mod. A34



UNIVERSITÀ DEGLI STUDI DI PISA

Facoltà di SCIENZE MATEM. FIS. E NATURALI

REGISTRO DELLE LEZIONI

di CIBERNETICA

dettate dal Sig. Prof. Alfonso CARACCIOLO

nell'Anno Scolastico 19_61 - 19_62

Argomento della lezione N. <u>13</u>	Argomento della lezione N. <u>14</u>
Descrizione formalizzata e descrizione procedurale di una macchina di Turing	Descrizione formalizzata e procedurale delle reti neuronaliche - Reti neuroniche e macchine di Turing
Addi <u>12 gennaio 1962</u> ore <u>10</u>	Addi <u>16 gennaio 1962</u> ore <u>18</u>
Firma dell'insegnante <u>Al. Caracciolo</u>	Firma dell'insegnante <u>Al. Caracciolo</u>

Argomento della lezione N. <u>15</u>	Argomento della lezione N. <u>15</u>
Concetto di sintassi e di semantica di un linguaggio più formalizzato - Concetto di frammentazione Morfologia e intenzione	Concetto di metalinguaggio Formalizzazione distinzione fra metalinguaggio e linguaggio più opportuno - "Crespi" soni
Addi <u>17 gennaio 1962</u> ore <u>10</u>	Addi <u>19 gennaio 1962</u> ore <u>10</u>

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Alfonso's lectures in Pisa

UNIVERSITÀ DEGLI STUDI DI PISA

Facoltà di SCIENZE MATEM. FIS. E NATURALI

REGISTRO DELLE LEZIONI

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Mod. A34

Argomento della lezione N. <u>13</u> Descrizione formalizzata e descrizione procedurale di una macchina di Turing Addì 12 gennaio 1962 ore 10 Firma dell'insegnante A. Caracciolo	Argomento della lezione N. <u>14</u> Descrizione formalizzata e procedurale delle reti neuronaliche - Reti neuroniche e macchine di Turing Addì 16 gennaio 1962 ore 18 Firma dell'insegnante A. Caracciolo
Argomento della lezione N. <u>15</u> Concetto di sintassi e di semantica di un linguaggio più formalizzato - Concetto di grammatica Neofolopsia e N'utenti Addì 17 gennaio 1962 ore 10	Argomento della lezione N. <u>15</u> Concetto di metalinguaggio Formalizzazione distinguibile fra metalinguaggio e linguaggio più sottile - Crespianti Addì 19 gennaio 1962 ore 10

[©Archivio Storico Università di Pisa]

Caracciolo's lectures in Pisa, 1961

- ... automi, neuroni, percettrone, ...
- TMs; sistemi di Post; equivalenza
- Struttura generale di un linguaggio di programmazione
- Sintassi e semantica di un LP
- Matalinguaggio e sua formalizzazione: Forma di Backus
- Operazioni logico combinatorie
- Sistemi a regole
- Linguaggio algoritmico ALGOL
- Cenni a Fortran
- CEP e sua programmazione

Böhm's thesis, again

0.32. Le « programme » est susceptible, par rapport aux calculatrices universelles, d'une double interprétation. La première est : « Description d'un comportement de la calculatrice ». La deuxième : « Description d'une méthode numérique de calcul ».

Duality between:

- an operational description of the behaviour of the (abstract) machine
- the numerical function that results from that sequence of operations

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Is mostly mentioned for:

- being (probably) the second PhD thesis explicitly in computing after David Wheeler's August 1951 Cambridge thesis
- the first language given via a meta-circular compiler [Knuth 1977]
- the “reflection” inside a language is a constant trademark of his work see the Separation (aka “Böhm's”) theorem

Böhm's thesis

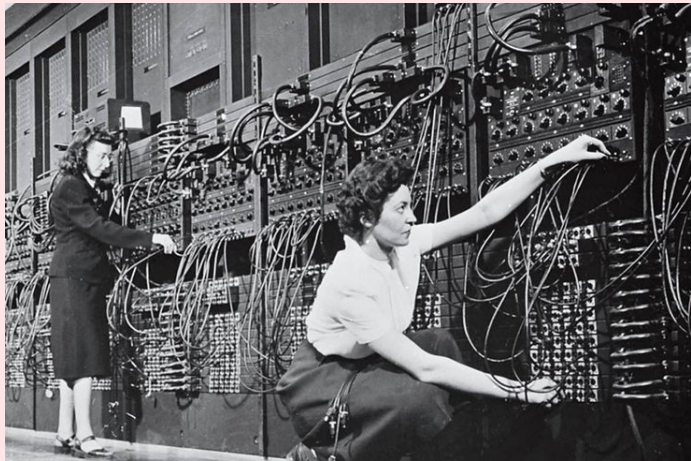
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Böhm's language

A. Set $i = 0$ (plus the base address 100 for the input array a).	$\pi' \rightarrow A$ <u>100</u> $\rightarrow i$ $B \rightarrow \pi$
B. Let a new input a_1 be given. Increase i by unity, and <u>proceed to C if $i > 10$, otherwise repeat B.</u>	$\pi' \rightarrow B$ $? \rightarrow ii$ $i+1 \rightarrow i$ <u>$[(1 \cap (i \neq 110)) \cdot C] + [(1 \neq (i \neq 110)) \cdot B] \rightarrow \pi$</u>
C. Set $i = 10$.	$\pi' \rightarrow C$ <u>110</u> $\rightarrow i$
D. Call x the number a_1 , and prepare to calculate its square root r (using subroutine R), returning to E .	$\pi' \rightarrow D$ $ii \rightarrow x$ $E \rightarrow X$ $R \rightarrow \pi$
E. Calculate $f(a_1)$ and attribute it to y . If $y > 400$, continue at F , otherwise at G .	$\pi' \rightarrow E$ $r+5 \cdot ii \cdot ii \cdot ii \rightarrow y$ <u>$[(1 \cap (y \neq 400)) \cdot F] + [(1 \neq (y \neq 400)) \cdot G] \rightarrow \pi$</u>
F. Output the actual value of i , then the value 999 ("too large"). Proceed to H.	$\pi' \rightarrow F$ <u>$i \neq 100$</u> $\rightarrow ?$ <u>999</u> $\rightarrow ?$ <u>$H \rightarrow \pi$</u>

GOTO H



Programming ENIAC, 1945-46

Programming is hardware dependent **technology**

Teaching

In the teaching of Caracciolo (in Pisa) and Böhm (in Pisa and Rome) informatics is a “section” of logic, from Turing onwards

Caracciolo and Böhm's remarkable observations!

Universality + General purpose languages

- The “linguistic turn” is not completed yet
Nofre et al. When Technology Became Language: The Origins of the Linguistic Conception of Computer Programming, 1950–1960. *Technology and Culture* 55(1):40-75. 2014
- Universality requires a distance from physical reality
- Towards the “standard model”

The standard model

True arithmetic and (in principle) unbounded resources

The standard model is to PL what movement without friction is to mechanics.

The standard model

True arithmetic and (in principle) unbounded resources

The standard model is to PL what movement without friction is to mechanics.

Caracciolo's early papers

- 1963 **CACM** 6(8), 456-460.
Some remarks on the syntax of symbolic programming languages
[On contextual constraints on PL definitions]
- 1964 **IFIP Conference**, 37–51 (published 1964).
On the concept of formal linguistic systems,
in: Formal Language Description Languages for Computer Programming
- 1965 IFIP Conference, 223–228.
Linguistic problems in programming theory
- 1966 **CACM** 9(3), 226-227.
Some preliminary remarks on **theoretical pragmatics**
- 1966 **First ACM symposium** on Symbolic and algebraic manipulation
PANON-1B: A programming language for symbol manipulation

Pisa: 1965

NATO Summer School on Programming Languages

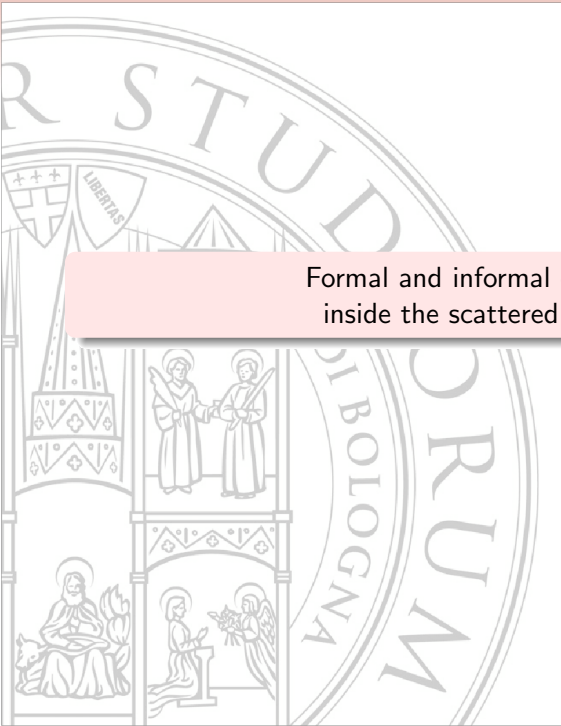
Three weeks

- A. Caracciolo: Special programming languages
- S. Ginsburg: Theory of context-free languages
- P. Landin: λ -calculus (?) and its applications
- P. Naur: The systematic design of effective compilers
- A. van Wijngaarten: Formal definition of syntax and semantics of programming languages

Some attendees:

Giorgio Ausiello, Jaco de Bakker, Antonio Grasselli, Fabrizio Luccio.

In G. Ausiello's recollection "the lecturers were some of the most prominent computer scientists in the world"

The background of the slide features a large, faint watermark of the official seal of the University of Bologna. The seal is circular and contains several elements: a central figure of a seated man with a halo, likely a saint or scholar; a figure kneeling in prayer; a figure holding a book; and a figure holding a staff. The text 'LIBERTAS' is visible at the top, and 'BOLOGNA' and 'CRUM' are partially visible at the bottom. The seal is surrounded by a decorative border.

Formal and informal contacts
inside the scattered galaxy

Centro di studi metodologici

Congress 1952

under “Metodologia delle scienze matematiche e naturali” :

- A. Caracciolo: Sulla arbitrarietà della logica dei sistemi formali
- B. De Finetti, La nozione di evento
- D. Insolera, Considerazioni sulla tecnica matematica richiesta dalle macchine calcolatrici ad alta velocità

1963-64

Moderne tecnologie della computazione elettronica

E. Caianiello

A. Caracciolo



Convegno Nazionale di Logica CSM, Torino 5-7 aprile 1961

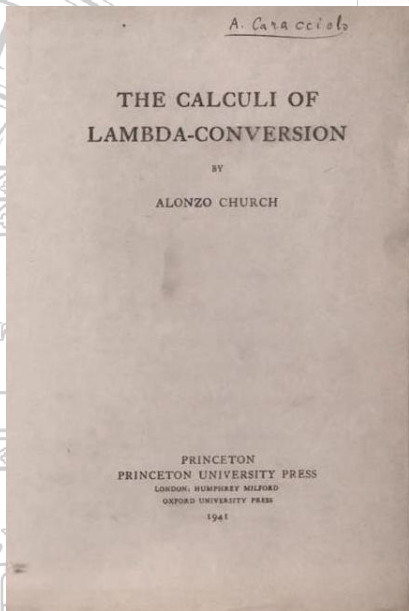
- Lombardo-Radice, Pasquinelli, Carruccio, Bertolini, Casari, Ciampa, Previale, Carugo, Mangione
- Alfio Andronico (C.S.C.E. – Pisa): Sul minimo numero di prove necessario per il controllo delle reti logiche
- Roberto Vacca (I.N.A.C. – Roma): Decomposizioni di funzioni logiche di commutazione
- Alfonso Caracciolo (C.S.C.E. – Pisa): Sulla definizione delle funzioni di selezione
- Corrado Böhm (I.N.A.C. – Roma): Ricerca di una misura dell'efficienza [negli] algoritmi grafici



And informal...

Pisa C.S.C.E, 28 november 1961:
Caianiello (Naples) is asked to hand back the copy of "Digital Computer Principles" by W.C. Irving he borrowed the previous year. Caianiello lost it and offers to buy it anew.

And informal...



Concluding...

It is reasonable to hope that the relationship between computation and mathematical logic will be as fruitful in the next century as that between analysis and physics in the last.

[J. McCarthy. A basis for a Mathematical Theory of Computation. 1963]

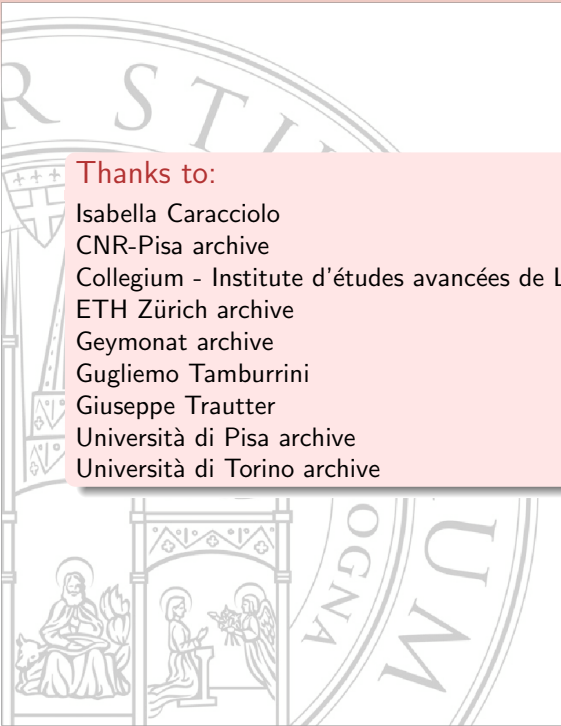
Alfonso and Corrado shared the same vision,
and contributed to make it happen

Concluding...

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[J. McCarthy. A basis for a Mathematical Theory of Computation. 1963]

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Thanks to:

Isabella Caracciolo

CNR-Pisa archive

Collegium - Institute d'études avancées de Lyon

ETH Zürich archive

Geymonat archive

Guglielmo Tamburrini

Giuseppe Trautter

Università di Pisa archive

Università di Torino archive