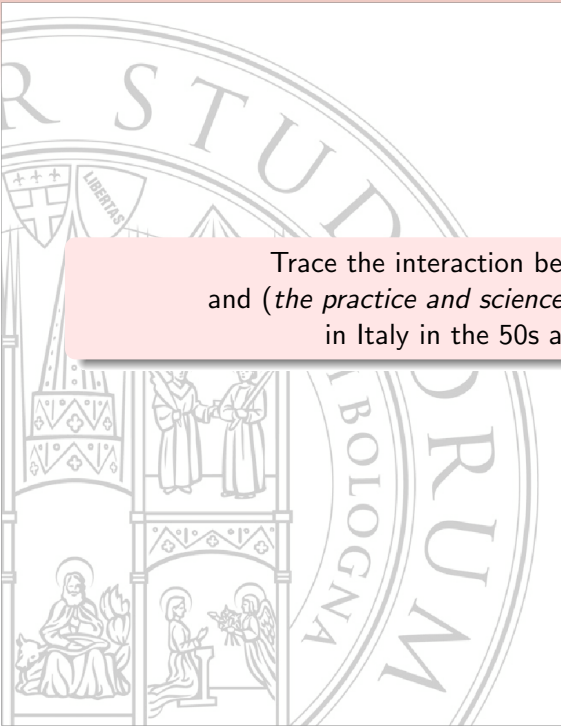


Logic and Computing in Italy at the birth of the Italian Computer Science

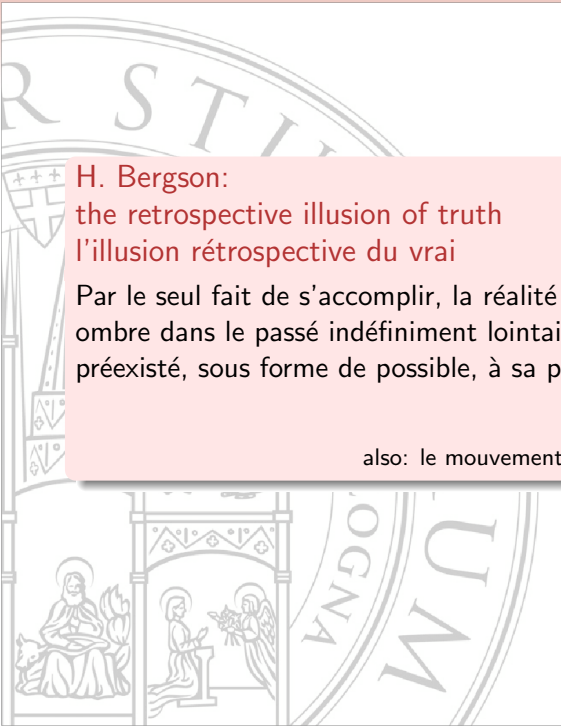
Simone Martini

Alma mater studiorum • Università di Bologna
and
INRIA FoCUS – Sophia / Bologna
and
Collegium - Institut d'études avancées de Lyon 2018-2019

On the occasion of Abrusci's retirement:
thank you, Michele!



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



H. Bergson:
the retrospective illusion of truth
l'illusion rétrospective du vrai

Par le seul fait de s'accomplir, la réalité projette derrière elle son ombre dans le passé indéfiniment lointain ; elle paraît ainsi avoir préexisté, sous forme de possible, à sa propre réalisation

[H. Bergson, La pensée et le mouvant, 1934]

also: le mouvement rétrospectif/rétrograde du vrai

The myth



Computer Science from Logic

The myth²



Computing from Logic

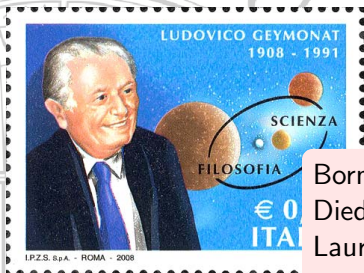
Turing the father of CS?

- 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)

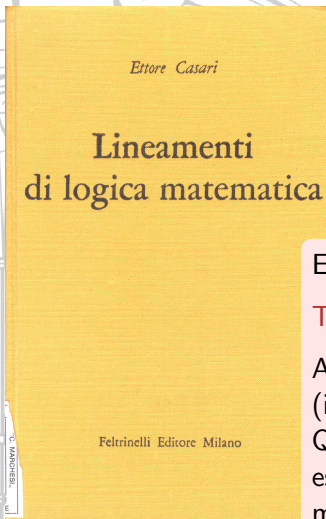
Vienna, 1934

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

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

Prof in Milan, 1956-1978: Philosophy of science

Mathematical Logic, 1959



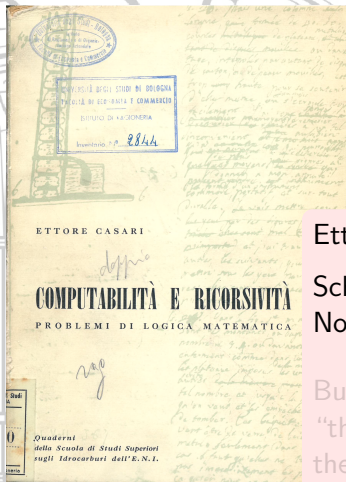
Ettore Casari, 1933-2019

Textbook, on Hermes' model (Münster)

Amedeo Conte's review on JSL 27(1), 1962
(in... *Italian*):

Questi Lineamenti sono sì istituzionali; ma vogliono
esser proprio tali, poiché appunto un libro così
mancava in Italia.

Computability theory, 1959



Ettore Casari, 1933-2019

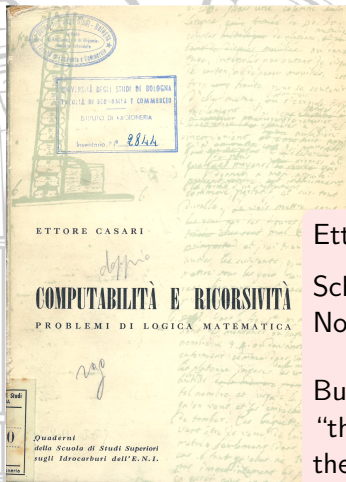
School of ENI (Italian national oil company)

No mention of computing applications

But in the foreword (by Geymonat):

“the concept of computable function is central for the problem to determine the tasks that could be assigned to a computing machine.”

Computability theory, 1959



Ettore Casari, 1933-2019

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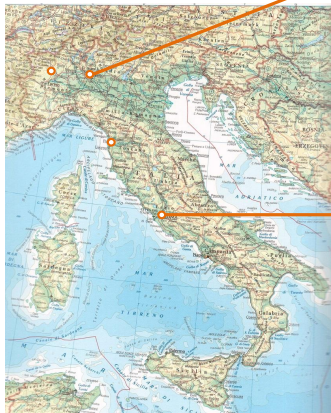
“the concept of computable function is central for the problem to determine the tasks that could be assigned to a computing machine.”

The Italian context (2): computing

1953-55: Buy vs Build

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

The “buy” approach

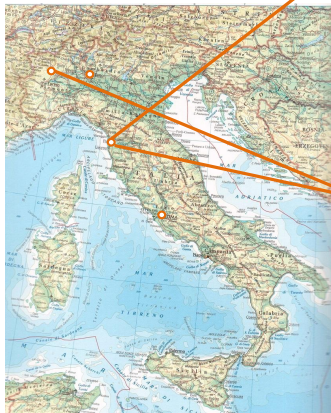


○ The Polytechnic of **Milano** acquired in USA a Crc 102-A computer to equip the just then set up *Centro di Calcoli Numerici*. The machine was running by **October 1954** and the Centre officially opened some months later.

○ The *Consiglio Nazionale delle Ricerche* (C.n.r.) bought in UK a Ferranti Mark I* for the *Istituto Nazionale per le Applicazioni del Calcolo* (Inac). The Finac machine (a contraction of “Ferranti Inac”) arrived in **Roma** in **November 1954** and completed acceptance test on **June 1955**.

[slide © Corrado Bonfanti, 2014]

The “make” approach



○ The University of **Pisa** established his *Centro Studi Calcolatrici Elettroniche* (Csce) with the aim of designing and build the *Calcolatrice Elettronica Pisana* (Cep) scientific computer. Csce activities started in **March 1955**.

○ The internationally renowned firm Olivetti decided to enter the then emerging computer industry. His *Laboratorio Ricerche Elettroniche* (Lre) was then established at Barbaricina – nearby **Pisa** – in order to design and prototype the Elea commercial mainframe. R&D begun at **mid 1955**. Olivetti's headquarters were located in **Ivrea**.

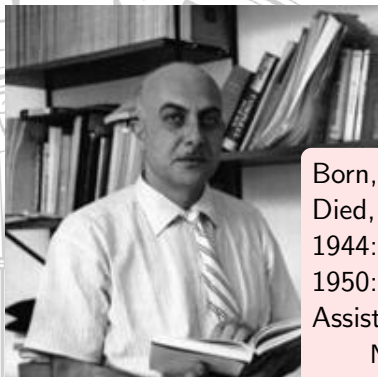
[slide © Corrado Bonfanti, 2014]

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

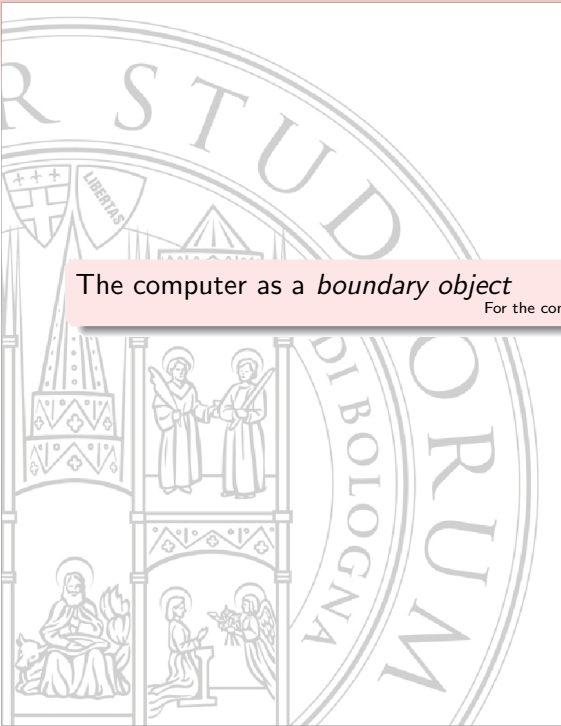
...

Journals:

Archimede 1948–

Methodos 1949–1969 (Vaccarino, Ceccato, Somenzi)

Civiltà delle macchine 1953–1979

The background of the slide features a large, faint watermark of the seal of the University of Bologna. The seal is circular and contains the text 'R STUD' at the top and 'ORUM' at the bottom. In the center, there is a shield with a cross and three stars, and the word 'LIBERTAS' written below it. Below the shield, there are two figures standing and holding a book, and two figures kneeling in prayer. The seal is rendered in a light gray color.

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



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

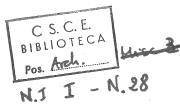
Caracciolo: Universal machines

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 è in grado di risolvere qualunque problema che possa essere risolto da ogni altra calcolatrice elettronica a cifre. La



Böhm: Universal machines

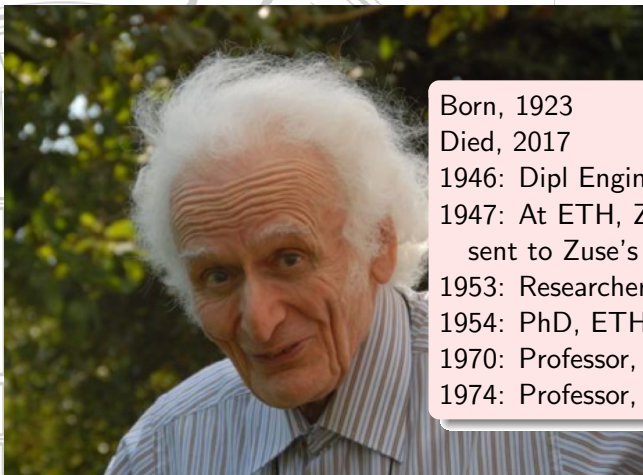
Calculatrices digitales.
Du déchiffrage de formules logico-mathématiques par la
machine même dans la conception du programme.

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 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. Axioma di scelta. Axioma di un numero sul campo reale; ruolo di assioma.
Adde <u>3-2-1959</u> ore <u>17</u>	Adde <u>4-2-1959</u> ore <u>16</u>
Firma dell'insegnante <u>Corrado Böhm</u>	Firma dell'insegnante <u>Corrado Böhm</u>

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>48</u> Esempio di macchina di Turing. Rappresentazione dei numeri interi. Definizione di funzioni calcolabili e funzioni non calcolabili.
Adde <u>17-2-1959</u> ore <u>17</u>	Adde <u>18-2-1959</u> ore <u>16</u>
Firma dell'insegnante <u>Corrado Böhm</u>	Firma dell'insegnante <u>Corrado Böhm</u>

[©Archivio Storico Università di Pisa]

Böhm 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 ...

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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Böhm's thesis

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

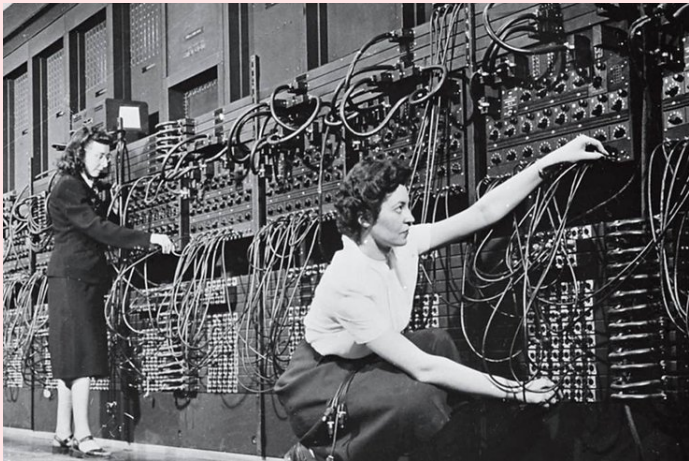
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Böhm's language

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 proceed to C if $i > 10$, otherwise repeat B.	$\pi' \rightarrow B$
	? $\rightarrow ii$
	$i+1 \rightarrow i$
	$[(1 \cap (i \neq 110)) \cdot C] + [(1 \neq (i \neq 110)) \cdot B] \rightarrow \pi$
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.	$\pi' \rightarrow E$
	$r+5 \cdot ii \cdot ii \cdot ii \rightarrow y$
	$[(1 \cap (y \neq 400)) \cdot F] + [(1 \neq (y \neq 400)) \cdot G] \rightarrow \pi$
F. Output the actual value of i , then the value 999 ("too large"). Proceed to H.	$\pi' \rightarrow F$
	$i \neq 100 \rightarrow ?$
	999 $\rightarrow ?$
	$H \rightarrow \pi$

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

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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

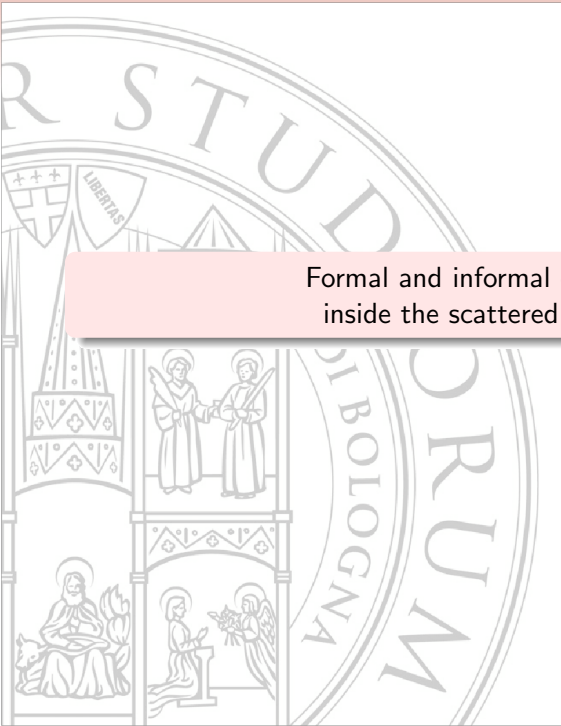
Three weeks

- 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"



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.



In the meantime

The official, academic Italian logic community seems little interested in the problems and opportunities offered by the new science

From the CS camp

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]

When the correctness of a program, its compiler, and the hardware of the computer have all been established with mathematical certainty, it will be possible to place great reliance on the results of the program, and predict their properties with a confidence limited only by the reliability of the electronics.

[C. A. R. Hoare. An Axiomatic Basis for Computer Programming. CACM 12(10), 1969.]

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Still in 1975...

*Could the young Italian researcher X with publications in
recursion theory
complexity of decision problems
lambda calculus
be classified as “studioso di logica”?*

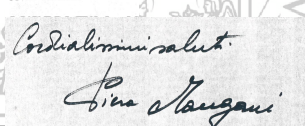
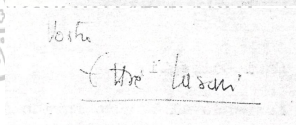
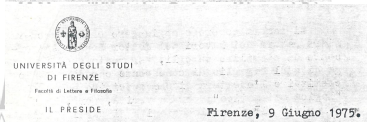
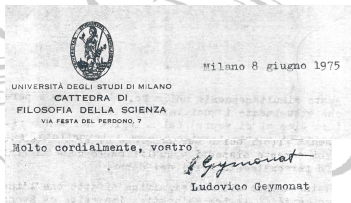
*By the way, in Rome Mathematical Logic was taught since 1973 by
Giuseppe Jacopini.*

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Still in 1975...



Still in 1975...



Molto cordial



Vesta

UNIVERSITÀ DEGLI STUDI DI FIRENZE
DIPARTIMENTO DI MATEMATICA
ULISSE DINI
0565 0714 - TEL. 411.000 - 411.111
50134 FIRENZE

Geymonat: mi sembra che possenga bene *alcuni strumenti* usati dalla logica moderna. Ma altra cosa è dire questo, altra affermare che sia un vero e proprio studioso di logica.

Casari: i lavori di X, pur senza escluderla categoricamente, non sembrano autorizzare la conclusione che egli possa esser considerato un "cultore di logica". I lavori [...] si collocano o fuori o molto ai margini [dell'] accademica "logica matematica".

Mangani (joint opinion with Magari): ritengo che X sia da considerare senz'altro studioso di logica matematica.

Cordiali

Sino Mangani

The background of the slide features a large, faint watermark of the University of Bologna seal. The seal is circular and contains the text 'R STUD' at the top and 'BOLOGNA' and 'RUM' at the bottom. In the center, there are several figures: two standing figures in the upper part, and two seated figures in the lower part, one of whom appears to be a saint or a religious figure. A shield with the word 'LIBERTAS' is also visible on the left side of the seal.

Let's read it in the positive:

Computer Science was well established:
it no longer needed the “logic” endorsement



Thanks to:

Isabella Caracciolo

CNR-Pisa archive

Collegium - Institute d'études avancées de Lyon

ETH Zürich archive

Geymonat archive

Giuseppe Longo

Guglielmo Tamburrini

Giuseppe Trautter

Università di Pisa archive

Università di Torino archive