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IMPLEMENTATION OF SEISMIC SENSOR TO DETECT TANK

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ABSTRACT
This study aims to investigate seismic sensors in detecting ground vibrations caused by tank or military vehicle movements. Ground vibrations generated by tank movements have specific characteristics, where the produced frequency remains constant depending on the tank's weight and the area of the track's footprint. The amplitude of these vibrations provides information about the detection range, wherein the larger the amplitude, the closer the detection range to the tank. The method employed involves field experiments or the collection of quantitative data from field trials. Test results indicate that ground vibrations produced by tanks have an average frequency of 332 Hz, depending on the tank's weight and the area of the track's footprint. The average amplitude is 4.3 volts at a detection range of 1000 meters, 5.1 volts at 500 meters, 7.6 volts at 200 meters, 8.8 volts at 100 meters, and 12.1 volts at 50 meters. The implication of this research is that seismic sensors can be effectively used as tools to detect tank or military vehicle movements at different distances. These findings could be beneficial in the development of security systems or early detection in areas vulnerable to potential threats from tanks or military vehicles.

Keyword: Seismic Sensor, Vibration, Frekuensi, Amplitudo.

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INTRODUCTION

Seismic sensors are a component system based on the principle of sensitive inertia to ground vibrations originating from sound propagation, while the inertial mass is constant (Ding et al., 2022); (Li et al., 2014). So, the difference between the two components helps measure seismic waves. Geophone is a sensitive ground movement transducer sensor (Hou et al., 2021); (Cheng et al., 2014). This tool converts seismic energy, or vibrations, into electrical voltage that can be measured accurately (Attia et al., 2020); (Tzavaras et al., 2012). Simply put, a geophone uses a mass wrapped around a wire that is in a magnetic field.

Seismic velocity and elastic modulus of rock vary significantly with application stress, indicating that these materials exhibit nonlinear elasticity (Yurikov et al., 2022). Monochromatic waves in Nonlinear elastic media produce higher harmonics and combinational frequencies (Rushchitsky, 2014). The first field experiment used two vibration sources to produce signals with two monochromatic frequencies (Bellino et al., 2013). The second field experiment uses a surface orbital vibrator with two eccentric motors at different frequencies. The resulting wavefield was recorded in a drilled hole using distributed optical fibers acoustic sensing cable in both experiments. Both experiments show combinational, harmonic, and other frequencies' fundamental frequency intermodulation products at the surface and depth. Laboratory experiments replicated field test setups with vibration sources and showed similar results in a nonlinear combination of fundamental frequencies. Observed nonlinear signal amplitude in the laboratory shows variations in fluid saturation (Yunzhen, 2014).

The research objective of obtaining high hitting accuracy for main battle tanks is challenging when the tank moves (Dursun et al., 2017); (Wei et al., 2012). This can be achieved with properly designed weapon controls and weapon systems. To design an effective weapons system while the tank is in motion, a better understanding of the dynamic behavior of the weapons system is required. In this study, the dynamic behavior of weapons systems is discussed. Methods such as using muzzle reference systems (MRS), vibration dampening, and active vibration control technology for control and reduction of muzzle tip deflection are also reviewed (Banerjee et al., 2021); (Dai et al., 2015); (Fu*, 2015). MRS can be useful in controlling weapon barrel deflection with estimation/prediction algorithms for existing weapon systems without major modifications.

Based on the background above, the aim of the research in this paper is to detect ground vibrations generated by tank movements on the surface. The vibrations received by the seismic sensor are converted into digital values through artificial neural network algorithms, enabling the specific attribution of the received vibration specifications to the tank. The benefits of this research include the development of more efficient seismic sensor technology for detecting tank or military vehicle movements, which can enhance the security system's reliability in potentially militarily threatened areas. Additionally, it contributes to the development of signal processing technology and artificial intelligence algorithms in the context of vibration detection and identification, with broad applications in security and defense fields.

METHOD

A magnet is a permanent magnet placed together with the earth's surface to follow the earth's vertical vibrations when seismic waves spread across the earth's surface. Wire Coil Wire coils rely on springs and will move when seismic waves arrive. This tool is flexible enough for applications, earthquake approaches, and landslide detection. Oil and gas exploration, structural strength analysis, road strength testing, and bridge vibration detection. As shown in Figure 1, the principal of the seismic sensor.

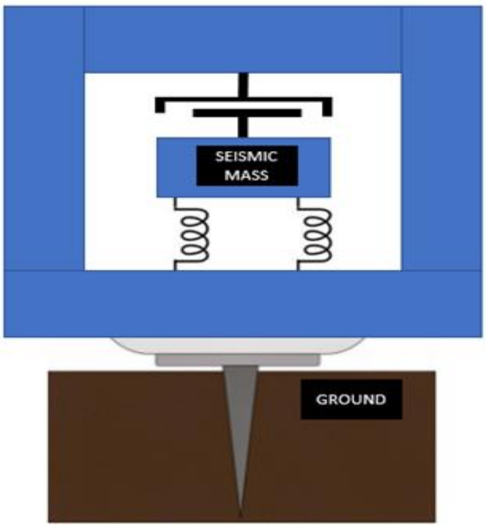

Figure 1. Principal of Seismic Sensor

These tools are connected and inserted in the ground to a depth of 40 cm. They will be connected to a battery that provides vibrations. The installation of these sensors will be carried out continuously to obtain soil characteristics. The working principle of this tool is that when a vibration occurs, the geophone sensor will start working. The vertical seismic movement of the earth hitting the geophone causes the spring inside to oscillate. The oscillatory motion of the spring creates flux due to changes in the position of the coil relative to the magnet or vice versa. Due to the presence of flux, an induced EMF appears. The induced voltage detected in the wire coil is proportional to the magnitude of the vibration captured by the sensor. The output is a voltage that can be visualized as a sinusoidal signal. This seismic working principle is applied to detect ground vibrations produced by tanks, as shown in Figure 2. Experimental setup :

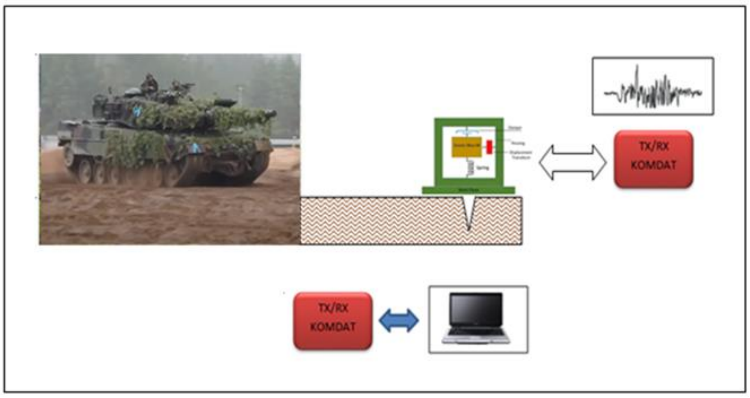

Figure 2. Experimental Setup

Figure 2 shows the experimental setup, where the sensor is placed in the detection area. It is planted to a depth of 40 cm. On the sesmiseismic, a microcontroller and a data link modem send information signals to the operator, who can see it via the laptop monitor. The seismic sensor will be active in real-time when it receives a real-time vibration signal originating from tank movement. This signal will be sent to the operator in the form of a digital signal and, by the microcontroller at the receiver it w, it will be converted into a coding signal which,h, is visualized in the form of an active signal indicator and the control distance between tanks against sensors. In this way, the presence and distance of the tank to the operator will be known. Figure 3 shows the seismic sensor detection area, where the seismic sensor can detect tanks.

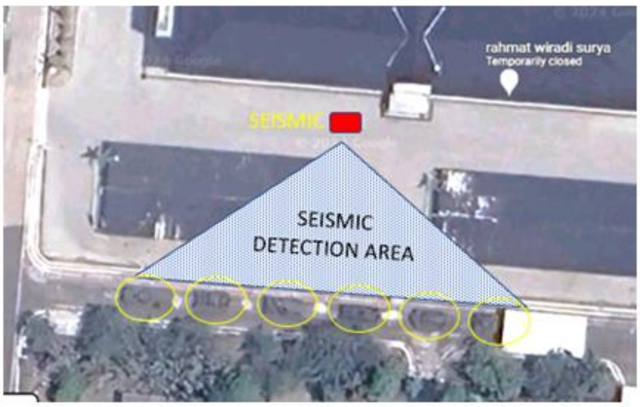

Figure 3. Seismic Detection Area

RESULTS AND DISCUSSION

The seismic sensor components used consist of 100 weber neodymium permanent magnets with sizes (l, w, t) 120mm, 120mm, 200mm; mass 2kg, spring double 200mm, coil diameter 0.5mm, moving magnet connector. The interface components consist of ADC Arduino Uno, laptop, Embarcadero Xe7 program application.

The focus of this research is limited to ground vibrations produced by the Leopard 2 tank. Specifications for the Leopard 2 tank made in Germany in 1970: mass of 62.3 tonnes, Length of 9.97 m, Width of 3.75 m, Height of 3.0 m, Cruising range of 550 km, Speed of 72 km/h. The results of vibration measurement trials include distance, frequency, and amplitude, as shown in Table 1. Seismic testing on the Leopard Tank.

This seismic work process, if it receives vibrations produced by the tank, the magnet in the seismic will vibrate vertically up and down, the up and down movement of this magnet can generate electrical energy and the frequency of electric current which is then connected to the Arduino Uno interface, the output of the Arduino in the form of digital data which has been converted and analyzed by the embarcadero application using an artificial neural network algorithm to assess the vibration source into a seismic detection distance to the tank.

Table 1. Result of Seismic Measurement

Test	Detection Range (m)	Amplitude Mean (V)	Frequency (Hz)
1	50	12,1	334
2	100	8,8	332
3	200	7,6	332
4	500	5,2	332
5	1000	4,3	331

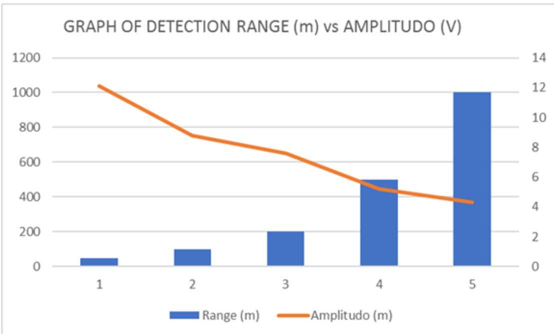

Figure 4. Graph of Detection Range (m) VS Amplitudo (Volt)

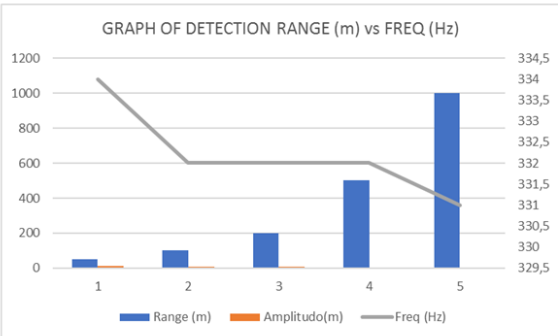

Figure 5. Graph of Detection Range (m) VS Amplitudo (Volt)

As shown in Figure 4, the graph of distance and amplitude, where at a distance of 50 meters, the resulting amplitude is 12.1 volts; at a distance of 100 meters, the resulting amplitude is 8.8 volts; at a distance of 200 meters, the resulting amplitude is 7.6 volts, at a distance of 500 meters the amplitude is 5.2 volts produced and a distance of 1000 meters the resulting amplitude is 4.3 volts. This shows that the farther the detection distance between the seismic sensor and the tank, the lower the resulting amplitude; the closer the target distance, the greater the resulting amplitude. As shown in Figure 5, the graph of distance and frequency, where at a distance of 50 meters, the frequency received is 334 Hz; at a distance of 100 meters, the frequency received is 332 Hz; at a distance of 200 meters, the amplitude produced by the frequency received is 332 Hz, at a distance of 500 meters the frequency received is 332 Hz and a distance of 1000 meters, the received frequency is 330 Hz. This shows that relative distance does not have a big effect on the frequency of seismic vibrations, which, on average, is 332 Hz.

CONCLUSION

The results of this research can conclude that the detection distance greatly influences the amplitude of the signal received; the greater the amplitude received, the closer the detection distance between the tank and the seismic sensor. The smaller the signal amplitude, the farther the seismic detection distance to the tank. Meanwhile, the effect of distance on the frequency of ground vibrations is relatively constant on average, namely 332 Hz.

The implications of these findings are significant. Firstly, it highlights the importance of considering detection distance when deploying seismic sensors for military applications. Understanding how distance affects signal amplitude can inform the placement and configuration of sensor networks to optimize detection capabilities. Secondly, the consistent frequency of ground vibrations regardless of distance suggests that frequency analysis may not be as reliable for determining proximity to the tank as amplitude analysis. This insight can guide the development of more accurate and efficient detection algorithms. Overall, the research underscores the practical implications of distance-related variables in seismic detection technology, enhancing its effectiveness in military and security applications..

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