The MARS Station: Algorithm Design and Real Time Performance

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Abstract
Since the first announcement of the MARS station (ICMC '92), the workstation developed by IRIS has evolved in several ways: it is now open to user-defined modules and applications, its user interface has been improved, and the underlying software architecture has been redesigned while being ported to different target platforms. During the development of MARS, an object library has been built to give access to the station and to control the interaction in a more flexible way. The use of different fast communication links allows easier data exchange with MM1000 board. Furthermore, a number of applications have been developed by early users and IRIS internal staff: these applications contribute to make MARS more powerful and easy to use.

1. Introduction
The Musical Audio Research Station (MARS) is a specialized digital machine and a software environment for real-time audio applications [Andreacci et al., 1992]. Developed by the Italian research institute IRIS (Istituto di Ricerca per l'Industria dello Spettacolo), MARS has been conceived as an interactive and integrated environment for audio research, musical production, and computer music pedagogy. The easy and intuitive user interface provides a means of graphic definition for audio objects and an immediate sound feedback.

MARS is a development system for every type of real-time digital signal processing such as synthesis, analysis, filters, and sound effects. It is also a development system for sound and MIDI environments that allows programmers to use it, once configured, as a musical MIDI instrument or any MIDI piece of equipment in a musical studio. Since the first announcement of the station, the software of MARS has been redesigned in order to achieve greater flexibility, portability [Maggi and Prestigiacomo, 1993], user-friendliness, and ease of access by those who want to develop custom applications [Andreacci et al., 1993].

2. MARS and the research on sound
The common line that crossed the entire range of researches and experiments in computer music from its beginning, has been the need for a new relationship between the composer and the instrument. The synthesis equipment used for the generation of sound, from the early microcomputers to the specialized DSP or the internal cards of personal computers, has dramatically changed in cost and dimensions. While hardware equipment has become more simple and powerful, software environments have become of main importance in computer-based musical systems.

In the MARS workstation, musicians have access to the computing power of the system by expressing the instrument in terms of the generating algorithms and the related parameters, placing and connecting modules in a graphical workspace. The MARS main editor, EEDIT, allows the definition of the links between the algorithm's parameters and the incoming MIDI signals, as well as the archiving of algorithms, timbres, MIDI setups, and orchestrations. The current real-time implementation of the graphical user interface is based upon four main editors which allow:

* Graphical design of algorithms

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• Definition of the algorithm's parameters and their link to MIDI controls
• Specification of orchestrations as a collection of parameters in terms of number of voices, entry points and audio routing
• Linking of timbres to MIDI channels.

Four secondary editors provide a mean for the definition of parameters, LFOs, envelopes and tables.

The musical programmer has an even deeper access to the resource of the system by writing their own code on different host platforms. This allows for the design of fine-tuned applications for special purposes and custom controls. The software architecture of MARS is now built on a well-founded, object-oriented base: the possibility for the expert user to create external DSP modules has been the first step toward an open audio system, which is programmable from different platforms, and whose results are portable among those platforms.

The first version of MARS was available on ATARI: a great effort is currently in progress in IRIS in order to make the workstation portable across the most common platforms (Macintosh/Windows), in terms of:
• graphic user interface
• algorithms and data
• external modules developed by users
• early applications developed by the internal staff and external developers.

The direction of these researches is toward the definition of a system which is open to contributions coming from different users and fully-programmable at different levels of depth, from the acoustic level, to the MIDI configuration level, up to the development of whole applications.

3. The results

Several years of work with the MARS workstation have produced a considerable amount of applications and examples written by IRIS researchers and by external users.

The classical synthesis algorithms have been implemented on the station: Additive, FM, Non-linear distortion, subtractive synthesis, PCM, etc., allowing the most pedagogical usage.

A number of applications have been carried out in the area of modeling of acoustic phenomena, with the collaboration of important research centers. Among them, finite elements (springs and masses) simulations, Karplus-Strong and dispersive/dispersive algorithms for the vibrating strings [Paldin and Rocchiesso, 1992] and clarinet flute modeling.

The voice synthesis is one of the most representative applications of the system; several format and LPC algorithms were studied and implemented [Arman et al., 1994] in order to simulate the human voice, giving raise to algorithms for acquisition, analysis and synthesis of singing and speech signals.

A number of programs have been developed for the MARS station; the main application of the system is its editor, EDIT20: it allows the communication with the board, the design of algorithms, the definition of parameters, and the construction of timbres and orchestrations.

Other applications are currently based upon the APPL20 toolkit [Andreassi et al., 1993], written for the ATARI platform. Among them, a 2048-point real-time FFT, a recording (sample) application, and several musical examples, spanning from the additive synthesis to the use of chaotic maps in the generation of musical ideas.

The MARS board has the capability of processing incoming signals, by means of its four ADCs. Some of the signal processing possible with MARS are Phase shifting, Re-ereberation, Spatialization, Effects like Leslie and Chorus, Equalization, Pitch shifting, Harmonizing. For this capability, MARS is a very powerful system to produce works of computer music and live electronics performances and is currently used by many universities and research centers.

4. References


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