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Rediscovering the Very First Italian Digital Computer

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Abstract — Until recently, the ELEA 9003 by Olivetti and the CEP by the University of Pisa were considered the first digital computers built in Italy. The CEP was the final outcome of a project carried out from 1955 to 1961 by the University of Pisa with a substantial participation of Olivetti. Actually, this seven years long project delivered a first fully functional computer already in 1957: the MR. However, for a number of reasons, the relevance of MR has been overlooked by previous researchers that underestimated its accomplishments. This paper offers a revised introduction to the history of the CEP project and adds an original chapter, devoted to the MR. We also briefly present the experimental archeology project that rediscovered the MR. In particular, we highlight the benefits that a rebuilding approach brings to the proper reconstruction and to the correct evaluation of historical events.

Index Terms — History, computer industry, computer science education, computer simulation, research initiatives

I. Introduction

Until recently, the ELEA 9003 (for ELaboratore Elettronico Aritmetico, whose meaning is Arithmetical Electronic Computer) developed by Olivetti and the CEP (for Calcolatrice Elettronica Pisana, meaning Pisa Electronic Computer) built by the University of Pisa were considered the first Italian digital computers. The ELEA 9003 was announced in late 1959 as a commercial product with an audience geared towards manufacturing and accounting. The CEP debuted in middle 1961 as a machine mainly intended for research purposes and scientific and numerical elaborations.

The CEP was the final outcome of a project carried out from 1955 to 1961 by the University of Pisa, with a substantial participation of Olivetti. Actually, this long project delivered a first fully functional computer already in 1957: the MR (for Macchina Ridotta, meaning Smaller Machine). However, for a number of different reasons, the relevance of MR has been overlooked by previous researchers and its accomplishments have been often underestimated – sometimes plainly ignored.

The aim of our contribution is to illustrate and discuss the findings of the research project that rediscovered the MR. The project adopted experimental archaeology methods in order to rebuild the machine. What is noteworthy is that such a technically focused approach resulted also in a more faithful reconstruction of the historical events as well as in a better evaluation of their contribution to the development of Italian computer science in the following years. The MR example is an interesting case study since it also confirms that, in order to rigorously approach the history of technological artefacts, sound technology expertises are needed. The MR has been so far underestimated because the previous research works did not attempt to recover and study the technical documents of the CEP project. On the contrary, the precise understanding of the technology of the time that was needed to rebuild the MR led to fully acknowledge its prominent role in the history of Italian computer science.

Section II of the paper introduces the context of the early computer projects in Italy and summarizes the history of the CEP project. Sections III and IV present the technical findings collected during the rebuilding process: these new facts enrich the history of the CEP project, revealing how the 1957 MR was a more important accomplishment than the 1961 CEP.

II. The CEP Project

The birth of the CEP is traditionally part of the founding myth of Italian computer science and several authors have contributed to report the events to the public and to the scientific community [1]-[7] (most of the works, [1]-[5], are in Italian). The facts are here summarized and commented.

A. The CSCE is Established

In the early Fifties the University of Pisa received from the counties of Pisa, Lucca and Livorno a huge funding to build a synchrotron in Italy and to launch Tuscany as a prominent area for nuclear research. However, the initiative clashed with a better offer from Rome that ended up in the decision to have Frascati as the site for the Italian synchrotron.

As an alternative project to use the available funding, the Pisa Department of Physics (at the time Istituto di Fisica) suggested to build an electronic digital computer. The Nobel prize Enrico Fermi was involved to second the proposal which faced the wavering of the politicians and the doubts of some parties inside the University (mainly the Engineering Faculty). Thanks to the support of the illustrious scientist, the Rector of the University, Enrico Avanzi, won the local resistances: the project to build an electronic computer started in early 1955. The minutes of the meetings do record the disappointment of the representatives of the local counties: the synchrotron "exerted greater influence on public opinion" and it could have also "easily been a spectacular propaganda medium" [8].

In March 1955 the CSCE (Centro Studi sulle Calcolatrici Elettroniche, that is Centre for Studies on Electronic Computers) was formally established. By June the new destination of the funding was definitively formalized. Marcello Conversi, by then the Director of the Department of Physics, was appointed responsible of the Centre: he had an important role in the start-up of the project, in particular in the involvement of Fermi. The CSCE was charged with the task of designing and building in four years an electronic computer. The target machine was named CEP – an acronym that sounds particular in the drawl Tuscany dialect spoken under the leaning tower.

B. The Olivetti Connection

Olivetti was involved in the CEP project since its beginning. The company based in Ivrea has since long identified the need to invest in the nascent field of computer: in 1949 it had established a partnership with the French Bull, in 1952 it had opened in New Canaan, in the United States, a centre to serve as observatory and laboratory on electronic technologies [9]. Furthermore, as highlighted by the rich correspondence of Mauro Picone [10], Olivetti had already tried to start an Italian project for the construction of an electronic computer with the INAC (for Istituto Nazionale per le Applicazioni del Calcolo, that is National Institute for Applied Mathematics) of Rome.

The availability of funds in Pisa was for Olivetti an opportunity not to miss: its willingness to participate in the CSCE project is evident in the availability of the Piedmont firm, which offered specialized personnel, skills, materials and, in the final stages of negotiations, it included a relevant direct financial investment. The collaboration will be formalized in an agreement signed in May 1956, but in fact it began in early 1955 with the participation of the Olivetti engineer Mario Tchou to the drafting of the four-year plan for the CEP project.

Olivetti further invested in Pisa. To put in the works its own product, better suited to the needs of the business market, Olivetti set up LRE (for Laboratorio Ricerche Elettroniche, that is Electronic Research Laboratory), a second research group directed by Tchou. LRE was placed in a mansion in Barbaricina, a residential suburb of Pisa. There, the ELEA computers line was started. In 1958 a prototype using vacuum tube technology was completed: the Macchina Zero, later renamed ELEA 9001. Then LRE moved to Borgolombardo, near Milan, were a second prototype, ELEA 9002, was completed using the transistor technology. ELEA 9002 was presented at the Milan Fair of 1959 were its mass-production with the product name of ELEA 9003 was announced. The first ELEAs were delivered to customers in 1960.

C. An Assessment on the CEP

The University CEP was completed in the first half of 1961, with about a year and a half delay with respect to the original plan. It was officially inaugurated on November 13 in a ceremony attended by the then President of the Italian Republic, Giovanni Gronchi. The computer remained in operation for about seven years and was subject to successive extensions.

The CEP was a remarkable machine. Some observers who were responsible for assessing the potential U.S. competitors in research and industry [11]-[12] recognized some interesting features of the CEP, among which the micro-programmability, the mechanism of changing the instructions for passing parameters to subroutines, the good performance results.

However, the computer world was radically changed over the years when the CEP was completed. The technology of the CEP delivered in 1961 fully reflects the delay of the project and the consequent financial problems: while still an interesting machine, the CEP was not a state of the art product.

The vacuum tubes upon which the CEP was almost completely based were already been replaced by transistors. Above all, the way to use computers changed. The 1961 CEP was still a tape-in/paper-out completely batch computer, while the most advanced projects were already working using real time user interaction. In 1961, the Bell Labs were ahead with experiments in speech synthesis, making an IBM 7090 sing "Daisy Bell", the same song that a few years after the most famous computer in film history would whisper while dying. At MIT, the Lincoln TX-2, which in 1958 was already fully realized in transistors, introduced the first interactive user interfaces. In 1960 the Digital PDP-1, the commercial derivative of the TX-2, was sold with a high resolution (1024x1024) video terminal and optical pointer, and it was ready to be used by MIT researchers for implementing Spacewar, the first graphic and interactive video game in history [13].

Even in Italy, things had changed. In 1961 more than twenty computers were already installed, a number of which were made by Olivetti. Indeed, the firm was fully reaping the fruits of its investments: besides ELEA 9003, it had on its price list the ELEA 6001, a modular computer able to fulfil a wide range of demand, from commercial application to scientific computing – by then it was already ordered by the University of Padua and by the Polytechnic of Torino.

Another significant change, more cultural than technological, is well represented by the Compasso d'Oro (Golden Compasses, an Italian prize for Industrial Design) awarded to the ELEA 9003 "dressed up" by Ettore Sottsass. In a few years the computer was not any more an obscure object of research with no appeal on the public (as the local sponsors of the CEP project were worried about), but it had become a commercial product and an almost basic component of the furniture of any modern company. And once again Olivetti, the first hour partner of the CEP project, was the record-holder.

The CEP project, however, had given the cue to the birth of Italian computer science, for both scientific and industrial applications, the latter particularly well represented by the successes of Olivetti.

Above all, the CEP had allowed the University to collect in Pisa a wealth of expertise and human resources able to grow year by year. The most remarkable result was the start-up of the Degree in Computer Science in the academic year 1969/70, at that time the only one in Italy and among the first ones in Europe.

III. The Primacy of the Smaller Machine

Actually, in 1957 the CSCE delivered a first fully functional computer, the MR. The archival research and the careful reading of the retrieved technical documents has allowed us to shed a new light on the early years of the CEP project and to discover a whole new chapter of the Italian computer science history, whose facts are summarized here.

A. The Designs of MR

The first detailed design of the MR [14] was delivered by the end of July 1956. It was the result of the work of the first team of four researchers which started the CEP project: Alfonso Caracciolo di Forino, Giuseppe Cecchini, Elio Fabri and Sergio Sibani. The team was set up together with the CSCE. Caracciolo and Fabri were hired as researchers of the University of Pisa, however they actually came from the Physics Department of the University of Rome. Sibani was also part of the same group of physicists from Rome, but to support his shift to CSCE he was formally hired by Olivetti. Cecchini was an electronic engineer from Olivetti.

As recalled above, the first design of the MR is witnessed by a technical report [14]. In the acknowledgements, situated in the last page, three other persons involved in the design team were mentioned. These were the technician Menotto Baldeschi and the engineers Wladimiro Sabbadini, from Olivetti, and Giovan Battista Gerace, by then just hired as a "young researcher" by the University of Pisa.

In the following years, Gerace will assume a prominent role in the project and, later on, he will become on of the pivotal player in the development of Computer Science in Pisa [15].

Figure 1. The Control Panel of the MR built in 1957 in Pisa.

After an intense period of study and rethink to improve the initial design, the MR was finally completed an year later: the revised design was apparently ready already by April 26, 1957 [16], while instead the machine itself was announced as successfully working on July 24 of the same year.

B. The Exploitation of MR

In the following months, the MR was used to validate the solutions and to finalize the design of the "ultimate" CEP (definitiva, as they called it), that is the machine that was planned as the final outcome of the project.

What is however more important, the MR was also used to provide computation services to other research fields. There are many accounts of the use of MR for purposes external to the CEP project. The first calculation service was requested by the Institute of Mineralogy of the University of Pisa and involved Fourier analysis of crystalline structures: it was reported completed in April 1958. Other uses are surveyed in a paper published in Il Nuovo Cimento, a journal of the Italian Society of Physics [17]. In the few months of its life the MR accounted a total of 150 machine hours "sold" for usage in external research projects: the report of the project proudly boosted the fact that such a workload would amount to a "total of 8 millions lire" [18].

One particular project of theoretical physics [19] used symbolic computation. At the time, the standard approach was instead numerical, while in this case the MR produced the result as an exact expression. Its use for research and development of new programming techniques is a further evidence of the versatility of the computer. Besides the chronological primacy, the consistent use for research makes it difficult to define the MR "just" a prototype.

Furthermore, the MR was the machine where the first educational activities of computer science in Pisa were held. Already in 1956 Elio Fabri kept a course for Engineering students called Introduction to Programming an Electronic Calculator [20]: his experience as one of the MR designers was immediately used for knowledge transfer. Moreover, in 1958 the National Institute Nuclear Physics detached at the CSCE four researchers from its headquarters of Milan, Padua, Pisa and Rome to learn how to use the MR, at that time definitely the most advanced machine in Italy.

C. An Assessment on the MR

Quite interesting is the comparison of the MR with other machines of its time. Unlike the 1961 CEP, that compared to its contemporaries machines suffered the delay and the difficulties of the final years of the project, the 1957 MR proves to be an up-to-date product. Indeed, from a technological point of view, the MR adopted state of the art solutions that it was not easy to find all together on others machines of that period.

- Parallel bit processing. At the time most machines were "serial", i.e. the bits of the memory word were processed one at time. The MR was instead "parallel": it was able, like today computers, to elaborate all the bits of a word at once.
- Ferrite core memory. In the Fifties, computers implemented the main memory using a variety of different technologies: magnetic drums, acoustic delay lines, Williams tubes were the most used solutions. The CSCE researchers adopted the ferrite cores, choosing an emerging technology that was destined to dominate for a couple of decades.

- Microprogrammed control. The implementation of machine instructions by means of programmable microinstructions stored in a read-only memory is generally recognized as a result of the British EDSAC 2 project. However, almost simultaneously, the MR adopted a solution that, although simplified by the small set of instructions (just 32) and implemented in a less sophisticated technology (diodes instead of ferrite cores), makes the MR one of the first fully micro-programmable machines in history.

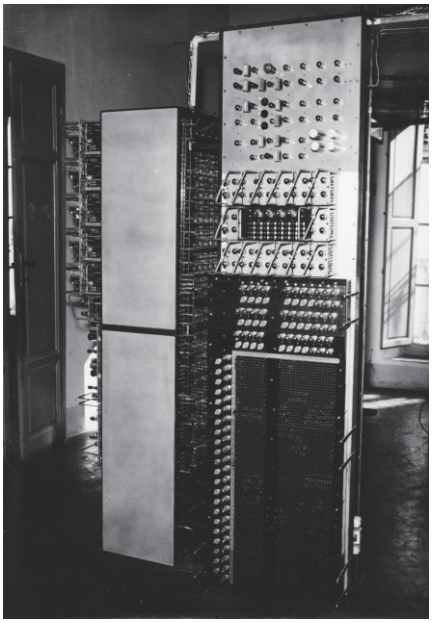

Figure 2. Microprogrammed control of the 1957 MR.

To get an idea of the peculiarities of the MR, it suffices to say that none of those three design choices occurred on the two other computers present at the time in Italy: the American CRC102, bought by the Polytechnic of Milan in the late 1954, and the British Ferranti MK1 that was installed in the early 1955 at the INAC in Rome. These machines, being both geographically near and owned by public research facilities, could be easily studied and used as starting models by the researchers at CSCE. Instead, and not without some risks, new solutions were experimented. And in a very little time they were successfully assembled into a working machine.

Also on the performance side the MR was a fast machine. Thanks to a careful fine tuning, the execution time of the instructions was reduced by 30% with respect to the project estimates, so that, according to Conversi, it was "superior to all the other machines on the market, including the IBM now located in Paris" [21]. The reference is to the IBM 704, in 1957 installed in the French headquarters of IBM, that in those years was considered the most powerful computer in Europe (and widely advertised as such). However, it should be noted that the "superiority" Conversi refers to only concerns speed: the IBM 704 had more memory and more flexible I/O devices; most importantly, it was equipped with a Fortran compiler. Nevertheless, surpassing the IBM 704 on the most straightforward benchmark was a remarkable achievement.

IV. The Rediscovery of a Forgotten Machine

It is surprising that both the chronological and technological achievements of the MR has been forgotten by those who, at various times, worked on the history of the CEP project. Only a few lines are devoted to MR in [6], while it completely disappears in [7] as well as in recent and dedicated works like [4]. In any case, no one had previously identified and acknowledged the value that the building of the MR had in the context of the technology of its time. Actually, there are several reasons that give a partial explanation for this neglect:

- among the four designers of the MR, only Caracciolo will remain in the CSCE for some time after the MR, and by the early Seventies he left Pisa altogether; in 1959 Fabri went back to his main area of research, astrophysics; shortly after Sibani returned to Olivetti and so will do Cecchini and Sabbadini; only Gerace remained in Pisa, but he was much more involved in the CSCE history after the MR;
- there was neither an inauguration nor an official presentation of the MR, which was completed and used in a period of strong tensions between the University of Pisa and the National Government; as an example of the unsupportive climate surrounding the MR début, as an act of protest the University of Pisa did not hold the traditional opening ceremony of the academic year 1957/58;
- no physical traces were left of MR, since it was completely dismantled in order to reuse its components in the building of the ultimate CEP;
- in the plan submitted to CIU by the CSCE, as the target for the biennium 1956/57, there is no mention of a first machine, but instead of "the central core of the machine, that is everything except the external components: the magnetic drum and the fast input and output devices" [22].

Of all the reasons that contributed to the oblivion of the MR, perhaps the most crucial is its formal description as "central core". By considering the MR as an incomplete CEP, it was natural for many historians to underestimate its importance.

In fact, the MR was a different machine and very little of it migrated "as it was" into the ultimate CEP. As an example, the memory, perhaps one of the easier components to reuse, was completely redesigned: the 32x32 ferrite core planes will become 64x64 ones. The single ferrite cores were eventually reused, but in a different memory architecture – actually easy to be recognized even by looking at the photos. Starting from the binary adder to the microprogrammed control, the differences between the MR and the CEP are numerous and substantial.

Some authors cited the MR with more details, like [2], [3], and [5]. But instead of describing the machine that was actually built, they referred to the 1956 first design [14]. Indeed, this version survived in more copies, and it is easier to find in the Archives. Sadly, this first design represented a different, quite simpler, and less interesting machine.

We started to suspect that these where wrong descriptions of the MR by matching the blueprints of the 1956 design with the few photos and the user manual [23] of the machine built in 1957 and used in 1958. Eventually, we were able to retrieve a precious copy of [21], where Caracciolo and Fabri summarized the changes between the initial design and the MR that was actually built. In this way we were able to give credit to a number of substantial, most likely original, solutions that were otherwise forgotten, such as:

- I/O devices; with respect to the first version an additional teletypewriter, a tape puncher and a second tape reader were added; moreover, the teletypewriters were now also input devices, thus adding a keyboard to the MR user interface;
- machine bootstrap; the system software, a mix of utility and basic operating system routines, was now easily loadable at MR start-up by using a technique that today we would call direct memory access;
- hot breakpoints; a mechanism was added to set debugging breakpoints in the assembler programs and to activate them at any moment by using switches on the MR control panel;
- ergonomics and usability; several improvements in the organization of the MR control panel were introduced, in order to provide feedback about the status of the machine.

Besides the technical details, what was previously ignored is the remarkable effort and work carried out by the CSCE researchers in the refinement of the MR design: a continuous process of identifying and solving problems. A process that reflects the importance of the MR as a prominent chapter in the history of the CEP project and, in general, in the formation of the first Italian computer scientists.

V. Conclusions

The project to rebuild the MR started in 2006 at the Department of Computer Science of the University of Pisa. The project was named HMR: it stands for Hackerando la Macchina Ridotta (whose meaning is Hacking the MR) and it highlights both the technical enthusiasm and the challenge that characterized the initiative. We started by recovering, identifying and making digitally available the historical documentation of the early years of the CEP project. Then we started to rebuild the MR: the whole machine was implemented as a software simulator and 1/3 of the adder was rebuilt as an accurate hardware replica. The adder was chosen both for its didactic value and its historical relevance: it was one of the very first component built and it was inspired by the IBM 701 adder – uncited, another of the findings of our hacking.

The simulator and the adder are now part of the laboratories offered to the schools visiting the Museo degli Strumenti per il Calcolo (Museum of Computing Machinery) in Pisa.

The relevance of the MR was indeed an unforeseen result: it emerged day by day together with the understanding of the machine. A whole chapter in the history of the CEP has been recovered by a careful research documentation, and, in particular, thanks to an in-depth technical analysis which revealed the differences between the various versions of the MR and allowed for acknowledging its importance.

Figure 3. Young students playing with the MR simulator.

Figure 4. The rebuilt MR adder exhibited at the Museum in Pisa.

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