DYNAMAP MONITORING NETWORK HARDWARE DEVELOPMENT

Luca Nencini

Bluewave acoustics Via del Fonditore 344,58022 Follonica, Italy
e-mail: nencini@blue-wave.com

In the Dynamap project the development of a fleet of low cost sound level meters is foreseen in order to set up a wireless distributed noise monitoring system aimed at automatic updating of road noise maps. In this work, a prior art analysis on this kind of systems is presented and Dynamapp sensors technical specifications are described.

1. Introduction

The DYNAMAP project has been approved for co-financing by the European Commission through the Life+ 2013 program. DYNAMAP aims at the installation of a prototype system in the municipalities of Rome and Milan, based on pervasive low-cost hardware network for noise measurement together with some artificial intelligence algorithm to perform the automatic creation of real time noise maps. The project aims at developing a dynamic noise mapping system able to detect and represent in real time the acoustic impact due to road infrastructures. Scope of the project is the European Directive 2002/49/EC relating to the assessment and management of environmental noise (END)[1]. In particular, the project refers to the need of updating noise maps every five years, as stated in the END.

2. Projects involving distributed monitoring systems

In the last decade distributed acoustic monitoring systems started to appear, due to lowering costs of electronic components and to cheaper and smaller hardware for telecommunication. Below some projects using such technologies are listed

2.1.1 SENSEable Pisa

The SENSEable Pisa project [2], started in 2011, aims at building a network of noise sensors hosted at houses of volunteer citizens to produce in real time a detailed acoustic photograph of the territory.

2.1.2 NoiseTube

NoiseTube [3] is a research project, started in 2008 at the Sony Computer Science Lab in Paris and currently hosted by the BrusSense Team at the Vrije Universiteit Brussel, which proposes a participative approach for monitoring noise pollution by involving the general public. The NoiseTube mobile app extends the current usage of mobile phones by turning them into noise sensors enabling citizens to measure the sound exposure in their everyday environment.

2.1.3 Smart citizens

Smart Citizen [4] is a platform to generate participatory processes of people in the cities. Connecting data, people and knowledge, the objective of the platform is to serve as a node for building productive and open indicators, and distributed tools, and thereafter the collective construction of the city for its own inhabitants

2.1.4 IDEA

The IDEA project [5] focuses in particular on environmental stressors that have a very local character such as (ultra) fine particulate matter and noise. An important goal of IDEA is to develop a measurement network of less performing (and thus much cheaper) sensors that makes use of bio-inspired intelligent systems to reduce the loss of quality of global data.

2.1.5 Harmonica

The Harmonica project [6] suggests the creation of a simple, adimensional noise index, closer to the feelings of the populations than the usual averaged indicators, in a similar way to the ones used for air quality.

2.1.6 Hear-it

The EAR-IT project [7] is an EU FP7 co-funded project working over a two-years period (Oct'2012-Sep'2014) on the exiting challenges of using acoustic sensing in smart cities and smart building. With innovation and research in this area, the project experiment in the city of Santander (Spain) and for intelligent building in Geneva, applications improving security, energy saving, traffic management and more.

2.1.7 Noisemote®

Noisemote [8] is a real-time control service for environmental noise control. It has true wireless capabilities, that means no cables are really needed for powering and data transmission.

3. Categories of acoustic sensor networks

"Standard" noise monitoring system are the ones like Norsonic, Bruel&Kjaer, 01dB etc. and they are commonly used for environmental monitoring. These system are highly reliable and they are compliant with class I IEC 61672[9] or previous standards. They can work in a very wide range of environmental conditions varying from very low temperatures to highest ones and they are accurate over a wide dynamic range from 20 dB(A) to 140 dB(A). They are very expensive and not equipped for remote data transmission, so they are not well suitable for pervasive use.

In this work, sensor networks for environmental noise monitoring have been roughly distinguished in two different groups. These groups are discussed in the following sections giving some example.

3.1 Embedded pc monitoring systems

In the last decade, the exponential growth in computing technologies made possible to reduce a lot personal computer size. Actually it is possible to find small personal computer boards of sizes less than 10x10 cm at very cheap prices, equipped with high quality sound board. Such system can be equipped with gprs/3g/4g modem or Wi-Fi connection and a signal analysis software that processes incoming data from the sound board, using a cheap microphone. These kind of system present the advantage of being low cost and they can be remotely fully updated and reprogrammed. Moreover they can be coded with specific algorithm executing particular complex tasks as noise recognition, source position tracking etc. The disadvantage of those systems is the power consumption, that is actually at least 2-3W, so there is the need of power supply or big solar panel making difficult the application for pervasive monitoring.

3.2 Units with microcontroller and digital signal processor

The main advantage of this kind of system is the possibility to implement low power applications (200 mW mean equivalent consumption or less) that permit to power these devices with solar panels or with other energy harvesting systems. The disadvantage of those systems is the limited possibility to modify and remotely control the device in order to implement complex tasks. “Standard” noise monitoring systems can be included in this group.

4. Dynamap sensor specifications

The Dynamap objective is to render noise maps will faithfully represent the noise levels caused by road infrastructures solely, so anomalous events need to be eliminated. It will be used a supervised learning technique consisting of two main processes: i) signal feature extraction, and ii) noise event recognition. On one hand, the signal feature extraction process aims at obtaining a set of numeric coefficients (or features) representing the acoustic characteristics of the noise signal. On the other hand, the noise event recognition process should automatically decide whether the noise signal corresponds to road traffic noise or not.

Due to prototypal nature of the sensors network to be installed, it is advisable to use a flexible system, precisely like embedded computers, that can be remotely accessed and programmed in order to run specific audio processing scripts. Another opportunity given by this choice is to preprocess data onboard, reducing the size of data streaming to the central server that will make the final task of recognizing the acoustic events. This will also guarantee better scalability of the system, reducing the computational load on the central server when the number of sensing units is increased.

A first set of basic specifications has been defined for each monitoring station and it is listed below:

- 40-100 dB(A) broadband linearity range
- 35-115 dB working range whit acceptable THD and narrowband floor noise level
- 1 second time base 1/3 octave spectrum
- Possibility of audio recording
- VPN connection
- GPRS/3G/WiFi connection

5. Conclusion

In this paper some basic technical specifications of acoustic sensors to be used in the Dynamapp project have been listed. Due to the prototypal nature of the whole system, the use of embedded computers seems to be the simplest way to perform all the task required and to permit a direct remote control on each monitoring node.

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