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From Analog to Digital: The computer and the digital equipment win recognition as compositional tools

Vlad ROMAN[1]

Abstract: *In the 1970s, composers interested in the new working techniques manifested an obvious desire to complement analog technology with digital technology. Among the early attempts, worthy of merit in the field of using the computer as a tool for writing music, we find the contribution of Lejaren Hiller in collaboration with Leonard Isaacson and Iannis Xennakis that started building his textures with the aid of the computer, determining the possible combinations resulting from the probability calculus. Writing music with the help of the computer appealed to many important composers, such as Gottfried Michael Koenig, Max Mathews, Morton Subotnick and Jean-Claude Risset. In 1977 the latter founded, with Pierre Boulez, one of the most prestigious new music research centres dedicated to new music, IRCAM (Institut de Recherche et Coordination Acoustique/Musique). As in the last fifty years computer music programs developed spectacularly, a list of important composers, software, research and composition centers are mentioned.*

Key-words: *computer music, digital, analog, electronic music composers*

1. Introduction

In the 1970s, composers interested in the new working techniques manifested an obvious desire to complement analog technology, which had been used until that time, with digital technology. Creators were aware of the veritable benefits brought by the digital equipment which, through software, could generate waveforms and therefore the desired sounds and the possibility of future development.

There was undoubtedly a change for the better as concerns the ease of generating complex sounds, if we compare it to analog techniques used in the traditional studios where the creation of waves with a particular frequency, amplitude, continuity in time and form, that is, of sounds with certain pitches,

[1] PhD, National University of Music Bucharest, romanvlad@yahoo.com

intensity, timber and duration required complex and lengthy manoeuvres while sonic result not always lived up to the expectations, nor did the hard work pay off.

Binary numerical information, digital, is specific to the operation system of computers, so a set of convertors from analog to digital (AD) and digital to analog (DA) was needed to process audio and play it back on speakers. The AD converter would convert the analog signal into a digital one so the computer could work with it, and the DA converter would convert the signal from digital to analog so that it could be listened through the speakers (Campbell 2024).

The advantages of digital synthesis led to the development of an increasingly efficient technology. Numerical synthesis was not only the prerogative of computers, but proliferated and became determining in many sophisticated yet easy to handle equipment, used both in the studio and during live performances in concert halls or other types of venues dedicated to events in which music plays a major part (Schwartz 1993, 345).

The early results of using the computer as a compositional tool can seem modest today, with electronics present and exerting an obvious, ever increasing influence on the world, on life itself. The increase and gradual dominance of digital technology over analog technology, a process which peaked in the 1990s, the extraordinary attraction exerted by the synthesiser and later by the computer on composers, opened, through the possibilities they offered, ways to approaching new musical horizons. Of course, analog technology has not been eliminated from audio studios, in fact it has its place of honor, but the advantages of working digitally are the decisive factor in choosing the equipment used daily in studios.

The interest for the various multimedia applications and the use of computers not only in complex working points supplied with advanced equipment but also in smaller, private studios resulted in the use of the computer, with its many integrated systems, as an instrument for generating musical scores, including the acoustic result, and as a helping tool for identifying creative ideas.

2. Early stages

Among the early attempts, worthy of merit in the field of using the computer as a tool for writing music, we find the contribution of Lejaren Hiller (1924-1994) researcher and composer in collaboration with Leonard Isaacson (1925-2018) composer and chemist. In 1955-1956, at the University of Illinois at Urbana-Champaign, the two obtained musical information with the help of a mathematical software which generated a numeric code subsequently transposed manually into a traditional music score and performed during live chamber concerts. It is the case

of *Illiac Suite* for string quartet (Parolini 2017, 288), composed in 1957 by the ILLIAC I computer, published the same year by New Music Quarterly and explained by its authors in their 1959 *Experimental Music* (Cope 1973, 160). *Illiac Suite*, the fruit of early explorations in applying probabilistic in music, was followed by Hiller's *Computer Cantata* (1963) for voice, tape and chamber ensemble, and by *Algorithms I* (1968) for tape and nine instruments.

The literature notes that in the mid 1950s the same usage initiated by Hiller and Isaacson (using mathematical software in composition) was also used by Iannis Xenakis (1922-2001), who started building his textures with the aid of the computer (Luque 2009, 77), the ideal tool in determining the possible combinations resulting from the probability calculus. *Metastasis* (1954) for 61 performers is the composer's first computer-assisted work, with all parameters, including the articulations of the musical form, obtained by means of computer programs (Schwartz 1993, 348).

The analysis of the previous examples of how the computer was used in music reveals two types of approach: Xenakis', resulting in stochastic music, and Hiller's algorithmic music, the outcome of the two being a type of music which was ultimately to be played on traditional instruments. The computer was asked, in both cases, to solve the problems caused by the necessity to resolve a huge number of calculations. The results led to obtaining a particular instrumental texture structure at Xenakis and to identifying superior compositional decisions at Hiller (Schwartz 1993, 348).

In the same period of time, engineer Max Mathews (1926-2011) explored the computer's capacities in a different direction, that of digital sound generation, in the Bell Telephone Laboratories in Murray Hill, New Jersey. Starting with 1957, Mathews and his collaborators created several programs, among which Music 4 (1962-1963) attracted a great number of composers, such as James Tenney (1934-2006), Jean Claude Risset (1938-2016), Hubert Howe (born 1942), James K. Randall (1929-2014), Godfrey Winham (1934-1975). Through the efforts of Howe, Randall and Winham, an IBM computer was installed at Princeton University, so that in the 1960s composing with the help of computers was being conducted (in the USA) at Bell Telephone Laboratories and at the Stanford University, California and Princeton University, New Jersey (Schwartz 1993, 347).

Writing music with the help of the computer appealed, in addition to Iannis Xenakis, to other important European composers, such as Gottfried Michael Koenig (1926-2021), Pierre Barbaud (1911-1990), Luciano Berio (1925-2003) and Jean-Claude Risset. Koenig started focusing on algorithmic music based on mathematical analysis from 1964, when he was working at the Institute of Sonology in Utrecht, the Netherlands. Risset had worked for three years in the USA at the Bell

Laboratories with Max Mathews and upon his return to France founded, with Pierre Boulez (1925-2016), one of the most prestigious research centres dedicated to new music in its various forms (created by analog synthesis, digital synthesis, computer-assisted, and also on traditional bases), the IRCAM (Institut de Recherche et Coordination Acoustique/Musique), in 1977. Among Jean Claude Risset important computer-assisted works we find *Inharmonic Soundscapes* for tape (1977), a piece of remarkably complex timbrality, a reworking, with the aid of Music V and MIXSND, of his *Inharmonic* for soprano and tape composed also in 1977 and with a first performance in April 1977 at IRCAM, *Mutations* (1969) and *Sud* (1985) (Cope 1973, 154).

3. Composers, research centers and software

3.1. Composers

Compiling a list of established composers and researchers of electronic and computer-assisted music can be toilsome, given the number of authors and consequently of works. Here are some important names in alphabetical order:

Gérard Assayag	Richard Feliciano	Pauline Oliveros
Milton Babbitt	Kenneth Gaburo	Henri Pousseur
Pierre Barbaud	Karel Goeyvaerts	James K. Randall
Bebe Barron	Lejaren Hiller	Jean Claude Risset
Louis Barron	Hubert Howe	Karlheinz Stockhausen
Luciano Berio	Gottfried Michael Koenig	Morton Subotnick
Pierre Boulez	Otto Luening	James Tenney
Wendy Carlos	Bruno Maderna	Isao Tomita
Pierre Cointe	Max Mathews	Barry Truax
Alvin Curran	Olivier Messiaen	Vladimir Ussachevsky
Mario Davidovsky	Gordon Mumma	Edgar Varèse
Donald Erb	Luigi Nono	Iannis Xenakis

Table 1. *Electronic music composers*

As the first stage of the electronic music, concrete music authors had a major role in the development of electronic music, authors like Pierre Schaeffer, Pierre Henry, François-Bernard Mâche and François Bayle must be named. In 1951, Schaeffer succeeded in forming with the before mentioned composers the *Groupe de*

Recherche de Musique Concrète, later, in 1958, renamed *Groupe de Recherche Musicale* (Bay 2024, 115).

3.2. Research centers

Important research and composition centers in the field of computer-generated, digital and analog sound:

- IRCAM - Institut de Recherche et Coordination Acoustique / Musique, Paris;
- Institut International de Musique Électroacoustique de Bourges;
- Institute of Sonology at the Royal Conservatoire of The Hague, Netherlands (the institute was founded at Utrecht University in 1960 and moved in 1986 to the current location);
- Electronic Music Studios, Putney, London;
- Columbia-Princeton Electronic Music Center, New York;
- Center for Music Experiment, University of California, San Diego;
- The Center for New Music and Audio Technologies, University of California, Berkeley, California;
- Center for Computer Research in Music and Acoustics, Stanford University, California.

3.3. Music software

3.3.1. Early stages of music software

A tool utilised in elaborating musical compositions, the computer, or more precisely computer programs - conceived and employed also as compositional processes generating system - developed spectacularly in the last fifty years. This real challenge represented by the desire to obtain an optimal relation between the device operating exclusively with scientifically predetermined operations and music, a top field of artistic creativity, led to the appearance of a variety of accessible programs, more friendly interfaces as time passed, for the various types of computers.

Below are some of the music software created in the early stages and used in computer-assisted music, some of them being foundation for other software, some of them still in use in newer variants (information partly taken from Borza 2008):

- Music I (1957), Music II (1958), Music III (1959/1960), Music IV (1963), Music V (1966/1968) designed by Max Mathews at the Bell Laboratories;
- Music 360 (1968), designed by Barry Vercoe;
- Music 10 (1969), designed by John Crowning and James Moorer;
- Music 11 (1973), designed by Barry Vercoe;

- MP1 (1973), created by Sever Tipei;
- UPIC-A (1977), designed at CEMAMu by Iannis Xenakis and Guy Médigue;
- Chant (1979), designed at IRCAM and which synthesizes the voice;
- Synthetic Performer (1983), designed by Barry Vercoe and Pierre Boulez;
- Sound Designer (1985), designed by Digidesign;
- Csound (1985), designed by Barry Vercoe;
- MAX (1986), designed by Miller Puckette;
- Sound Tools (1989), designed by Digidesign;
- RTCsound (1990), designed by Barry Vercoe and Daniel Ellis;
- AudioSculpt (1994), designed at IRCAM;
- Extended Csound (1996), designed by Barry Vercoe;
- MetaSynth (1997), designed by Eric Wenger;
- OpenMusic (1997), designed at IRCAM by Gérard Assayag and Carlos Agon;
- jMAX (1998), designed at IRCAM by François Déchelle.

In the last decades, the big companies developing music software focused mainly on developing the already established software in a great number of versions: Steinberg Cubase, Steinberg Nuendo, Pro Tools, Logic, Ableton, Reason, Finale, Sibelius, Wave Lab, Sound Forge, MAX.

3.3.2. MP1 music program

In his article *The Computer: A Composer's Collaborator*, Sever Tipei (born 1943), composer and professor at the University of Illinois at Urbana-Champaign, shows his preference for using "comprehensive" programs with which to experiment the production of aleatoric sound events and the creation of numerous variants for the different works (Tipei 1989).

Tipei explains his complex MP1 program, "the aesthetics behind it", that is, how he designed it so that it would lead to the experimentation of areas of non-traditional musical structures (Tipei 1989, 189). The presentation of the way this program facilitates an innovative, non-traditional approach to music writing is illustrated with examples from his own *Cuniculi* (1986) for five tubas, composed with the aid of the computer, and is accompanied by a series of his beliefs, such as:

- music creators are more than artists, trying with the help of their own working tools, less rigorous than those of scientists, to explain their universe, their purpose in this world.
- indeterminacy and uncertainty are defining features of the physical world as we currently understand it, and the computer has the ability to produce structures

featuring aleatoric elements through probabilistic distributions with an objective result that can be experienced by the composer.

- in musical creation one cannot disregard indeterminacy and uncertainty as seen by Cage and Xenakis, just as physics cannot overcome quantum theory. What is accepted by science must be imagined and admitted in music too, so that art can be on the same frequency with "the course of society and its forecasts" (Tipei 1989, 191).

3.3.3. Modern computer programs

Currently, there is practically no field in which, in one form or another, the computer is not used. Of the multitude of questions raised by the relationship between man and scientific equipment, it is extremely important to understand the limits of the computer, namely its programs, which at the current stage of evolution can easily solve a multitude of necessary operations, without, however, being able to generate novel ideas.

The user applies judgments to concretize solutions necessary for the constructive strategy, but cannot program complex judgments to obtain superior reasoning. Therefore, the computer forces the user to restrict the area of their free thinking and permanently attune to the computer's possibilities of understanding.

More precisely, creative ideas, once formulated, are to be translated into operational systems, compatible with the capabilities of the electronic equipment. The obtained results become starting points for the emergence of other ideas in the practitioner's mind, continuing the creative chain from different evolutionary positions, according to the needs of each stage in the elaboration of the respective work. Of course, the shortcomings of restricting creative thinking to the level of the computer understanding can't be ignored, especially in arts, in music, where exceptions, deviations from systems, contribute effectively to conferring the brilliance of uniqueness.

Theoretically speaking, a computer placed at the disposal of a passionate user can transform him from a simple listener into a composer responsible for everything he produces, without the pretense of having his own musical ideas, unlike the professional composer who has an ideology of contemporary culture, through concepts that go beyond the moment of creation, who presents his own ideas, openings in the multitude of sound parameters and their combinations throughout the work (Brün 1979, 24).

Where will composition and performing be in the future, and what role will composers and performers have compared to what we know today? Will software still exist or will it all be replaced in time by AI? Where will AI composed music be in five, ten, twenty, fifty years from now? Time will tell…

4. Conclusions

During the last decades, the computer has become not only the electronic music composer's assistant in solving extremely complicated and numerous calculations that could be executed quickly and efficiently, but also a "performer" and a tool in live electronic processing. The stages that electronic music went through in a relatively short period of time make us wonder where music technology will reach in terms of multifunctional performance, tendency to miniaturize equipment, ease of use, etc.

What will the future bring to composition? It is an enigma, as superior technology does not intrinsically mean the creation of a better music. It is however certain, that for composers the richness of the electronic sound world and the possibility of entering novel acoustic spaces, where new sound colors, harmonics, formants, etc. are at their fingertips, will always represent an irresistible temptation (Schwartz 1993, 369).

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