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Article

The Mind Amplifier: Software Composition in José Vicente Asuar's COMDASUAR

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Abstract

This paper re-evaluates the significance of José Vicente Asuar (1933–2017), a pioneering figure in Latin American computer music, shifting the focus from the hardware construction of his COMDASUAR system to the innovative software he developed for algorithmic composition. While Asuar's hybrid digital-analog computer is noteworthy, the true core of his contribution lies in his original machine language programs designed for the Intel 8080 microprocessor. This study examines how Asuar thought about and designed algorithms specifically created for generating musical structures, processing symbolic data in real-time, and enabling interactive performance. By analyzing newly discovered handwritten notebooks containing his meticulous code documentation, we uncover Asuar's deep engagement with low-level programming to express complex musical ideas. His approach, focused on the computer as an "amplifier of the imagination," prioritized the development of software to facilitate generative composition and real-time manipulation of musical parameters. This paper argues that Asuar's legacy rests not solely on the COMDASUAR hardware but primarily on his visionary software architecture, which transformed the computer into a dynamic compositional partner. In doing so, he anticipated later developments in interactive music systems, demonstrating a pioneering approach to computer music that placed software innovation at its center.

Keywords: Asuar; COMDASUAR; computer music; electroacoustics; Chile

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1. Asuar and computer music

José Vicente Asuar (1933–2017), due to his dual role as both a composer and an electrical engineer, was undoubtedly the first Chilean composer to foresee the possibilities of music with computers. His interest in and the stages of his work with computer music are well documented in numerous writings, as well as in his musical works. The first mention of the possibility of computer music appears in his article *Fatalidades* (1969), published in the *Revista Musical Chilena*. In the text, which is dedicated to an aesthetic discussion on serialism and randomness, Asuar briefly touches upon the application of computers to music, noting that by that time something had been done, but "nothing significant" (Asuar 1969: 42). This statement could be seen as a lack of awareness of the achievements in the field of computer music up to that point. However, there is evidence that, despite Chile's geographical isolation, Asuar, through his frequent travels abroad and extensive correspondence, was well informed about the main topics of discussion in the musical field of the time. As he himself points out,

> Undoubtedly, the highlight of 1960 was my participation in the New Music courses held annually in Darmstadt, where I met many of the avant-garde elite of the time: Boulez, Stockhausen, Nono, Maderna, Ligeti, etc., attended their classes, engaged in dialogue with them, and listened to their music and comments. (Asuar 1975: 11)[1]

The radical nature of the statement in question relates to his view on the role the computer should play in musical composition, specifically in the generation of musical structures, which we will discuss further in this text.

Just a year later, Asuar, along with a group of students from the Sound Technology program he had founded at the Faculty of Arts at the University of Chile, initiated the project *Formas Probabilísticas Orientadas a la Creación Musical* (Formas I, Asuar 1972), which aimed to "develop a musical composition system that would be especially suitable to be solved by a computer" (Asuar 1972: 51). In this article, Asuar not only technically describes the project and its results but also defines the aesthetic use of computing in music as "an amplifier of imagination" (Asuar 1972: 45). In summary, the project involved defining a set of instructions that would allow the computer to generate alphanumeric sequences related to the main sound parameters defined by a probabilistic system that was neither serial nor tonal. These sequences would then be transcribed into musical notation, with the selection of timbres, instrumentation, and agogic being reserved for later. The programming, which consisted of "nearly one thousand instructions" (Asuar 1972: 64), was done in Fortran IV (Backus 1998), and the computer used was an IBM 360 belonging to the Faculty of Engineering at the University of Chile, which had been acquired in 1967. In addition to its academic use, this computer also processed payroll data for public employees in Chile.[2] The result of this

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[1]Translations of this and other texts made by the authors of this article.

[2]https://uchile.cl/noticias/224262/u-de-chile-y-el-ibm-360-pioneros-de-la-computacion-en-america-latina

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project was the chamber work *Formas I*, which premiered in December 1971 at the Isidora Zegers Hall of the Faculty of Arts, University of Chile. The premiered material corresponded to sequences 8, 17, and 21 out of approximately 30 sequences generated by the computer and transcribed by Asuar and team members.

As mentioned earlier, Asuar was aware of the evolution of computer music at the time and was familiar with the advances made by Max Mathews and Laurent Hiller, with whom he co-authored a technical report during his stay in 1973 at the University of Buffalo in New York. This report, titled "Programmed Control Analog Sound Generators by a Digital Computer," proved to be prescient for the next computer music project that Asuar would embark upon. In 1971, the *Laboratorio de Fonología Musical* was created at the Faculty of Arts, University of Chile. For this laboratory, an ARP-2600 synthesizer and various MOOG modules were acquired for synthesis, ring modulation, and filters, among others (902, 911, 904A, 904B, 904C, 6402, and 901). With this equipment, a project was carried out to explore the possibilities of voltage control of these modules using a PDP 8 computer located in the Department of Physics at the University of Chile's Faculty of Engineering. This project resulted in the 1973 release of *El Computador Virtuoso*. On one side of the record, an explanation of the possibilities of electronic music and the use of computers in music is provided by Asuar himself, along with sound examples that illustrate these possibilities, developed by the team (in addition to Asuar, Víctor Rivera, and Cristián Vergara). On the B-side, electronic versions of classical works by composers such as Ravel, Debussy, J. S. Bach, and Manuel de Falla can be heard. The purpose of the album was to disseminate scientific work, with 5,000 copies produced, all of which were sold. Some Latin American authors harshly criticized the work, such as Uruguayan composer Coriún Aharonian, who described it as insignificant and a copy of Walter/Wendy Carlos's album *Switched on Bach* (Aharonian 1992). However, the primary goal of the project, controlling analog modules with a digital computer, was successfully achieved. As Asuar himself states,

> We can say that the system proved to be operational, versatile, and flexible, and especially suited for contemporary music production and research into sound and its influence on human beings (Asuar 1973: 82).

The next project involved designing and building a computer dedicated exclusively to music that integrated the previous system: analog sound modules controlled by a microprocessor. Two key developments shaped this phase. In 1975, Asuar left the Faculty of Arts over disagreements about managing the lab, meaning he had no institutional support and carried out this project on his own. Secondly, the Intel 8080 microprocessor was released in late 1974, and its capabilities and size made such a project more feasible.

Although the exact start date is unclear, Asuar likely began working on COMDASUAR (Asuar's Digital-Analog Musical Computer) around 1975–76. His 1979 album *Así Habló el Computador* was entirely produced using this computer. Asuar sourced the components directly from manufacturers, including a CT 64 keyboard from Southwest Technical Products. He kept the user manual for the Intel 8080 board, annotated with his notes. Other parts came from dismantled telecom equipment or were handmade. This led Asuar to write that the computer was "affordable. Component cost less than US$1,000" (Asuar 1980: 8).

He described the computer's architecture and programming language in detail in a 1980 *Revista Musical Chilena* article. In addition to the educational album *Así Habló el Computador*, Asuar composed ten electroacoustic works using COMDASUAR between 1982's *Elegía* and *Cuatro Piezas Instrumentales* in 1989[3] (Gallegos 2017). Over time, he expanded the system with other equipment: a Yamaha CS 70M synthesizer (1982), an Ensoniq Mirage sampler (1984), a Yamaha TX 81Z FM tone module (1987), and a Yamaha SY 99 synthesizer (1991), as well as four Tokyo Electro-Acoustic Company (TEAC) tape recorders.

In 1989, Asuar ceased composing, abandoned music, and moved to Spain. This decision was due to several personal reasons, which he addressed in various interviews and in the documentary *Variaciones Espectrales* (Lértora 2016), reasons that have been discussed elsewhere (Fuentes and Schumacher 2021). José Vicente Asuar passed away in January 2017 in Santiago, Chile.

2. Historical context: Computer music in the global landscape (1960s–early 1980s)

The decades spanning the 1960s through the early 1980s were marked by vibrant and diverse experimentation with computing technologies in the arts, laying the foundation for what would become the field of computer music. These efforts took root in various centers across the United States, Europe, and Japan, reflecting different technological, aesthetic, and philosophical approaches. Despite these regional differences, these centers converged around two major paradigms: using computers to emulate analog sound synthesis and manipulation and employing computers to generate musical structures algorithmically. José Vicente Asuar's work, notably his emphasis on generative structures, positioned him as a key figure in the latter approach.

2.1. United States: Bell labs, hiller, cage, chowning, and algorithmic composition

In the United States, the most significant early developments in computer music occurred at Bell Telephone Laboratories. Max Mathews, with his creation of *MUSIC I* (1957), pioneered digital sound synthesis on the IBM 704 mainframe, laying the foundation for the field (National Academy of Engineering 2012). This marked the beginning of using computers for sound generation, and Bell Labs became a major hub for computer music research.

Lejaren Hiller further expanded these ideas, notably with his *Illiac Suite* (1957), which utilized the ILLIAC I computer to create the first fully realized computer-generated score. Hiller's approach was one of algorithmic composition, and his use of the computer to generate musical material directly influenced subsequent generations of composers exploring the intersection of music and technology (Hiller and Isaacson 1959:170–77). One of the key moments in the history of computer music came with John Cage's *HPSCHD* (1969), a collaboration with Hiller. In this work, Cage employed computer-generated chance operations to combine harpsichord fragments with synthetic and taped sounds. The piece is an early example of the integration of computers in experimental music, laying the groundwork for the algorithmic and stochastic aesthetics that would dominate much of the field's future development (Pritchett 1996: 159–161).

Following these pioneering figures, John Chowning's work at Stanford University in the 1970s further revolutionized the field. Chowning developed frequency modulation (FM) synthesis, a groundbreaking technique that would become a cornerstone of digital sound synthesis. His compositions, such as *Stria* (1977), utilized FM synthesis to explore new timbres and textures,

[3]Available on: https://archivoasuar.uchile.cl/

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expanding the expressive possibilities of computer-generated sound (Chowning 2007: 23–5). FM synthesis later became widely used in commercial music production, particularly with Yamaha's DX7 synthesizer in the 1980s (Chowning 1977: 46–54).

2.2. Europe: The legacy of Koenig and the emergence of algorithmic composition

In Europe, centers like the Westdeutscher Rundfunk (WDR) in Cologne, the GRM in Paris, and the RAI in Milan initially focused on analog sound synthesis and tape-based sound manipulation. These studios emphasized hands-on manipulation of recorded sounds, reflecting an early preference for electroacoustic music over pure algorithmic composition. However, by the mid-1960s, a significant shift toward algorithmic composition emerged, largely due to the work of composers like Gottfried Michael Koenig.

Koenig, after his work at WDR, moved to the Institute of Sonology in Utrecht, where he developed *Project 1* (1964) and *Project X* (1971), using stochastic processes and algorithmic rules to define musical parameters (Koenig 1970). These projects sought not to create sound directly but to generate compositional structures, thus aligning more with Asuar's own interests in algorithmic structure rather than sound synthesis. Koenig's systems exemplified a broader movement toward using computers to develop formal structures through rule-based systems.

While Koenig's systems were largely academic, their philosophical implications were profound. He proposed that composers should design systems for music generation rather than individual works, an idea that resonates with Asuar's 1972 statement that the computer is "an amplifier of imagination" (Asuar 1972: 45). Asuar's exploration of probabilistic logic in works like *Formas I* is a direct reflection of these generative approaches, albeit with a distinct emphasis on personal, hands-on programming and a more pragmatic approach to using available technology.

2.3. France: GRM, IRCAM, and the innovation of electroacoustic music

In France, the early developments in computer music were heavily influenced by the work at the Groupe de Recherches Musicales (GRM), founded by Pierre Schaeffer in 1958. Schaeffer's work in *musique concrète* focused on the manipulation of recorded sounds, a tradition that would evolve into the complex digital techniques used by composers like François Bayle and Gérard Grisey. The GRM would remain a critical center for sound research throughout the 1960s and 1970s, serving as a hub for technological innovation (Gayou 2025: 190–219).

A major turning point for French electronic music came in the 1970s with the founding of IRCAM (Institut de Recherche et Coordination Acoustique/Musique) in Paris by composer Pierre Boulez. IRCAM played a crucial role in the development of computer-assisted composition and real-time processing. It became a center for composers like Georges Aperghis, Jean-Claude Risset, and Tristan Murail, who incorporated cutting-edge computer technology into their works (The World of Music 1975).

One of the major figures of this era was American composer and trombonist George Lewis, who worked extensively with computer systems in the 1980s. His series of *Voyager* works (1986–) were some of the earlier explorations of interactive, real-time music-making using computer systems. His later work, particularly in live electronics, had a lasting impact on the trajectory of computer music and the development of algorithmic improvisation (Lewis 2000: 34).

The link between the U.S. and Europe in electronic music history is perhaps most vividly illustrated in the collaborations and technological exchanges that shaped the development of new musical tools. The development of the 4a, 4c, 4x, and other successors by Peppino di Giugnio on both sides of the Atlantic positions him as the precursor of much of the compositional design quests that fueled the development of computer-based tools for music creation in the decade of the 80s (Puckette 1991: 65–9).

2.4. Xenakis and the UPIC system

Iannis Xenakis, another key figure in the development of electronic music, made profound contributions to both the theoretical and technical aspects of computer music. Xenakis's work with stochastic processes in music led to the creation of the UPIC system (Electronic Unit for Polyphonic Information in Composition), a computer system he developed since 1977 at CEMAMu (Center for Studies in Mathematics and Automation of Music). The UPIC system allowed for real-time interaction with compositional processes using graphical interfaces and was an innovative tool for composers working with complex, algorithmically generated structures. Xenakis's contribution is significant because he linked the theoretical framework of stochastic processes with the practical application of computer technology, influencing the future of computer-assisted composition (Xenakis 1985: 329–34).

2.5. The emergence of interactive and performative computer music in Japan

In Japan, developments in computer music were initially shaped by analog electronic studios such as the NHK Studio in Tokyo. However, by the late 1970s, Japanese composers began integrating computer technology into their work, focusing particularly on real-time interaction and performance. Institutions like Keio University and Yamaha became key players in this shift, and their work contributed to a unique fusion of Western systems and Japanese musical aesthetics (Holmes 2020: 240–42). This combination resulted in highly interactive and performative systems, with composers such as Kenjiro Ezaki and Yuji Takahashi exploring the creative potential of these tools in their compositions (Shimazu 1994: 102–06).

The convergence of digital technologies and Japanese aesthetic sensibilities helped set the stage for later advances in real-time computer music performance. Unlike the purely structural applications in the U.S. and Europe, Japan's integration of these systems was more focused on live interaction and improvisation, offering a different angle on the evolving possibilities of computer music.

As we have seen, Asuar's innovative development of the COMDASUAR, a hybrid digital-analog music composition and performance system, was a significant contribution to computer music not solely in Latin America. Placed within this international panorama, Asuar occupied a singular position: not fully embedded in the institutional hubs of the United States, Europe, or Japan, yet in active dialogue with them through study, correspondence, and technological exchange. His trajectory was thus not isolated but entwined with the centers shaping computer music, while his work in Chile underscored the realities of creating outside those infrastructures. Adapting global models to local contexts and limited resources became a defining feature of his practice. This dual position – connected yet peripheral – highlights the originality of his contributions and situates him within a broader transnational history of computer music. Musically, his legacy is closely aligned

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with the early visions articulated by pioneers like Max Mathews and Lejaren Hiller – namely, that the true potential of computers in music lay not only in sound but in form, structure, and logic. His work anticipates later developments in interactive and hybrid systems of the 1980s, positioning him as an early visionary in the field.

3. The computer as mind amplifier

Beyond the technical and hardware dimensions involved in the various computer music projects undertaken by José Vicente Asuar, what stands out is his distinctive conceptualization of the computer's role in musical composition. "The computer is an amplifier of the imagination," he declared in a 1980 interview with Chilean television.[4] This notion recurs consistently across Asuar's writings and interviews. For instance, following the release of *El Computador Virtuoso*, he evaluated the project in the following terms:

> Personally, I am only partially satisfied with this album, since the most interesting and important thing that can be done with this system is to create music. In this case, there was no creative compositional work; rather, creativity was directed toward the interpretation and 'electronic orchestration' of traditional pieces. Thus, there remains work to be done, which I hope to complete one day. (Asuar 1975: 19)

Asuar clearly envisioned the computer not merely as a tool for sound synthesis but as a catalyst for creative exploration and compositional development. In an interview with composer Andrés Burbano, he further articulated this dual role:

> The process of conception was, in a way, the convergence of two previous experiments – one that employed the computer as a tool for composition and musical creation, and another that used it as a mechanical device to perform a piece. Both approaches required the guidance of a trained human mind. The goal was to develop an instrument capable of serving both functions: to assist the composer's creativity and to immediately render the resulting sounds – in other words, real-time audio feedback. (Burbano and Nieto 2008: 3)

To support compositional creativity, Asuar developed a series of software applications in machine language, often reconfiguring code that had not originally been intended for musical purposes. As he noted:

> Even a person who is familiar with the software of the 8080, I believe that from seeing that, it is not possible to understand some things, because some instructions were used for something completely different from what they were invented. (Burbano and Nieto 2008: 4)

Despite his lack of formal training in computer science, Asuar taught himself subjects such as systems analysis, programming, and computer architecture (Asuar 1975: 18). He referred to the resulting applications as *heuristic programs* – algorithms designed to efficiently generate viable (though not necessarily optimal) solutions to complex creative problems. He elaborated:

> With these elements I did a few games – it surprised me, all the things you can do, the enormous variety of things obtainable from the code. I conducted many such experiments and spent memorable times doing so. I'll say something – we called them 'heuristic programs.' In fact, the term heuristic programming is known, and such programs differ from orthodox, traditional ones in that they do not 'solve' anything in the conventional sense. (Burbano and Nieto 2008: 4)

These heuristic programs played a central role in Asuar's compositional process, particularly in his electroacoustic works from 1980 to 1989. They also featured in the track "Así Habló el Computador," in which "a numerical series and several arithmetic games were used to determine the rhythm of some of its voices" (Asuar 1980: 18).

In the same article, Asuar classified the software he developed for the COMDASUAR system into multiple categories. Under the heuristic programs category, he listed subprograms such as *Canon*, *Retrogradation*, *Transpose Pitches*, *Transpose Durations*, *Probability*, and *Insert Group of Durations* (Asuar 1980: 9). While his descriptions of these programs were often concise, they offer insight into his compositional strategies. For instance, regarding *transpose pitches*, he wrote:

> To use this program, at least two voices must first be entered into memory. That is, the pitch values of the tones in the two voices are permuted, while the durations remain unchanged. In practice, the program is somewhat more sophisticated, as it allows the user to specify from which tones in each voice the transposition is to begin. This makes it possible to quickly and audibly test a wide range of transpositional variants. (Asuar 1980: 16)

In conclusion, Asuar's writings also reveal a prescient vision for the future of computer-based musical interaction, anticipating developments that are now standard in both composition and performance contexts. His speculative reflections underscore not only his pioneering status but also his forward-thinking approach to the integration of technology in music:

> Other input elements: there exists a wide array of sensors responsive to touch, temperature, light, sound, etc., which could be employed to input scores or musical ideas into the computer. While it would be too lengthy to delve into all of these possibilities, I wish to highlight the field of optoelectronics, which will enable computers to be controlled through light, movement, gesture, mime, or dance. One can imagine a new kind of concert or musical performance in which the resulting sounds are largely determined by data transmitted through these means. (Asuar 1980: 27)

Therefore, as we have argued elsewhere, Asuar and COMDASUAR formed what is known in extended cognition as functional coupling (Krueger 2018; Fuentes and Schumacher 2021), wherein the composer and the computer become part of a single, codependent compositional system. Their individual cognitive processes are enhanced through the integration of new capabilities provided by an external device, resulting in an integrated system that works collaboratively to produce a final output: the musical work. This human-machine integration is most evident in the software development process, which we will describe in more detail below.

4. COMDASUAR as a software tool for musical composition

Martín Fumarola (1998) highlights José Vicente Asuar's exceptional dual expertise in music and engineering as foundational to the creation of the COMDASUAR. While many Latin American composers of the time operated in relative isolation, Asuar demonstrated a rare and rigorous awareness of international developments in computer music, including the work of Hiller, Mathews, and Xenakis. This informed both his theoretical grounding and the technical sophistication of the COMDASUAR. Fumarola emphasizes that Asuar not only understood the emerging distinction between supercomputing and microcomputing but also leveraged the Intel 8080 to build the first Latin American system for computer-based composition and performance. His prior work with probabilistic processes in FORTRAN, notably in *Formas I* (1970), laid the conceptual groundwork for the compositional strategies embedded in the COMDASUAR.

On the software side, Fumarola stresses the system's richness and modularity: 26 core subprograms stored in EPROM (labeled

[4] https://www.youtube.com/watch?v=z0EFvO8kdaE

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A–Z) and a range of additional routines loaded from cassette expanded the system into a customizable musical environment. These programs were grouped into command handling, data editing, heuristic procedures, real-time sound generation, and peripheral control. Particularly significant is the heuristic layer, which included canonical transformations, retrogradation, probabilistic structuring, and transmutation of pitch and rhythm. Fumarola also details how Asuar designed symbolic input modes to streamline score entry and reduce redundancy, enabling interaction through textual codes rather than traditional notation. With real-time performance capabilities, six-voice polyphony, and a robust software framework rooted in assembly language, the COMDASUAR emerges as not only a technical achievement but also a profound reimagining of the computer as a compositional partner.

In the mid-1970s, the Intel 8080 microprocessor represented a major step in making computing accessible for individual developers and experimenters. Programming the 8080 required direct engagement with its 8-bit instruction set, consisting of simple operations such as data movement (MOV, LDA, STA), arithmetic (ADD, SUB, INR, DCR), logic (ANA, ORA, XRA), and control flow (JMP, CALL, RET, JZ, JNZ, etc.). Each instruction corresponded to a specific hexadecimal opcode and could operate on the processor's limited set of registers (A, B, C, D, E, H, L). Developers wrote code in assembly language, mnemonic shorthand for machine instructions, and then used an assembler to translate the code into executable binary. Without operating systems or compilers in early microcomputer setups, programmers worked "close to the metal," manually managing memory, timing, and I/O, often using hex editors, monitors, or hand-assembled code.

For musical applications, this meant the composer-programmer had to define everything: symbolic representation of musical data, timing logic, real-time interaction with hardware, and sound output. There were no libraries or musical Application Programming Interfaces (APIs), but instead, one had to create custom routines to handle pitch encoding, duration, polyphony management, and I/O coordination with sound generators such as DACs or analog synthesizers. Musical input could be entered as hex-encoded events in memory or through symbolic systems of the programmer's own design. Output typically involved writing to parallel ports or addressable DACs to control voltage levels corresponding to pitch or amplitude. Timing, a critical concern for musical expression, had to be handled with either internal counters, software loops calibrated in cycles, or hardware interrupts triggered by external clocks or peripherals.

Given these constraints, options for writing computer code for music in the 8080 era were limited to bespoke solutions custom-built by composers with engineering knowledge. Commercial alternatives were rare and generally inaccessible outside large institutions. Systems like Max Mathews's GROOVE, one of the first digital systems to enable real-time interaction between a performer and a computer-controlled synthesizer (National Academy of Engineering 2012), or EMS MUSYS, an early digital sampling and control platform built on dual PDP-8 minicomputers (Morgan 2021), offered integrated environments but required costly hardware and mainframe support. In contrast, programming music on the 8080 was an act of deep integration between composition and electronics: the programmer had to think musically in terms of bytes, flags, and subroutine calls. This environment demanded not just technical fluency but also inventiveness in designing new musical logics – exactly the kind of cognitive and creative territory explored in the COMDASUAR.

While José Vicente Asuar's work was undoubtedly a remarkable example of do-it-yourself computer engineering, its lasting significance in the history of computer music lies not in its hardware but in the originality and depth of its software architecture. Asuar's system was assembled from largely commercial or salvaged components, using the Intel 8080 microprocessor as the basis but also a CT-64 ASCII keyboard and standard analog synthesis circuits. Yet it was the software, written in pure 8080 machine language, that transformed this modest configuration into a living musical system.

In October 2024, the authors of this article visited Asuar's home in Calera de Tango, a locality near Santiago in Chile. Asuar's family has stored many of his belongings in a specially designated storage area of the house. Not only can the famous COMDASUAR be found there, but also many speakers, synthesizers, old computers, cables, and a handful of handwritten notebooks, which have been unknown to the academic community until now. Asuar's meticulous approach to documenting his computer code is particularly noteworthy. Instead of relying on the printed output of a compiler or assembler, he undertook the laborious task of transcribing the entire source code by hand into several personal notebooks. This act of manual documentation provides a fascinating glimpse into the early days of computer programming, where the physical act of writing code was often intertwined with the conceptualization and design processes. This handwritten record serves not only as a testament to Asuar's dedication and thoroughness but also as a unique artifact that captures the essence of his creative and technical work at a fundamental level. These notebooks, filled with handwritten instructions and notations, circuit diagrams, and formulas, stand in stark contrast to the digital documentation methods prevalent today, highlighting the tangible and intellectual investment required in the nascent stages of computer science and electronic music.

During this visit, we had the privilege of inspecting both the interior of the COMDASUAR (Figure 1) and the full contents of these notebooks (Figure 2). By inspection, we could determine that Asuar indeed incorporated already existing oscillators, Attack, Decay, Sustain, Releases (ADSRs), and filters into the hardware, as well as the Intel 8080 processor and Universal Asynchronous Receiver-Transmitter (UART) serial communication circuits for handling the keyboard and screen.

Among the clearest and most compelling examples of Asuar's way of thinking and designing software can be found in one of those notebooks, where he documented a series of unpublished routines. One such example is a routine that he labeled Programa I (Figure 3). This routine represents a miniature musical operating system designed for real-time interpretation and sound production. It is not a known composition nor a publicized module but rather a skeletal execution core that reveals Asuar's thinking from the ground up: musical structure expressed directly in microprocessor code. Programa I is written entirely in Intel 8080 assembly, using no abstraction layers or external libraries. It handles real-time musical event processing by interpreting symbolic data from memory, reacting to external input signals, and dispatching control to a set of modular subroutines. The code is highly compact, yet carefully structured around decision branches, hardware polling, symbolic condition evaluation, and temporal control. Each subroutine is named in Spanish by Asuar and corresponds to a distinct musical or logical function: BORRA (Erase/Clear) clears memory or display; COMIENZO initializes the system; CALCULA (Calculate) processes values related to duration or pitch; CONTADOR updates counters or interface displays; WAIT halts execution until a synchronization signal is

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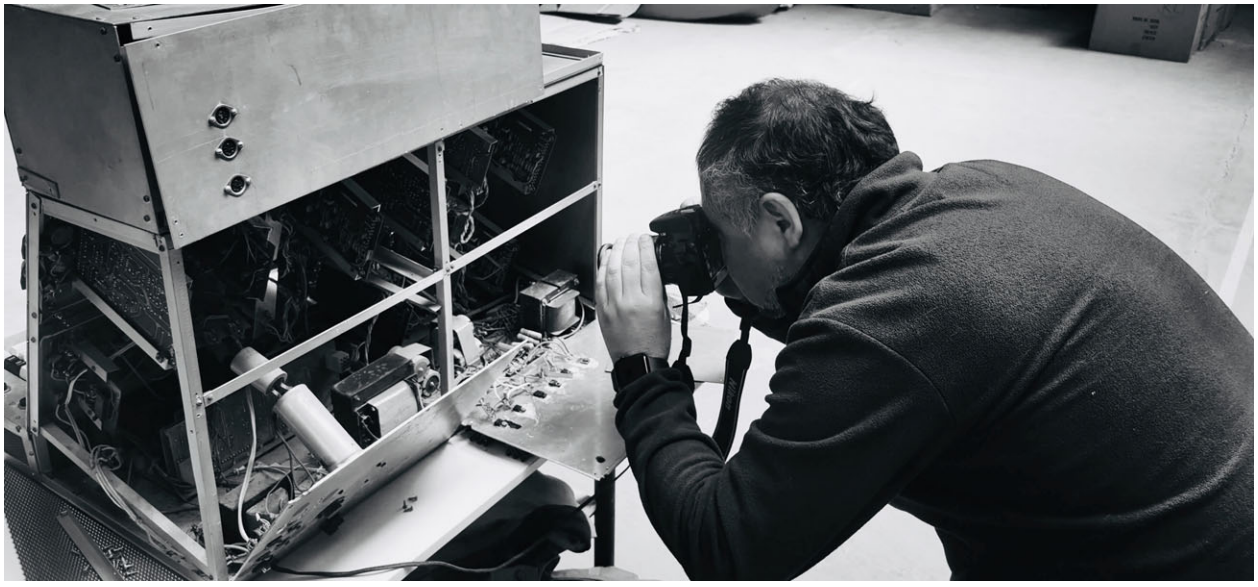


Figure 1. One of the authors is inspecting the interior of the COMSADUAR. Picture taken by Juan Parra.



Figure 2. Asuar's handwritten notebooks. Picture taken by Federico Schumacher.

received; DISTRIBUIDOR interprets symbolic input or control bytes; SPACER generates pauses or inserts structural spacing; TONO (Tone) computes and triggers sound output; CAMBIA OCTAVA modifies the register of events; ACEPTA (Accept/Set Parameter) performs memory operations related to parameter setting; CONS OUT projects output to display or peripheral;

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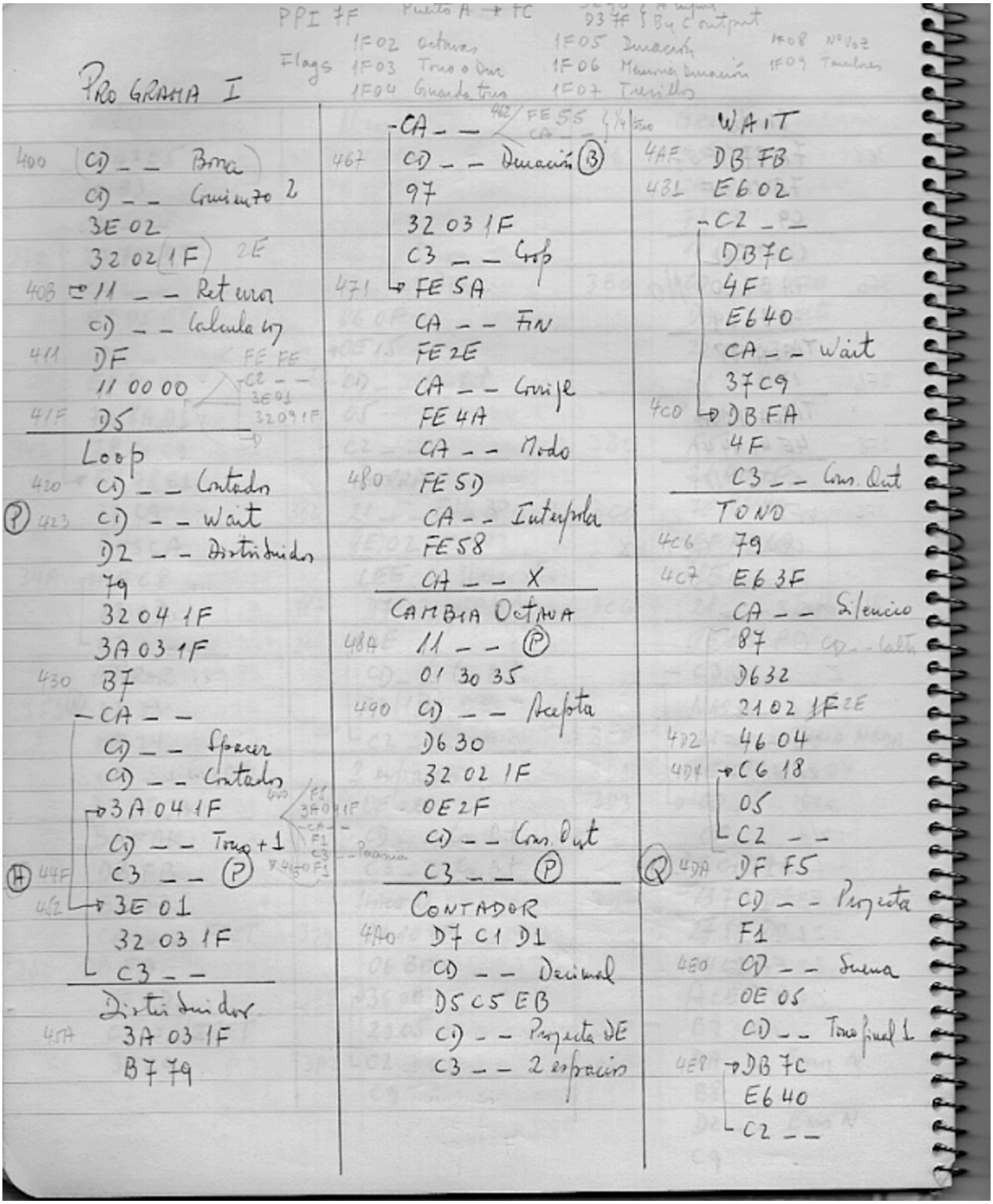


Figure 3. Scan of Programa I. This computer code, written in Intel's 8080 assembly, can be found in one of Asuar's handwritten notebooks. This figure shows the first page, written by Asuar himself.

TONO+1 increments pitch data; TONO FINAL 1 completes the tone event; SILENCIO handles null output; PROYECTA and SUENA (Sound/Play) execute screen and DAC output; CORRIGE, INTERPOLA, and MODO respond to specific symbolic instructions stored in memory; and FIN terminates the process.

A schema of this program is the following:

1. INIT
   - Clear state (BORRA)
   - Initialize system (COMIENZO 2)
   - Set control flag (STA 1F02h)

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2. CALL CALCULA
   - Prepare duration/pitch parameters
3. LOOP
   - CALL CONTADOR; update time/display
   - CALL WAIT; wait for external sync (IN 0FBh)
   - IF sync received:
     → CALL DISTRIBUIDOR; check for symbolic control codes
     → IF 1F03h = FE 5A: CALL FIN
     → IF 1F03h = FE 4A: CALL MODO
     → IF 1F03h = FE 5D: CALL INTERPOLA
     → IF 1F03h = FE 2E: CALL CORRIGE
     → ELSE: continue
   - LDA 1F03h
     → ORA A
     → IF zero: JUMP to SPACER (silence)
   - CALL CONTADOR; update counter again
   - LDA 1F04h
   - CALL TONO + 1; possibly increment pitch
   - CALL TONO
     → process pitch byte:
     → mask (ANI 3Fh)
     → adjust (ADD/SUI)
     → output to DAC (CALL PROYECTA, SUENA)
   - JUMP LOOP; repeat process
4. Additional Routines (called conditionally)
   - CAMBIA OCTAVA; change register/octave
   - ACEPTA; memory input/output
   - CONS OUT; visual/status projection
   - Tono final 1; finalize tone
   - SILENCIO; suppress output

After a careful inspection of this code, multiple lines of evidence indicate that Programa I was designed for real-time operation within the COMDASUAR system. First, the routine includes explicit I/O polling instructions, which are characteristic of hardware-level synchronization, pausing execution until an external trigger is received. This structure forms the basis of a timing mechanism aligned with real-time playback. Second, Programa I reads symbolic musical data from memory, evaluates it immediately using conditional branches, and dispatches it to output routines like TONO or Suena, which perform bit masking, pitch calculation, and direct DAC output. These behaviors reflect an interpreter operating synchronously with a performance clock. Third, Asuar himself confirmed in his 1980 writings that the COMDASUAR "composes and plays in real time" (Burbano and Nieto 2008: 4), directly interpreting musical data and producing sound without delay. This is further corroborated by the architecture of Programa I, which integrates transformation logic and tone output within a continuous loop. Together, these elements demonstrate that Programa I is not a batch processor or score generator but a reactive control program built for real-time musical execution.

Program I incorporates a flexible mode system ("MODOS") that governs how symbolic input is interpreted and transformed during execution. These modes are implemented through conditional branching based on specific byte values stored in memory. When the dispatcher routine (DISTRIBUIDOR) encounters specific control bytes, execution jumps to subroutines labeled MODO, INTERPOLA, or X, respectively. Each of these modes alters the behavior of the program by modifying how pitch, duration, or structure is processed, thus enabling operations such as interpolation between values, insertion of rests or groups, or application of probabilistic variation. The design allows the COMDASUAR to shift interpretative logic dynamically at runtime, effectively reprogramming its musical behavior on the fly. This system of symbolic mode-switching illustrates Asuar's vision of a compositional machine capable of transforming its own rules mid-performance, using compact byte-level control codes as gateways to complex musical logic.

The structure of Programa I can be described as follows. After a basic initialization phase that clears state variables and stores a startup flag, the routine sets up return pointers and calls CALCULA, likely to configure system timing or load basic playback parameters. Execution then enters the LOOP routine, which forms the heartbeat of the system. LOOP calls CONTADOR to increment counters (possibly visible on-screen), then WAIT, which polls the PPI (programmable peripheral interface) by reading I/O ports and checking specific bits. If the proper condition is met, such as the end of a timed pulse or trigger input, the routine jumps to DISTRIBUIDOR. This central dispatcher reads a command byte and evaluates it using a series of comparisons (CPI and JZ). Specific values such as 5Ah, 2Eh, 4Ah, 5Dh, and 58h correspond to known control codes: FIN, CORRIGE, MODO, INTERPOLA, and others. Depending on the match, execution transfers to the respective routine, modifying internal state, applying transformations, or updating pitch and duration arrays.

If no symbolic control is triggered, the LOOP resumes. The value at the memory location is checked to determine whether the tone is silent. If not, execution proceeds to CONTADOR again, then loads the pitch and calls the routine labeled Tono+1. This likely advances a counter or modifies frequency and finally dispatches to TONO. In this subroutine, the pitch byte is masked, compared against zero to detect silence, and adjusted with arithmetic operations (ADD, SUI) to derive frequency control values. These are then sent to the DAC via OUT instructions after some intermediary computation and memory projection using PROYECTA and SUENA. The execution returns to LOOP and continues processing the next symbol.

Other routines embedded in Programa I perform structural functions. CAMBIA OCTAVA shifts an entire voice to a different register, using memory displacement. ACEPTA accepts or sets a parameter. CONS OUT sends status to a console or screen. SILENCIO suppresses tone output. Tono final 1 may be a terminal call that handles the end of an event. WAIT uses input from the PPI to synchronize execution with external timing signals, forming the temporal grid that supports real-time output. Notably, all these operations are executed without any operating system, multitasking environment, or high-level interpreter: the logic is linear, immediate, and explicitly structured for musical timing.

Programa I thus functions as a symbolic interpreter, state machine, and tone generator all in one. Musical instructions are encoded in memory as bytes and interpreted one at a time, allowing live playback of musical sequences stored in RAM. The simplicity of the instruction set belies the expressive potential of the code, which branches and reacts to content using jumps (JZ, JNC, CALL) and manipulates flags with subtractions and bit masks (ANI, SUI, ORA). Rather than serving as a general-purpose sequencer, Programa I performs selective evaluation: it looks at the meaning of input data and dispatches accordingly – silence, tone, transformation, or control logic.

Programa I exemplifies Asuar's heuristic approach to composition by functioning as a modular interpreter rather than a fixed sequencer. Each routine – whether handling pitch, silence, control commands, or transformations – is a compact decision node that responds dynamically to symbolic input. Instead of following a

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predetermined score, the program evaluates and reacts to data in real time, allowing the system to generate structure through branching logic and condition-based flow. In doing so, Asuar encoded a compositional mindset directly into machine language, where the computer becomes a partner in musical exploration rather than a passive executor.

Compared to contemporaneous systems such as Max Mathews's GROOVE, which relied on graphical consoles and slider interfaces, or EMS MUSYS, which employed scriptable symbolic languages, Asuar's Programa I is entirely embedded in hardware. It interprets and reacts in real time, forming a self-contained musical system without reliance on external input beyond a keyboard and a timing pulse. What distinguishes Asuar's approach is not only that it is written in raw 8080 machine code but also that it is constructed from musical thinking. The instructions in this code are not just programmatic steps: they are compositional decisions rendered at the byte level. Asuar's software is not an extension of a synthesizer but a generative engine that interprets symbolic time-based structures in performance.

This style of programming, low-level, modular, and heuristic, was central to Asuar's philosophy of the computer as "an amplifier of the imagination." In Programa I, the machine does not merely execute instructions; it interprets events, decides on output, and transforms musical symbols into audible gestures. The modularity of the routines, labeled with clear musical roles (e.g., CAMBIA OCTAVA, INTERPOLA), underscores his approach: to encode musical structure as computational flow, using the simplest tools available. It is this conceptual compression – score, interpreter, and synthesis engine collapsed into a few hundred bytes – that positions Asuar's software work as visionary. Unlike systems developed with institutional support and higher-level programming languages, COMDASUAR was coded directly from musical logic to machine logic. The result, as exemplified by Programa I, is a minimal but expressive machine for sound, thinking, and composition.

5. Conclusions

José Vicente Asuar stands as a highly important figure in the nascent history of computer music, his contributions characterized by a remarkable synthesis of artistic foresight and rigorous technical mastery. More than simply recognizing the potential of computational tools for musical expression, Asuar actively engaged in the creation of one of the very systems and software that would unlock these possibilities. His intellectual and creative trajectory, beginning with initial explorations into probabilistic musical structures and culminating in the development of the comprehensive COMDASUAR system, vividly illustrates his pioneering spirit in seamlessly integrating the cutting-edge technology of its time with the intricacies of musical composition. Asuar's core conviction, viewing the computer not merely as a tool but as a profound "amplifier of the imagination," fueled his relentless pursuit of heuristic programs written directly in machine language. This demanding approach pushed the technological boundaries of early microprocessors, enabling him to forge a uniquely personal and deeply innovative methodology within the burgeoning field of computer music composition.

A particularly significant aspect of Asuar's legacy lies in his meticulous documentation of his creative and technical processes. His handwritten code notebooks serve as invaluable primary source materials, offering unparalleled insights into the foundational stages of both computer science and electronic music. Within these meticulously kept journals, detailed routines such as Programa I provide concrete evidence of his deeply interwoven approach to musical thought and low-level programming techniques. Programa I, for instance, embodies Asuar's core philosophy, functioning as a versatile modular interpreter, a sophisticated state machine, and a fundamental tone generator all within the integrated framework of the COMDASUAR system. Asuar's distinctive method of translating intricate musical structures into the language of computational flow, employing seemingly simple instructions to achieve remarkably complex sonic transformations, clearly distinguishes his work from that of his contemporaries. This approach underscores his truly visionary perspective on the potential for profound and interactive musical experiences mediated by computer technology.

In conclusion, the significance of José Vicente Asuar's contributions to the realm of computer music extends far beyond mere technical innovation. His work embodies a profound and enduring conceptual depth, representing a pioneering exploration into the intricate and evolving relationship between the boundless capacity of human creativity and the structured logic of computational systems. Although the symbol of Asuar's contribution to the computer music field is the COMDASUAR, a piece of sophisticated hybrid analog and digital hardware, we believe that his true legacy lies in his exceptional ability to transform abstract musical ideas into tangible and functional software, effectively harnessing the power of the computer as a versatile instrument for both the act of composition and the dynamic experience of performance. The detailed inspection of both the COMDASUAR hardware and, especially, the handwritten code, accessed here for the first time by researchers, has proved decisive, as it demonstrates with concrete evidence how Asuar's visionary software architecture fully embodied his conception of the computer as an amplifier of imagination. His unwavering dedication, remarkable technical expertise, and uniquely insightful artistic and engineering perspective have firmly established his position as a pivotal and foundational figure in the history of computer music, whose groundbreaking insights continue to resonate deeply and inspire new generations of artists and technologists today.

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