A.G.A.T.A.: A GUI for Ando's Temporal Analysis

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A.G.A.T.A. is a Matlab-based interface which implements literature methods and original proposals concerning analysis methods of sound signals to extract the parameters used in the Ando's theory of subjective preference.
Main requirements for the software package are the robustness of the implemented algorithms and the user control over each evaluated quantity. In this regard, all the parameters needed for any specific computation are user-selectable to give complete control on the performed computations.
In this way the software offers to the user many possibilities, i.e. wide versatility. The completeness of the features and the availability of a graphic user interface (GUI) make temporal analysis easier and useful.
The A.G.A.T.A. software is primarily a research tool due to the wide set of possibilities it offers, but it can also be used by other type of users.
Some examples of temporal factors extracted from different sound signals are proposed.

1. INTRODUCTION

In the last years the authors of this work studied the existing methods and proposals for the running analysis of the significant factors extracted from the auto correlation function of sound signals (ACF). Considerations and proposals may be found in [1] [2] [3].

One of the goals of the cited articles has been the use of nonlinear preprocessing which select only the local maxima contributing to extract the correct value of a certain factor. A simply overview on the non linear processing algorithm is proposed in [3].

Once obtained the 'correct' local maxima, the envelope evaluation (e.g. in case of τe extraction, or in case of reverberation time calculation) may obtained by cubic splines [2] or energy detection [3]. These two methods may have different uses depending on the computing platform used. Cubic splines require an adequate library of function and an higher software abstraction level; on the other hand this method seems to return correct results also for critical signals. Energy detection may be implemented even in most simple systems, but needs a careful check of accuracy in case of critical signals.

In a recent paper the evaluation of $\Delta t1$ based on the same non linear preprocessing algorithm has been proposed [4]. Some differences due to the statistical characteristics of the treated signal (Gaussian in case of an impulse response, deterministic in case of an anechoic signal) require different settings of the algorithm.
All the proposed methods have been developed using the Matlab© environment obtaining a tool which is equally applicable to the spatial, temporal and subjective preference analysis.

The first release of a tool for this kinds of analysis, using the algorithms proposed in the previous literature, has been presented in [5] in form of Toolbox. An improved version of this environment, in form of GUI, was called A.G.A.T.A. and has been presented for the first time at the 5th I.S.T.D.

and, in a improved version, in this paper.
At the time of writing (December 2011), A.G.A.T.A. is in advanced beta version and not yet released. The authors would like to distribute the tool as freeware for researchers in the future.

2. OVERVIEW

A.G.A.T.A. is a standalone software based on Matlab© and developed for a wide range of acoustical analyses in the frame of the well known Ando's theory. Following the Ando's theory, the A.G.A.T.A. interface is divided in three sections: the temporal factors, the spatial factors and the normal factors.

The first section of the GUI allows to extract the significant temporal factors from a signal; the second section of the GUI allows to extract from a set of binaural impulse responses all the needed factors in order to evaluate the subjective preference function; the third section is devoted to the calculation of the subjective preference function.

2.1 Temporal factors

Under the name of 'temporal factors' some quantities are reported in the literature, extracted from the autocorrelation function (ACF) of a recorded signal and related to neurophysiological perception. These factors are:

- τe, defined as 'the first ten-percentile of envelope decay of the normalized running ACF' expressed in dB.
- τ1, defined as the delay time of the first peak of the ACF;
- φ0, defined as the energy of the signal;
- φ1, defined as the magnitude of the first peak of the ACF.

τe has an important role, as is well-known, in the Ando's theory, but its calculation may be ambiguous [1]. A.G.A.T.A. calculates the τe with a cubic splines method after a nonlinear preprocessing [2]. A wide range of sound signals have been used to test this algorithm (Figures 1, 2, 3).

The resolution of the τe extraction method may be assumed as the lowest evaluable value. The minimum of τe, as is well-known [6], is related to subjective perception. The proposed algorithm permits to evaluate τe values above 5 ms; this value may characterize impulsive signals or environmental noise (Figure 2, 3). On the other hand the controllability of the results (by visual inspection of the envelope of every temporal window) may permit to isolate digital noises, glitch, or other factors that alter the τe value, e.g. in case of musical anechoic signals.

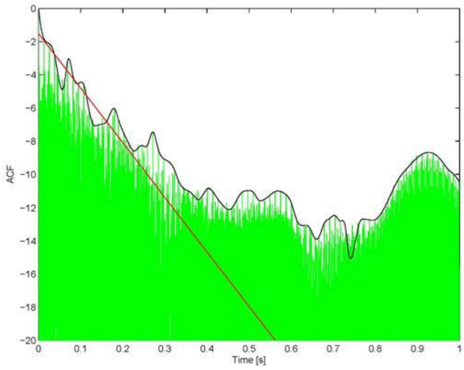


Figure 1: evaluation of τ_e for an anechoic signal (τe = 258 ms).

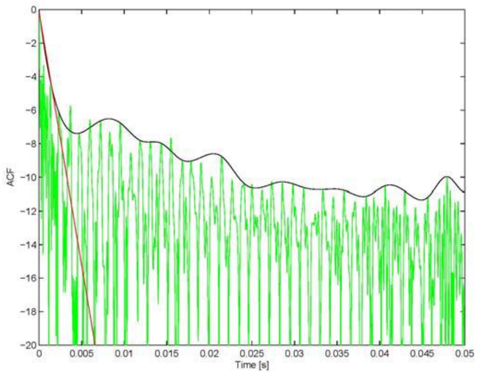


Figure 2: evaluation of τe for a speech signal (τe = 3.3 ms).

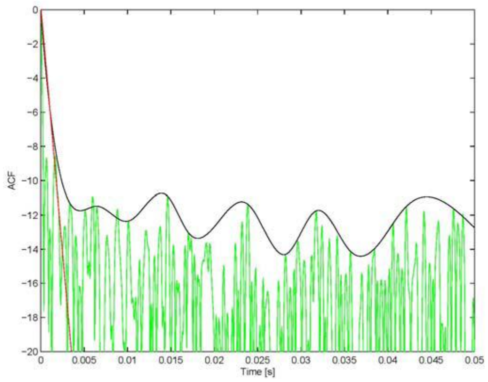


Figure 3: evaluation of τe for an environmental noise signal (τe = 1.8 ms).

The τ_1 (and the relative φ_1) may also be extracted using non linear preprocessing in the peak selection. The value of τ_1 may be related to the fundamental frequency, in case of a deterministic signal (Figures 4, 5).

The resolution and the robustness of the proposed algorithm also permit the use of τ_1 and of φ_1 to verify the non-deterministic character of a given signal (Figures 6, 7): a random value of τ_1 and a relative very low value of φ_1 suggest a low deterministic character of the signal.

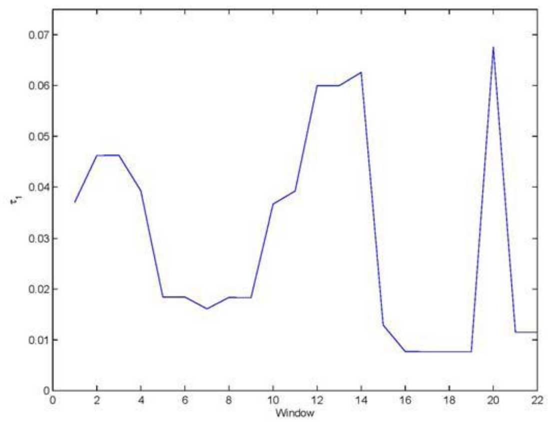


Figure 4: Running τ_1 of an anechoic signal.

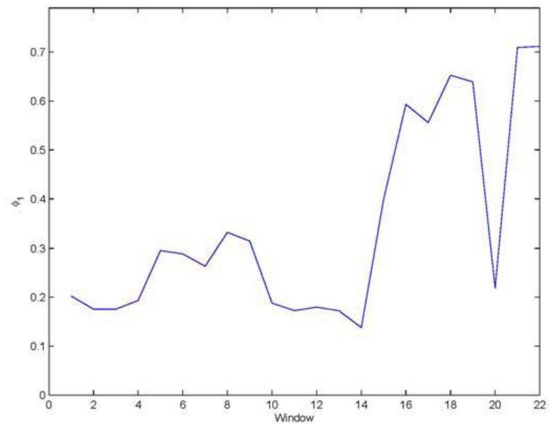


Figure 5: Running φ_1 of an anechoic signal.

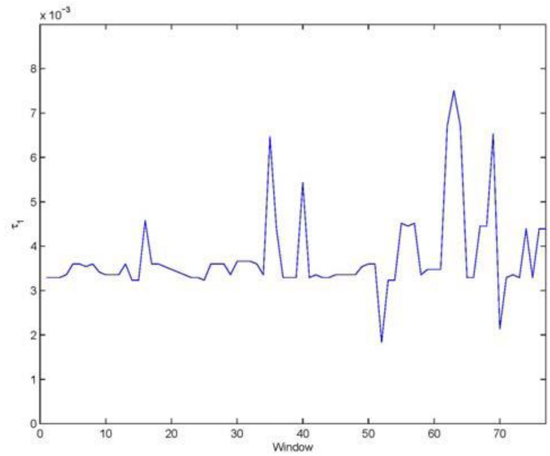


Figure 6: Running τ_1 of an environmental noise signal.

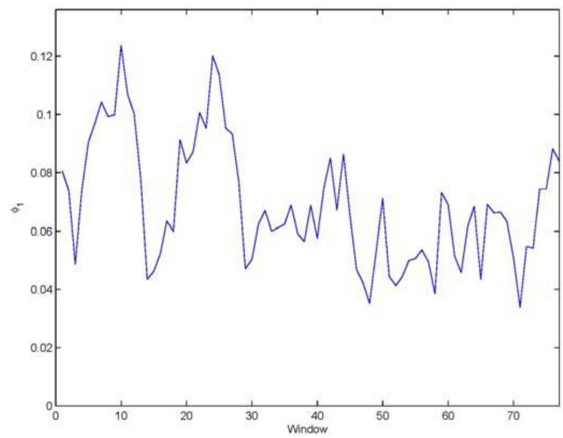


Figure 7: Running φ_1 of an environmental noise signal.

A parallel analysis of τ_e may confirm the stationary character of the analyzed signal, if the extracted values of τ_e are very low for all the analyzed temporal windows. It is worth noting that with most of methods from previous literature it may be difficult to extract a correct value of τ_e in the range of few milliseconds (as is the case for most environmental noises).

2.2 Spatial factors

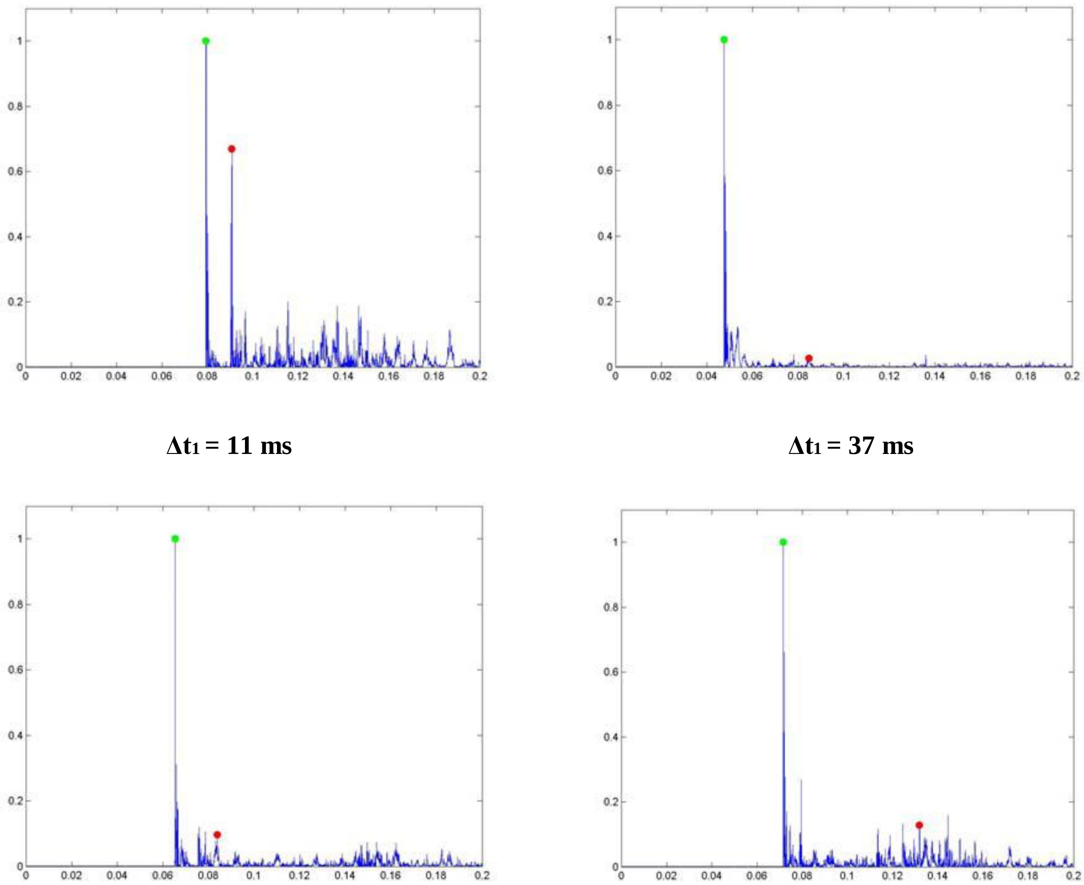
Under the name of 'spatial factors' the literature defines the factors extracted from the interaural cross correlation function (IACF) of a binaural impulse response. These factors are:

- IACC, defined as the magnitude of the interaural cross correlation function for $|\tau| \leq 1$;
- τ_{IACC}, defined as the interaural delay;
- W_{IACC}, defined as the temporal interval where IACF > IACC(1-δ), where $\delta = 0.1$.

The calculation of spatial factors is less ambiguous than the calculation of the temporal factors and the factors proposed in literature are calculated by A.G.A.T.A. without the need of improvements to the previous methods.

The second section of the GUI includes also the calculation of the remaining normal factors of the Ando's theory: Δt_1, T_{sub} and LL.

T_{sub} and LL are extracted using standard literature methods. The value of Δt_1 is extracted as follows [4]: the nonlinear preprocessing and a following discrete derivation isolates the arrival time and the delay of each reflection. A moving integration with temporal window evaluates the energy of each reflection. The delay of the reflection located near the maximum of the moving energy function is assumed as Δt_1 (Figure 8). Also in this case the visual controllability of the GUI allows to confirm the results.



Δt_1 = 11 ms **Δt_1 = 37 ms**

Δt_1 = 18 ms **Δt_1 = 60 ms**

Figure 8: Different examples of Δt_1 extraction.

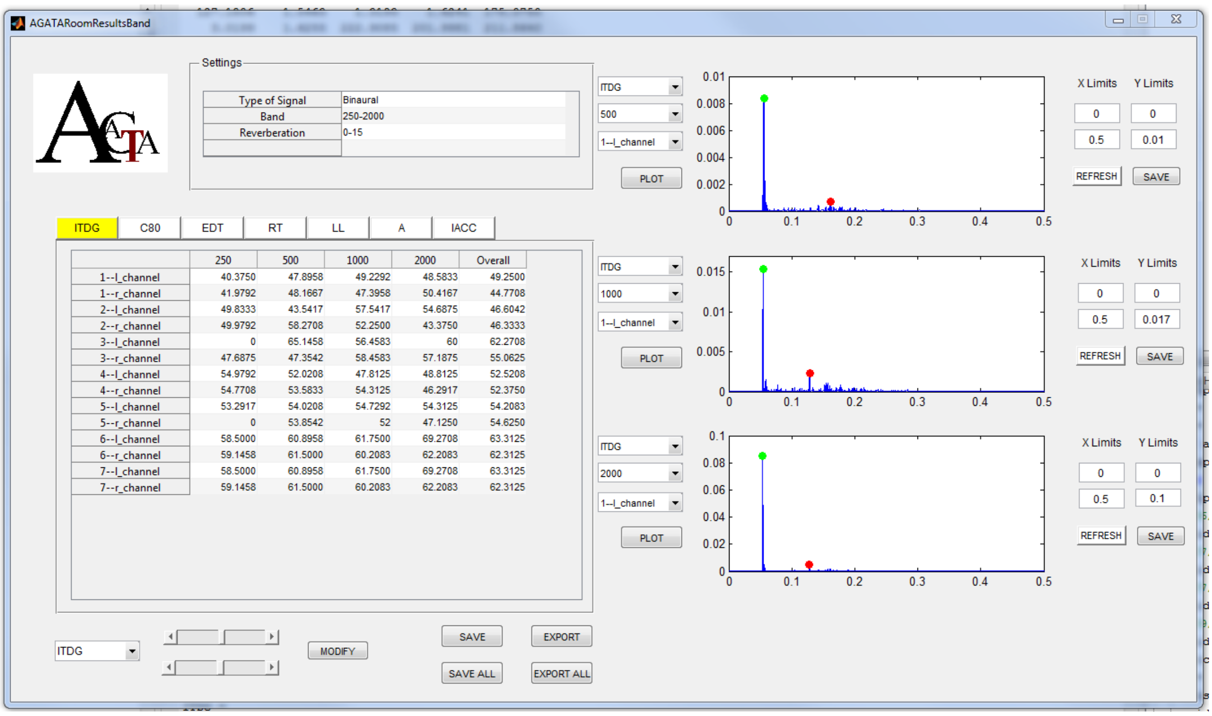


Figure 9: Screenshot of A.G.A.T.A. for BRIR analysis section.

Multiple BRIR (Binaural Room Impulse Response) relative to different positions may be analyzed in a single window; the results for each room parameter are available also in octave frequency bands (Figure 9).

The third part of the GUI allows to evaluate and export the subjective preference functions.

3. USAGE

A.G.A.T.A. has been primarily developed as a research oriented tool. In addition to the above described features, different types of temporal windows are possible, because the influence of different shapes of the temporal window may be related to the auditory perception (e.g. Rectangular, Hamming, Hanning, Blackmann, Blackmann-Harris).

The code is optimized to perform the results also with long duration sound signals (e.g. a musical motif). Decimation and filtering may improve the extraction of temporal factors based on different auditory models.

On the other hand A.G.A.T.A. may be used also as tool for non research-oriented users. In fact A.G.A.T.A. is an high level tool and doesn't require the knowledge of the operations at lower levels. From this point of view A.G.A.T.A. may be viewed as an interdisciplinary tool, usable by acousticians and also, e.g., by musicians or by researchers in medical disciplines. In fact A.G.A.T.A. allows a rapid interpretation, in terms of significant factors, of the processes related to dynamic range and tone coloration; moreover, A.G.A.T.A. permits the study of significant factors using different types of temporal windows, as discussed in hearing-related research.

Concerning the flexibility and the further fields of application, A.G.A.T.A. is based on a Matlab© Toolbox [5], so that others features could be easily added in the future, following hints about potential new fields of interest.

4. CONCLUSIONS

At the beginning of the research, the first goal of the authors was the specification of a robust and accurate method for the extraction of the running τ_e [1]. Thus, A.G.A.T.A. has been initially developed as tool to verify different extraction methods. After this initial stage, the others significant factors have been implemented with the same semantics and this permits a wide range of analyses within the same software environment.

At the present stage of development A.G.A.T.A. has high resolution and good robustness.

High resolution means the ability to properly identify values which sometimes could result ambiguous with previous literature methods. Robustness means that the software can detect and isolate possible digital disturbances (glitches, noises) that may alter the correct values of some factors which are critical in the Ando's theory.

A.G.A.T.A. allows the extraction of the significant factors of a long sound signal (e.g. a musical motif) and also the analysis of the ACF of each temporal window, to characterize possible singularities.

In addition A.G.A.T.A. can evaluate a complete set of room descriptors, as needed in the subjective preference evaluation theory. All the results may be exported in standard formats and so also non research-oriented users may exploit the potential of Ando's theory.

5. REFERENCES

[1] D. D'Orazio, M. Garai, *" Some considerations about the integration of r-ACF"*, Proc. 4th I.S.T.D. 2009, Kumamoto, Japan. Awarded as best paper of the Symposium and republished on J. Temporal Des. Arch. Environ., 9(1), 112-115 (2009).

[2] D. D'Orazio, S. De Cesaris and M. Garai, *"Evaluation of τ_e by use of cubic splines"* Proceedings of 2o Congreso Internacional de Acústica UNTREF (2010).

[3] D. D'Orazio, S. De Cesaris, M. Garai, *"A comparison of methods to compute the 'effective duration' of the autocorrelation function and an alternative proposal"*, J. Acoust. Soc. Am., **130**(4), 1954-1961 (2011).

[4] S. De Cesaris, D. D'Orazio, M. Garai, "I*TDG calculation with a non linear iterative algorithm*", Proc. 8th International Conference on Auditorium Acoustics and Proc. Institute of Acoustics 33(2), Dublin, Ireland (2011).

[5] D. D'Orazio, M. Garai and P. Guidorzi, *"A Matlab Toolbox for the analysis of Ando's factors"*, Convention Paper 7798, 126th A.E.S. Convention, Munich (2009).

[6] Y. Ando, "*Architectural Acoustics*", Springer-Verlag, New York (1998).