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ADAPTIVE DETECTOR FOR NOISE SOURCES AUTOMATIC RECOGNITION

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ABSTRACT
The necessary reduction of data processing of acoustic monitoring systems will lead to develop intelligent processes able to select pertinent sources to analyze and archive for easier consultation and exploitation. This paper presents an important improvement in MADRAS methodology concerning detection step, e.g. automatic decision to record signal to be post-treated by recognition processes. An adaptive detector, based on contrast evaluation between noise pattern dynamic evaluation and current audio event is presented and compared with statistical detectors on global acoustic level.

1 - INTRODUCTION
The last few years, several acoustic monitoring systems appeared to realize long term surveys of environmental noise, including weather conditions recording and communication functionalities to allow distance control and diagnostic. In addition to the classical measured values, such as Laeq and third octave spectrum, different new indicators appeared in real time systems such as PNL, PNLt or Loudness to improve notably annoyance description. These set of measured magnitude can be obtained really accurately on short time basis until few milliseconds, and thanks to increasing of data storage capacities, notably for PC based systems, it is possible today to realize measurements on several years. The 01dB'system (SALTO station) is based on a dual-channels (Symphonie) or four-channels (Harmonie) PC-Card acquisition board, allowing multiple points simultaneous measurements for complete and pertinent site characterization. Furthermore, implementation of release mechanisms based on logical conditions on measured magnitudes such as "(Laeq>L90+15dB) and (L500Hz >65 dBA)" allow to records audio or to encode data dynamically, allowing pertinent statistics post-treatment and re-listening for complementary analysis.
The global assessment for the final user is high possibilities not only in physical measurements but also in symbolic information collecting.
As a consequence with new exciting possibilities, two drawbacks did appeared, penalizing all monitoring systems: First, in many situations you do not know what are the acoustics characteristics of present noise sources to define release mechanisms; the consequences are non adapted threshold for automatic encoding and audio recordings and bad efficiency in using these tools. Secondly, the situation in long-term measurement today is that the work charge of post processing is more important that the measurement time because of the amount of the data. So the global challenge of the next five years will be to propose intelligent monitoring tools, able to extract in real-time necessary information to apply regulations, and then able to identify acoustic sources filling a dynamic database for final user consultation and referencing. Since few years, 01dB works at this future monitoring station, notably in managing the European MADRAS project. This paper presents current state of the art and an important recent improving of the methodology.

2 - MADRAS METHODOLOGY
MADRAS (Methods for Automatic Detection and Recognition of Acoustic Sources) is a European project (CEE DG12), which the aim is to study new tools for classifying the acoustic signatures of different kinds of noise sources. This arborescent classifier uses several and various techniques: signal processing

(time-frequency and time-scale analysis), mathematical morphology, factorial data analysis and neural networks. After realizing detection and segmentation in time domain, a neural network trained off-line to recognize different shapes based on Laeq evolution decides of meta-class membership among impulse, stationary, pass-by, heavy carrier and energy blasts. In each sub-family, a specialist will propose thanks to appropriate methodology (e.g. wavelet transform for impulsive signals, third octave statistical spectrum for pass-by, etc ...) to associate a shape to each source. By comparing known shapes of the dictionary with current events, MADRAS will be able to encode in real-time the acoustic source, allowing the final measurement file to contain only codes and symbolic information. The encoded file will allow regulation application and source statistics.

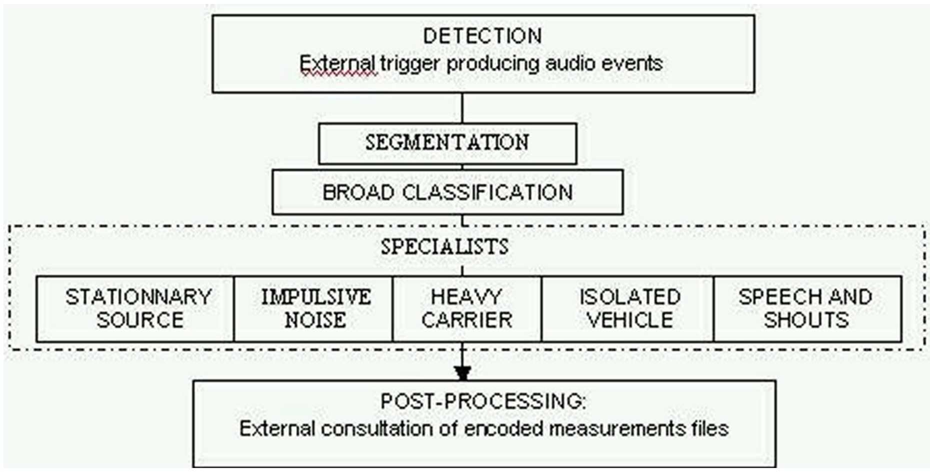

Figure 1: MADRAS architecture.

The current system reaches a success ratio of around 80 % in real but not excessive perturbed situations (no too much sources merging). For more noisy situations (urban area), some important adaptations are to be made, especially in the use to an external trigger more accurate. The use of a trigger is necessary to avoid analyzing audio continuously (it will be possible in next years thanks to improvement in calculation power). In the first MADRAS version, the trigger used to produce audio events to analyze was based on the overload of a statistical threshold, e.g. statistical L90 plus a fixed margin among measurements conditions. Using this non-fixed detection criteria was satisfying in regards with background noise evolution (days periods, day/night situation, weather changes,...) and improved considerably the detection robustness. But this criterion is really delicate with regard to statistical index choice and duration of statistical averaging. Choosing a 30 second period seems a good compromise between statistical needs and dynamic following of conditions changes in urban context. Choosing the L90 index means to base detection of events on a contrast with a good image of the background noise, to the detriment of reactivity and inertial time. Choosing a lower index, such as L10 will improve reactivity but will lead to hashing audio events.
A example of such analysis is presented in figure 2: a three minutes evolution including pass-by of cars, temporary stationary source establishment, and several shocks (dogs, shouts).
The Fig. 2 illustrates the compromise reactivity/relaxation that must be fulfilled to obtain a good indicator for detection: A shows robustness to source apparition <2>, but difficulties to follow changes of background noises <1>. B shows good reactivity <1> but will cut audio event <2>. The corresponding audio events are showed on C and D. To define a dynamic and pertinent threshold, we must assume to obtain both reactivity and relaxation efficiency. A compromise between L90 and L10 can be obtained by using arithmetic averaging of these two values, or by choosing L50. In conclusion, tests show that no statistical index seems to be adapted in complex urban situation where necessary reaction and relaxation time are uncontrolled: to improve MADRAS methodology, a robustness and better-adapted detector must be realized.

3 - ADAPTIVE DETECTOR

A natural idea for determining a detector structure consists in searching a contrast function in spectral domain. The method chosen is based on a comparison between two estimators operating on two time sliding windows (Fig 3). The largest will construct an adaptive pattern for background noise in computing a linear average third octave spectrum on a length depending of the noise fluctuation (typically few

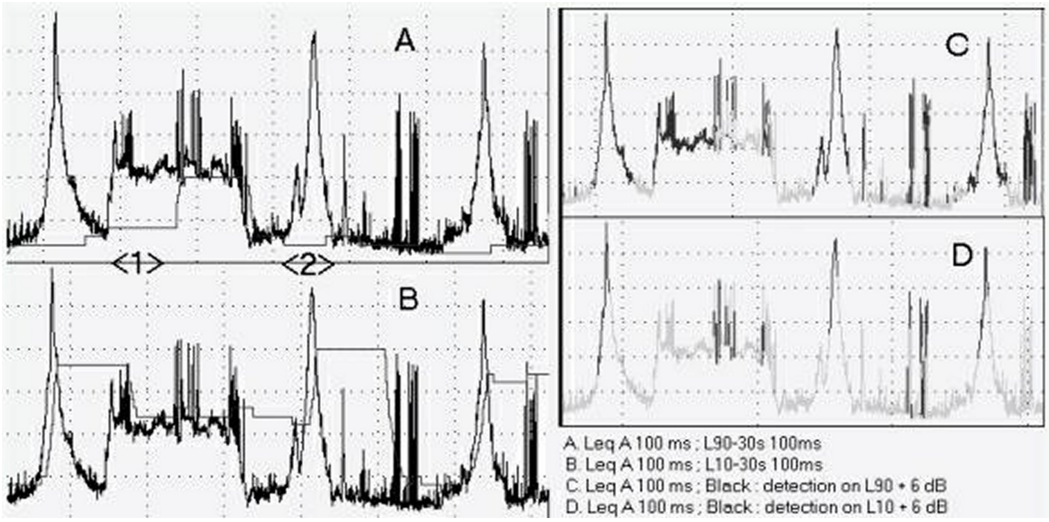

Figure 2: Detection on statistical index.

seconds in urban context). The pattern consists in calculating average and standard deviation in each spectral channel, and to realize classical structure detector: A second window, producing the current event (20 ms) third octave spectrum will be compared with the reference window. In each third octave, the event component will be compared with the pattern. If the contrast function is realized (typically level greater than average+alpha*standard deviation, where alpha represents a sensitiveness coefficient chosen by user depending on degree of robustness desired), the noise estimation is freezing until the contrast disappears. In parallel with new event apparition, new possible noise estimation is realized based on the event structure: in case of starting of stationary source, the method will check that the new event can become new noise reference. This will allow updating pattern dynamically to detect next transients sources and to reference several noise states.

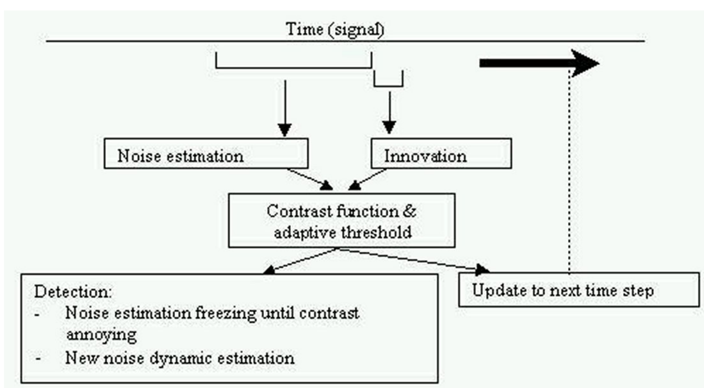

Figure 3: Adaptive detection structure.

The figure 4 presents the detection results on the same sequence with new detector: a great number of sources are now obtained (dark zones), including sources which emergence in the global level time history cannot appear (see $ symbols).

4 - CONCLUSION

The new detection structure adopted in MADRAS methodology allows robustness in urban environment for monitoring solutions. More than the improvement in quantity of detected events, the real gain is precise temporal localization of events and pertinent audio recordings including complete sources' signatures. The post treatment of recorded signals by specialists will be more precise, increasing the success ratio in recognition process. A recursive implementation of this detector is currently studied, allowing management of different noise states review.

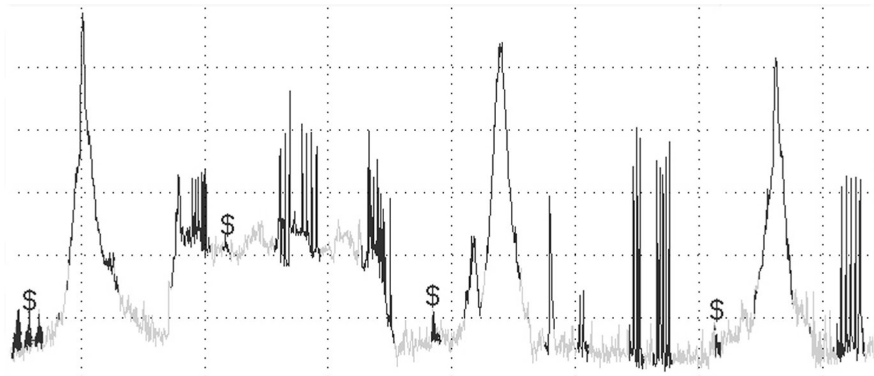

Figure 4: Adaptive detection example.

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