Multichannel Frequency Selective
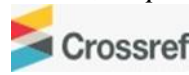
Seismograph Graphical User Interface (GUI)

Idara Okon Akpabio and Adebayo Olusakin Adeniran

AJP

Multichannel Frequency Selective Seismograph Graphical User Interface (GUI)

Idara Okon Akpabio[1*], Adebayo Olusakin Adeniran[2]

University of Uyo, Faculty of Science, Department of Physics, Uyo, Nigeria

Crossref

Abstract

Purpose: The research discusses the programming and setup of a frequency-selective Graphical User Interface (GUI) for a seismograph.

Materials and Methods: GUI was developed using Visual Basic Net with C language and Dundas Software which serves as the interface between the hardware system and the laptop to display real-time signals sent by the geophones. The studies conform to the feature of standard simulation and assist the users to perform a system-level simulation and reception of data from the geophones.

Findings: It allows the users to choose frequencies between the available frequencies, design a layout, and view the results. Users can choose and read the output display, making the measurements easy to record.

Implication to Theory, Practice and Policy: The GUI is explained with respect to the graphical layout and the interactive features of the components. The GUI picks from the low Band frequency cutoff of 1.989×10^{-5}Hz, 1.061×10^{-3}Hz for High Pass and Band-Pass cut-off.

Keywords: *GUI, Seismograph, Seismometer, Band-Pass, Low Pass, Graphical.*

1.0 INTRODUCTION

Almost every week we hear information about strong earthquakes. Many of them are disastrous, some arising from seismic activities (Uko *et al*, 2002), causing thousands of deaths and devastating destruction (Ahn *et al.,* 2021). Seismometers have been recording the motion of the ground during an earthquake for decades. They usually measure up and down motions and two horizontal motions. However, the ground also rotates around three orthogonal axes and it has been very difficult to record them Sollberger *et al*., 2020, Bernauer *et al*., 2014. Moreover, this has not been carried out routinely in seismology.

System models are essential engineering tools to represent real systems and to assist engineers in analyzing systems performance and design systems. They remove the necessity of expensive and time-consuming tests on the hardware to obtain optimal design results. A good model possesses most if not all the salient features of the real system. Thus, a model should be a very close approximation of the real system, such that the results of the evaluation performed on the model will be very close to the true reflection of the behaviour of the real system (Sratsav, 2017). A seismometer, also known as a ground motion detecting sensor, and a recording system make up a seismograph, a tool for monitoring the movement of the earth. Imagine a weight hanging on a spring to understand a simple seismometer that is sensitive to the up and down motions of the earth (Lee and Stewart, 1981). A frame that moves along a vertical ground motion supports the spring and the weight.

The relative motion between the weight and the earth can be recorded to create a history of ground motion known as a seismogram if a recording device is set up so that a revolving drum is fastened to the frame and a pen is fastened to the mass (Lawrence, 2001). Being able to locate earthquakes and determine their size instantly introduces us to two fundamental requirements of instrumentation: maintaining precise time and figuring out the frequency-dependent relationship between the measurement and the actual ground motion. Since most equipments are actually installed and maintained by people other than seismologists, the instrumentation is not solely a matter for them. To build seismic instruments, it is, therefore, necessary to include sensors and recorders that partially cover the broad frequency and dynamic range shown in Table 1.

Table 1: Measurement Type and Frequency Range

Frequency (Hz)	Type of Measurements
0.00001-0.0001	Earth tides
0.0001-0.001	Surface waves, earthquakes
0.001-0.01	Earth-free oscillations, earthquakes
0.01-0.1	Surface waves, P and S waves, earthquakes with M >6
0.1-10	P and S waves, earthquakes with M> 2
10-1000	P and S waves, earthquakes, M< 2

Source: Jen and Gerardo (2002).

2.0 MATERIALS AND METHODS

Materials

Graphical User Interface (GUI)

VB.NET is a programming language designed to create applications that work with Microsoft's new NET Framework. The .NET platform in turn addresses many of the limitations of "classic" COM, Microsoft's Component Object Model, which provides one approach towards application and component interoperability. These limitations include type incompatibilities when calling COM components, versioning difficulties ("DLL hell") when developing new versions of COM components, and the need for developers to write a certain amount of code (mostly in C++) to handle the COM "plumbing." In contrast to VB, with its reliance on COM, VB.NET offers a number of new features and advantages (Steven 2002).

A User Interface (UI) is a graphical display in one or more windows containing controls, called components that enable a user to perform interactively to enable the user does not have to create a script or type commands at the command line to accomplish the tasks. Unlike coding programs to accomplish tasks, the users do not need to understand the details of how the tasks are performed. The Graphical User Interface (GUI) was introduced in reaction to the steep learning curve and Command Line Interfaces (CLI) which require a command to be typed on a computer keyboard. The actions in GUI are usually performed through direct manipulation of the graphical elements. Beyond computers, GUIs are used in many handheld mobile devices, smartphones and smaller household, office and industrial controls. The term GUI tends to be applied to other lower display resolution types of the interface such as video games where Heads-up Display (HUD) is preferred including flat screens like volumetric displays because the term is restricted to the scope (Fig 1), (Meyer,2005).
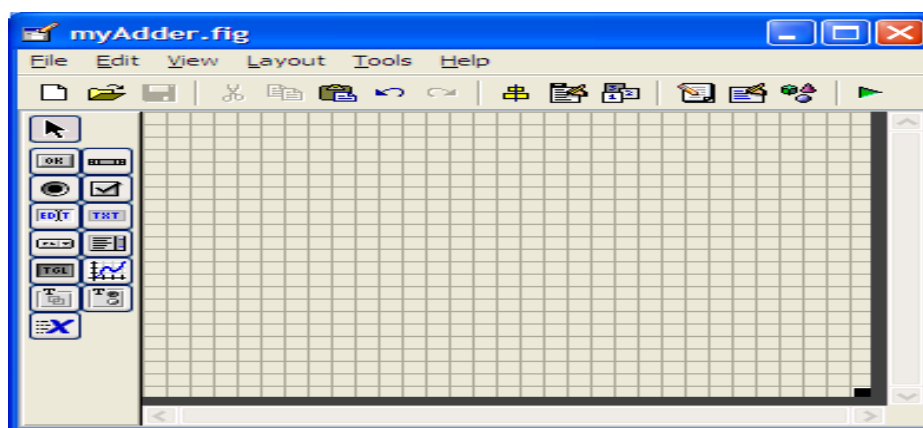

Figure 1: GUI Platform, (Source: Meyers, 2005).

GUI Elements

A GUI provides a platform that the user can interact with for the purpose of gathering and creating information by utilizing a variety of technologies and devices. Computer-stored data is represented using a variety of element-conforming graphic languages. This makes using and working with computer applications simpler for those with limited computer knowledge. Windows Icon, Menu, and Pointer (WMP) paradigm is the most prevalent GUI combination of these elements, particularly in personal computers (Meyers, 2005).

Programming with GUI

Graphical input actions produce a stream of interface computation, consequently, graphical user interface development is intrinsically more difficult than standard application programming. The computer operating system in Figure 2 processes all of the input activities made by a program user, including moving the mouse, clicking a mouse button, and typing a keystroke (Meyers, 2005).
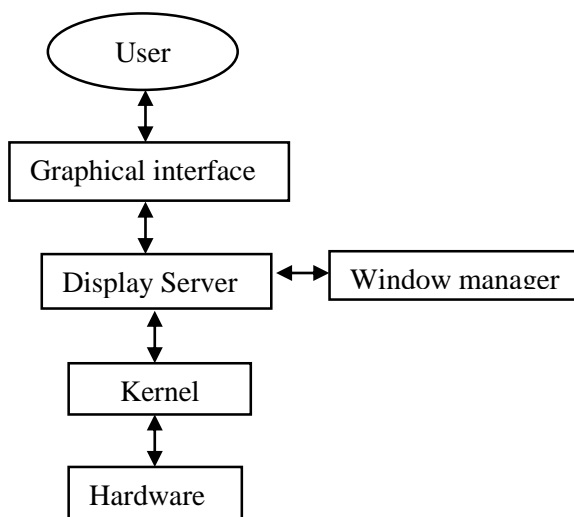

Figure 2: GUI-based Window System, (Meyers 2005).

Methods

The Graphical User Interface was designed using, VisualBasic.Net, Compiler and C-Compiler VISUAL.NET software which is a guide application. The last stage was the writing and compiling of a Graphical User Interface Application (App) using VisualBasic.Net for interfacing, the seismograph waveforms received to display on the laptop screen in real-time.The development of the GUI along with the manual analysis of filters using the basic filter equation and setting the low pass, band Pass and All pass band signal frequencies were programmed using C-language.

Filters Design

The four types of filters used in the work are defined and analyzed below:

Low Pass Filter

A filter that provides a constant output from dc up to a cutoff frequency (f_{OH}) and passes no signal above that frequency is called the ideal low pass filter; this is shown in Figure 3. The cutoff frequency is obtained from Equation 1 where R_1 is Resistor 1 and C_1 is the Capacitor. The cutoff frequencies are given by Equation 1.
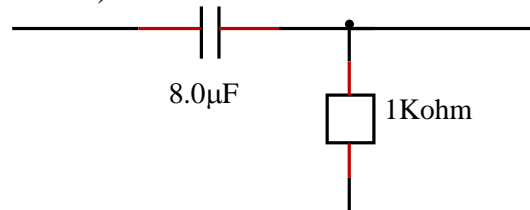
Cut off frequency=$1/(2\pi R_1 C_1)$ (1)

8.0µF   1Kohm

Figure 3: Low Pass Filter Circuit

Source: Researcher (2022).

High Pass Filter

The difference between a high pass filter and a low pass filter is shown in Figure 4. Majorly, is the position of the resistor and the capacitor. The value of cut-off frequencies f_1 and f_2 are obtained by using Equation 1 which is the same as Equation 2 for low-pass filters.
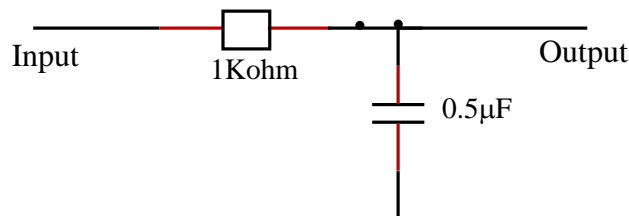
Cut off frequency=$1/(2\pi R_1 C_1)$ (2)

Input   1Kohm   Output

0.5µF

Figure 4: Circuit Diagram of High Pass Filter

Source: Researcher (2022).

Band Pass Filter

This was designed to allow all frequencies within its bandwidth. A simple way to construct a bandpass filter is to cascade low-pass filters and high-pass filters as shown in Figure 5. The first stage of the band pass filter will pass all frequencies that are below its cut-off frequency value f_2, and all frequencies passed by the first stage will head into the second stage. This stage will pass all frequencies above its value f_1. The frequencies that will pass through the amplifier are those that fall within the pass band of both amplifiers. The value of f_1 and f_2 can be obtained using equations 2 and 3 and the bandwidth shown in Equation 3.

$B_w = \sqrt{(f_H \times f_L)}$ (3)

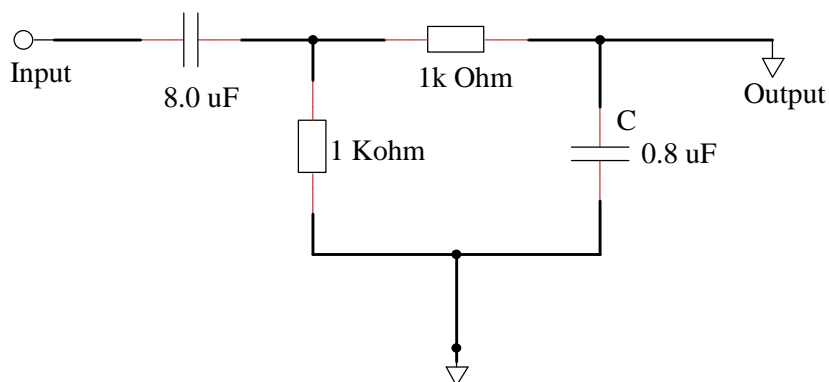where B_w is the bandwidth, f_H is the high frequency and f_L is a low-frequency band.

Figure 5: Circuit Diagram of a Bandpass Filter

Source: Researcher (2022).

Process in Software

On Windows XP, 7, 8, 8.1, and 10 PCs, the window program is operable. The Server app and the Client PC app are the two components of the software. The server PC is where the information sent from the embedded unit first arrives and is saved. When information from the server is retrieved and shown via the Graphical User Interface, it is determined by the client PC application GUI. The client PC app displays the output in graphical format, which can be exported to a spreadsheet for further analysis. Once the data is received from the embedded unit, the username is used to create a file in a different folder, bearing the received data (each embedded unit has its specific username). Regardless of whether the signal was previously displayed, the PC client app can replay the received or recorded signal on a specific date.

3.0 FINDINGS

Software Application Results

Figure 6 displays the graphical user interface opening menu that shows each menu with the application functions. While figures 7 to 11 are seismograph display platforms, user help, and Bandpass with data directory display. Figure 10 is the screenshot of the displayed signal received during the test and observation of the system at All Band Pass. The operating directory is explained which gives a guide to how the Software developed can be used by just anybody to obtain the required results.
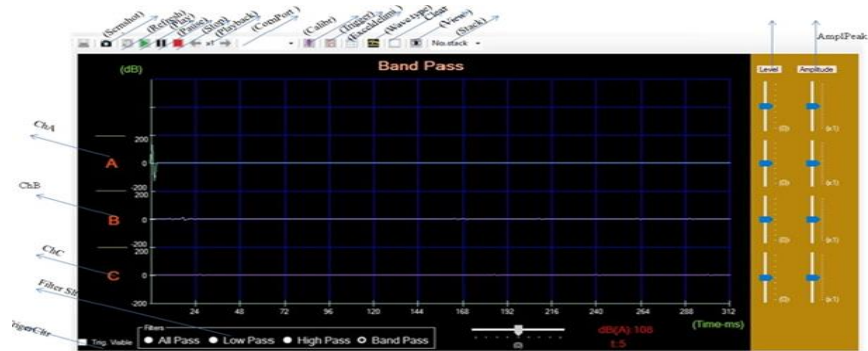
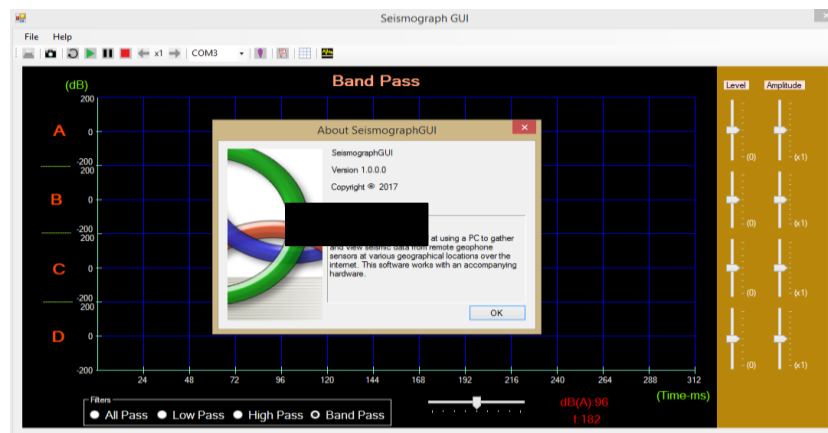Figure 6: Graphical User Interface Menus and Buttons

Source: Field Data (2022).

Figure 7: Seismograph Display Platform
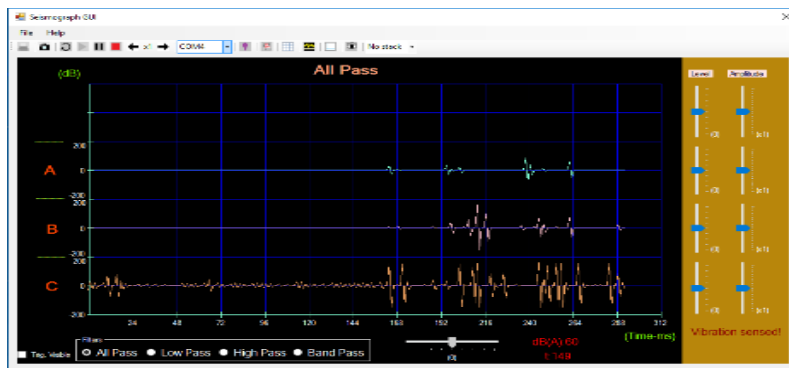

Figure 8: User Help

Figure 9: Band Pass
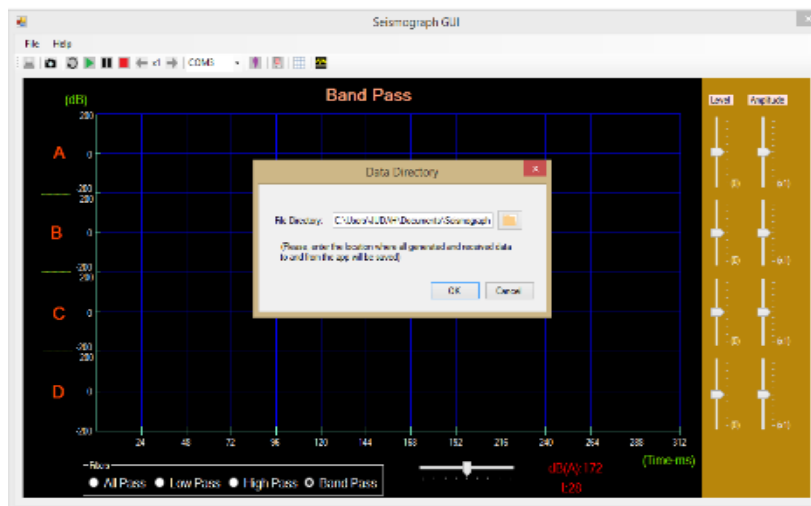

Figure 10: Completed Graphical Display

Figure 11: Data Directory Display

Source: Field Data (2022).

Main Menu (Start)

The main display of the GUI platform is shown in Figure 3 from the start, users can select the start button to pop up the welcome display where the respective frequency band is picked depending on the user's decision which could be Low Band, All Pass or Band Pass frequency range. The amplitude is selected and the channel is observed to determine the wiggles received by the system.

Operating the App

a) The step-by-step procedure for operating the App includes:
b) Plug the system into the source of power
c) Connect it (the system) to the computer
d) Launch the App
e) Pick the created folder from the pop-up box
f) Click on Communication port (Com Port) to choose the installed port.
g) Click the Start button
h) Allow the systems to switch the relays
i) Each time lapsed is 132 milli second
j) The system shows the data scanned
k) Click on the View button and the waveform is displayed.

Graphical User Interface Operation

The following are the steps to follow in using the GUI along with the system:

Step 1: Plug the system to power the source.

Step 2: Allow the system to switch automatically 8 times (the sound is audible)

Step 3: Plug the device into the Laptop through the USB port

Step 7: Launch the app on the laptop

Step 4: Choose the file location

Step 5: Click OK

Step 6: Select the Communication port (Com Port)

Step 8: Click OK

Step 9: Select filter

Step 10: Click START on the green button

Menu Description

Seismograph Opening Platform

This is displayed when the software is launched for operation.

Add Sensor (Com)

This is used to choose the sensor to be observed and it's denoted by the sensor's location and serial number of the sensor.

Read Data

This shows the Date, Time and Stop time. The date which the display format shows in this form: DD - Day, MM - Month and YY - Year, Time as: H- Hour, MM-Minutes and SS – Seconds Stop Time as HH- Hour, MM-Minutes and SS –Seconds

The plate shows the selection for the waveform to be read the and time and time duration for recorded signals that are either observed in real-time and be rechecked after some days.

Seismograph Graphical Unit Interface (GUI)

This shows the File Menu, Tools Menu, Connectivity address, Help Menu and Symbols like Sensors Connectivity mode, Zoom, Play, Pause Stop, Fast Forward and Rewind.

Tools Menu

This comprises tools under the tools menu such as adding sensors, settings and channels. It is very important because the channels are chosen from here, the channel for different filter types such as Low Filter Pass for signals between 0Hz – 50Hz, High Pass Filter for the signal between 60Hz – 150Hz and Band Pass Filter for frequencies between 150Hz – 250Hz this is necessary to show the frequency desired to be observed at any moment of the day, month, week and year.

File Menu

The Print and Exit of the system are located here for the print of waveform and the exit of the system after being used.

User Platform

Is the guide for the new users to show the step-by-step usage of the system, the user's guide and the about for detailed step-by-step and users procedure?

Stacking

5 stacking modes can be selected depending on your choice. The process is displayed to give the status of the process such as 1 of 2, 2 of 2 etc. The signal is saved and could be accessed later after the whole process. The trigger list and spreadsheet delimiter are depicted in Figure 12.
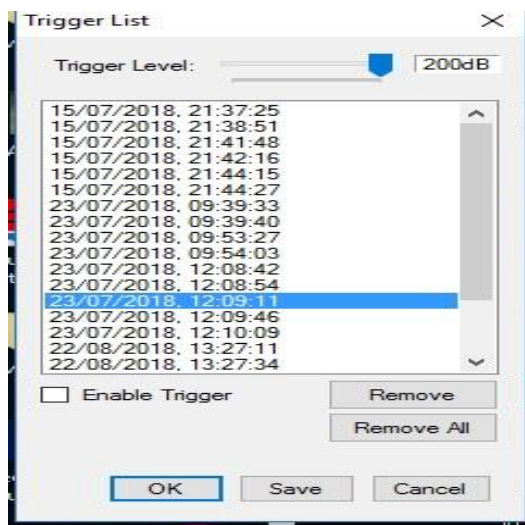
Figure 12: Trigger Records, (Source: Field Data 2022).

VB. NET Program Description

On the computer, another program developed for this system waits for data. This program acts as a visual interface for the received data, displaying the data as both text and graphically, if appropriate. The program was written in Visual Basic.NET (VB.NET) in order to rapidly prototype a working graphical interface. The operation of the program can be divided into two main parts, communicating with the microcontroller and displaying the data.

The communication with the microcontroller was analogous to communicating with the sensors, the computer must decode the packets in a similar manner. The first step is communicating with the serial port in VB.NET. Unfortunately, although previous versions of Visual Basic had included support for interfacing with the serial port, VB.NET had no such capability. To solve this problem, an open serial port class1 by Corrado Cavalli was adapted for this system. This serial class uses an event-driven interface, which allows a function to be called in response to an event. This mechanism is used to read data from the serial port when data is available. To decode the packets from the microcontroller, the program looks for the two start bytes specified by the protocol, (Obianwu, *et al*, 2019). Once the start bytes are found, the program makes a new instance of a "Packet" class to store the incoming data. The next three bytes are stored in appropriate variables in the packet class along with the length (Artit, 2005).

The program then reads the number of bytes indicated by the length and finally the checksum. The checksum for the data is calculated in the program using the same algorithm as discussed in the previous section, and if the calculated checksum matches the received checksum, the packet is marked as complete. After the program receives a complete packet, the program looks at the type id field to what type of data the packet contains. Based on this, it creates a new instance of a class appropriate to the packet, for example, an instance of the "IMU" class for IMU data. These classes were written to convert the raw data into VB.NET data types for easy display. The variables of these classes are used in the main program loop to populate text fields and add points to the graph. The graphing operations are handled by a third-party graph class from Dundas Software, Dundas Chart; a free version was included with the VB.NET resource kit. If logging of the data is desired, the program writes the incoming data into a comma-

delimited file using file classes provided by the VB.NET environment. The program works for its specified purpose, as shown in the results section the VBasic.Net codes for this study.

4.0 CONCLUSION AND RECOMMENDATIONS

The results show that the Graphical User Interface platform has the ability to display the signal from the connected sensors in form of a graph. All the required equations and codes were integrated with the GUI. The GUI can perform and display any output from the sensors (Geophones) and have the ability to give the peak values and minimum value with the ability to export it in form of data.

Acknowledgments

REFERENCES

[1]   Ahn, A.Y.E.; Takikawa, H.; Maly, E.; Bostrom, A.; Kuriyama, S.; Matsubara, H.; Izumi, T.; Torayashiki, T.; Imamura, F. Perception of earthquake risks and disaster prevention awareness: A comparison of resident surveys in Sendai, Japan and Seattle, WA, USA.*IJDRR* **2021**, *66*, 102624.

[2]   Artit, C. J. (2015). A multi-sensor embedded microcontroller system for condition monitoring of RC helicopters. BSc. (Hon). Thesis, Penstate University, Penstate, 187p.

[3]   Bernauer, F.; Behnen, K.; Wassermann, J.; Egdorf, S.; Igel, H.; Donner, S.; Stammler, K.; Hoffmann, M.; Edme, P.; Sollberger, D.; Rotation, Strain, and Translation Sensors Performance Tests with Active Seismic Sources. *Sensors* **2021**, *21*, 264.

[4]   Jens, H, and Gerador, J. (2002). *Instrumentation in earthquake seismology.* Institute of Solid Earth Physics, Springer International Publishing Switzerland, 413p.

[5]   Lawrence, F. B., (2001). *Explorations in earth science*. Hawker Brownlow Education pty Ltd, Australia, 40p.

[6]   Lee, W. H. and Stewart, S. W. (1981). *Principles and Applications of Micro Earthquake Networks*. Academic Press, Massachusetts, United State, 293p.

[7]   Meyers, S. (2005). *Effective C++:55 Specific Ways to Improve Your Programs and Designs.* Pearson Education, Addison Wesley Professional Stafford, Oregon, 320p.

[8]   Obianwu, I. V., Akpabio, I. O., Adeniran, A. O., Akankpo, A. O and Umoren, E. B. (2019). Design and Construction of a Multichannel Microcontroller Based Seismograph for Field and Laboratory use.

[9]   Sollberger, D.; Igel, H.; Schmelzbach, C.; Edme, P.; Van Manen, D.J.; Bernauer, F.; Yuan, S.; Wassermann, J.; Schreiber, U.; Robertsson, J.O.A. Seismological Processing of Six Degree-of-Freedom Ground-Motion Data. *Sensors* 2020**,** *20*, 6904.

[10]   Sratsav, R. S., 2017 "Graphical User Interface (GUI) Development for an Optical Communication Simulator" Cornerstone: A Collection of Scholarly and Creative Works for Minnesota State University, Mankato.

[11]   Uko E. D., Akpabio I. O. and Ekanem P. O. (2002). Ground vibration effects from seismic exploration in the Niger Delta. *Journal of Natural and Applied Sciences*, 3 (1), 64-69, Nigeria

[12]   Steven, R 2001, VB.NET language in a Nutshell, Publisher (s).: O'Reilly Media Incorporation. ISBN: 9780596000929.