SEISMIC-NOISE RECORDING SYSTEM WITH REAL-TIME DATA VISUALISATION

PATENTED TECHNOLOGY

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ABSTRACT

T h e **Engineering and Earthquake Risk Group (GIRS)** has developed a comprehensive system for the synchronised and simultaneous recording of environmental vibrations (also known as ambient noise or seismic noise) by means of a sensor array. After that, by means of the corresponding analysis, the dispersion curve of the surface waves or Rayleigh will be obtained, which will allow us to **characterise the soil**.

This invention solves the drawbacks of current systems and is characterised by the creation of a Wi-Fi network for communication between nodes and server or by its real-time data display.

The group is looking for companies interested in acquiring this technology for its commercial exploitation.



INTRODUCTION

Recent studies around the world have demonstrated the importance of local geology in seismic disasters and their consequences. Ground motion can be drastically amplified, depending on the particular characteristics of the subsoil, increasing the seismic effects. Therefore, soil characterisation becomes a crucial issue in seismic risk studies, particularly in urban areas located on soft sediments.

Ambient seismic noise corresponds to vibrations on the earth's surface due to different natural and man-made causes. These vibrations are imperceptible to humans, but not to seismic sensors. Therefore, their recording and analysis provides valuable information about the properties of the medium they pass through, i.e., the characteristics of the ground.

This characterisation can be carried out using different methods, such as array techniques, which make it possible to obtain the propagation speed of waves through the medium as a function of frequency, known as dispersion curves.

In terms of implementation and resources, these techniques require several sensors and a multichannel digitiser to record several signals simultaneously. The acquisition of these digitisers, together with the corresponding sensors, involves a significant financial outlay which is often not accessible toall research groups. As a result, advances in research related to subsoil characterisation or seismic hazard are often limited by the excessive cost of the necessary instrumentation.

In addition, most of this equipment is wired, which makes it difficult to implement in certain urban environments, where the arrangement of the geophones must be adapted to the available free spaces and their geometries.

On the other hand, in some cases, data recording is done locally at each node of the sensor network. Even in some systems it is not possible to visualise data in real time, which prevents the detection of errors in the field, with the economic cost of having to travel again and repeat the measurement.

For all these reasons, the present invention focuses on a proposal for an integral system, economically and technically viable,

based on the acquisition of ambient noise by means of a network of seismic sensors, and which provides a solution to the technical problems mentioned above.

TECHNICAL DESCRIPTION

The system of the invention *(see Figure 1)* makes it possible to **record wirelessly on a single server** all the measurements obtained from the different geophones or seismic sensors. The direct analysis of these signals makes it possible to obtain the Rayleigh wave dispersion curve (wave velocity as a function of frequency) and from there, the estimation of the shear wave velocity profile in the area under study (characterisation of the soil type).

To achieve the object of the invention, a system has been developed consisting of a series of nodes connected to a geophone or seismic sensor that measures at least the vertical component of the ground motion and to a central server that will collect the samples from each node via Wi-Fi and will display and store them in files locally. The arrangement of the nodes will normally be around the server, with the aperture depending on the depth of the sediments to be analysed. The area that can be measured with the developed system is up to 250 metres in diameter in an open field and free of interference.

The maximum number of nodes allowed in the system is 10 and they are made up of an adapter circuit designed specifically for the geophone or seismic sensor, an 8-channel 24-bit analogue-to-digital converter (ADC) and a CC3200 microcontroller that manages sampling, communications and synchronisation with the server.

In addition, an interface has been designed where the user can interact with the system, initiating and finalising the records, synchronising the nodes, and also visualising the signals from the nodes in real time.

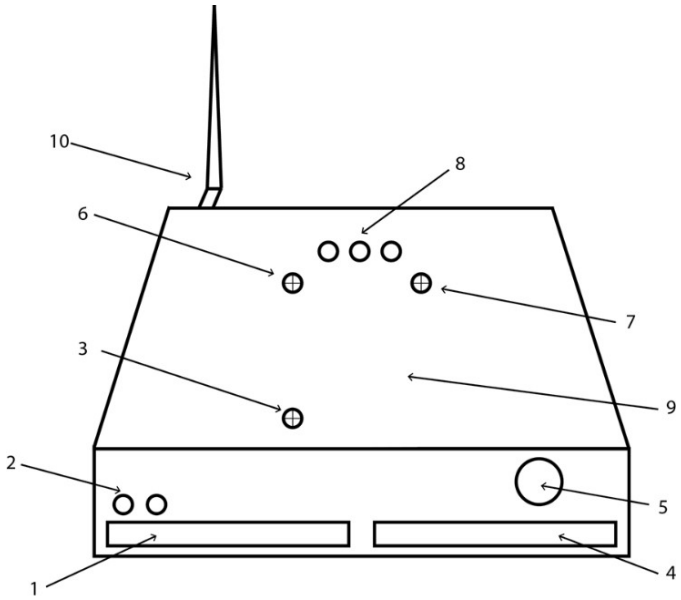


Figure 1: Drawing of the external housing of the invention with corresponding slots, buttons and antenna.

ADVANTAGES AND INNOVATIVE ASPECTS

MAIN ADVANTAGES OF THE TECHNOLOGY

The main advantages of this technology are the following:

- **Simultaneous recording** of the different seismic sensors, this synchronisation between all the nodes is fundamental for the subsequent analysis of the recorded signals.
- **Quick and easy** deployment of the entire system to carry out a series of measurements, saving time as no wiring has to be deployed to the nodes.
- **Centralisation** of sensor samples and **availability** of the log in standard format immediately after logging.
- Communication between nodes and server using a **unique proprietary protocol** via UDP. This has involved the invention and implementation of a proprietary system that controls the orderly flow of the packets containing the samples and error control and recovery.
- **Low noise signal** conditioning circuitry at each node, which allows the low amplitude of the seismic noise to be adapted to a volt signal adapted to the dynamic range of the analogue-to-digital converter.
- The **autonomy** of the nodes with their two batteries, recording continuously, reaches 32 hours without interruption.

INNOVATIVE ASPECTS

In terms of its most innovative aspects, it is worth highlighting the following:

- Creation of a **Wi-Fi network** for communication between nodes and server. This means leaving behind the limitations of wired equipment, allowing its implementation in any type of urban environment or natural space. Also, the fact that the nodes are on the same Wi-Fi network has led to the implementation of an exclusive mechanism based on transmission time slots for each node to transmit without collision, as the medium is shared and the nodes start sampling at the same time. The retransmission mechanism for lost frames is also dependent on the transmission time slots.
- Display of each of the signals sampled by each node in **real time**. In this way, it is possible to detect whether the measurement is being taken correctly or whether there is a problem with any node, thus avoiding the economic cost of having to travel again and repeat the measurement.

CURRENT STATE OF DEVELOPMENT

A prototype has been successfully tested and recorded in numerous scenarios.

MARKET APPLICATIONS

It is primarily aimed at the **geotechnical and geophysical** sector, more specifically, companies manufacturing geophysical measuring instruments.

COLLABORATION SOUGHT

The group is looking for companies or institutions interested in acquiring this technology for **commercial exploitation**.

INTELLECTUAL PROPERTY RIGHTS

This technology is protected by **patent application**:

- *Patent title: "Sistema de bajo ruido para la adquisición sincronizada e inalámbrica de señales de ruido ambiente en redes de sensores sísmicos".*
- *Application number: P202230702*
- *Application date: 29/07/2022*

MARKET APPLICATION (3)

Geological and Geophysical Studies
Computer Science, Language and Communication
Regional Planning

TECHNICAL IMAGES (1)

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