

The MARS Station: Algorithm Design and Real Time Performance

Enzo Maggi

Fabio Armani

IRIS S.r.l.
Parco La Selva 151
03018 Paliano (FR) ITALY
Fax +39 775 533343 - Tel +39 775 533441
E-mail: mc2842@mclink.it

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 SM1000 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 [Andrenacci *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 interactive 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 analysis, synthesis, filters, and sound effects. It is also a development system for sound and MIDI environments that allows musicians 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 Prestigiaco, 1993], user friendliness, and ease of access by those who want to develop custom applications [Andrenacci *et al.*, 1993].

2. MARS and the research on sound

The common line that crossed the entire range of researches and experimentations in computer music from its beginning, has been the need for a new relationship between the composer and the timbre. The synthesis equipment used for the generation of sound, from the early minicomputer implementations of MUSIC-V to the specialized DSP on the internal cards of personal computers, has dramatically changed in cost and dimensions.

While hardware equipments 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 timbre in terms of the generating algorithms and the related parameters, placing and connecting modules on a graphical work area.

The MARS main editor, EDIT20, 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 orchestras. The current real-time implementation of the graphical user interface is based upon four main editors which allow:

- Graphical design of algorithms

- Definition of the algorithm's parameters and their link to MIDI controls
- Specification of orchestras as a collection of algorithms described 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 acoustical 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 also a 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/dissipative algorithms for the vibrating strings [Paladin and Rocchesso, 1992] and clarinet/flute modeling.

The voice synthesis is one of the most representative applications of the system; several formant and LPC algorithms were studied and

implemented [Armani *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 orchestras.

Other applications are currently based upon the APPLI20 toolkit [Andrenacci *et al.*, 1993], written for the ATARI platform. Among them, a 2048-point real-time FFT, a recording (sampler) application, and several musical examples, spanning from the additive synthesis to the use of chaotic maps in the generation of musical tones.

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, Reverberation, 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

- [Andrenacci *et al.*, 1992] Paolo Andrenacci, Emmanuel Favreau, Nicola Larosa, Angelo Prestigiacomo, Claudio Rosati and Sylviane Sapir. *MARS: RT20M/EDIT20 - Development tools and graphical user interface for the sound generation board*. Proceedings of ICMC, San Jose 1992.
- [Andrenacci *et al.*, 1993] Paolo Andrenacci, Fabio Armani, Angelo Prestigiacomo and Claudio Rosati. *APPLI20: A Development Tool for Building MARS Applications with an Easy to Use Graphical Interface*. Proceedings of 10th Italian Colloquium of Computer Music, Milano 1993.
- [Armani *et al.*, 1994] Fabio Armani, Andrea Paladin and Claudio Rosati. *MARS Applications Using APPLI20 Development Tools: a Case of Study*. Proceedings of ICMC, Aarhus 1994.
- [Maggi and Prestigiacomo, 1993] Enzo Maggi and Angelo Prestigiacomo. *Portability of the MARS system*. Proceedings of 10th Italian Colloquium of Computer Music, Milano 1993.
- [Paladin and Rocchesso, 1992] Andrea Paladin and Davide Rocchesso. *A Dispersive Resonator in Real-Time on MARS Workstation*. Proceedings of ICMC, San Jose 1992.