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Transforming farming with intelligence: Smart vibration monitoring and alert system

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ABSTRACT

During the evolution towards digital agriculture, the pivotal role of tractor riding necessitates a focus on improving operator performance and well-being. While most research has centered around vibration analysis, tangible solutions to control elevated vibration levels remain rare. The study aims to introduce an intelligent ThingSpeak-Enabled IoT (Internet of Things) solution that provides real-time monitoring and generates prompt warning alerts for tractor operators when vibrations exceed safe thresholds. The initial phase involved the real-time measurement of WBV (whole-body vibration) and SEAT (seat effective amplitude transmissibility). Following this, the secondary phase encompassed the analysis and validation of the system in cases where WBV and SEAT exceeded the recommended limits. The experimental design comprised 135 trials by systematically varying tractor ride parameters, including average speed (m/s), average depth (m), and pulling force (kN) levels. Daily vibration exposure response ranged from 0.43 m/s^2 to 0.87 m/s^2 with a mean exposure of 0.64 m/s^2, surpassing the EAV (exposure action value) threshold of 0.5 m/s^2. The SEAT values ranged between 91.37 and 133.08 with a mean of 108.35, that indicates insufficient seat isolation capacity, i.e., < 100. Statistically, the study ascertained a significant influence of average speed and average depth WBV and SEAT responses at a 5% significance level. It underscores the potential efficacy of altering speed and depth parameters to attenuate vibration exposure levels. Further, the effectiveness of the system was tested through the automatic transmission of warning alerts via emails, text messages, and flashing red LED light on the IoT system. This critical feature provides considerable utility for tractor operators to adjust ride settings, ensuring that the ride remains within safe vibration limits. Furthermore, adopting such an advanced warning system in tractor manufacturing signifies a pioneering step towards sustainably enhancing operator well-being.

Introduction

Agriculture 4.0 represents the fourth agricultural revolution, utilizing digital technologies and fostering a smarter, more efficient, and environmentally responsible sector [1]. This revolution is driven by the mobile internet, the Internet of Things (IoT), computer vision, and intelligent decision-making, which facilitate a lean and intelligent on-line management approach in agriculture [2]. IoT has the potential to transform the agricultural industry by utilizing interconnected devices to gather real-time data, increase productivity, and streamline processes [3]. This refers to a system of interconnected devices that can interact with one another and transmit data without human intervention [4]. IoT technology has a broad range of applications in agriculture, from precision farming to livestock management [5]. For instance, smart devices equipped with sensors and actuators can be utilized to monitor soil moisture, temperature, humidity, and other environmental conditions [6,7]. By collecting the data, farmers can optimize crop growth and yield while minimizing the use of resources such as water and fertilizers. Additionally, IoT can be used to monitor the health and behaviour of farm workers, improving their well-being and productivity [8,9].

Numerous researchers have successfully developed IoT-based applications for the agricultural sector, addressing various aspects of farming and livestock management. These applications range from producing smart farming systems [10,11], understanding soil

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composition [2,12,13], managing the complete agriculture supply chain [14–16], measuring soil nutrition, temperature, and other variables [17, 18], to reducing the environmental impact of agriculture [19,20]. IoT has also been utilized in enhancing agricultural practices and production [21–23], reducing resource consumption [24], improving farming operations [25,26], and combating crop diseases [27]. The technology has further been applied in securing transactions and food tracking [28], providing precise tracking and prediction of weather [29,30], spraying for locusts [31,32], collecting soil and other relevant information [33, 34], and aiding in optimal decision-making [35]. Additionally, IoT has been leveraged to improve crop productivity and management [36,37], monitor water tank levels [38–40], gather meteorological conditions information [41,42], monitor water consumption [43], detect agricultural dangers [44,45], maintain animal reproductive health [46], study animal behavior changes [47], and assess vibration levels [48–52]. Various microcontroller systems, such as STM32F103C8T6, ATmega328, and PIC16F877A, have been utilized in studies, along with communication technologies like Cellular Networks, Wi-Fi, Bluetooth, LoRa, and NB-IoT. These studies also employed diverse applications and operating systems, including Sirrus, Manure Monitor, Agrivi, and TractorPal, which run on platforms like Android, iPad, and iPhone. Sensors used encompassed optical, mechanical, electro-mechanical, dielectric soil moisture, and location-based types tailored to specific applications. Furthermore, IoT platforms such as OnFarm, Phytech, and Semios were used or developed. These studies demonstrate the potential of digitalized farming to transform traditional operating models into data-driven ones that emphasize analytics and decision-making practices.

On the other hand, monitoring human health during various agricultural applications can be a spectacular way to improve human performance. A growing population necessitated agricultural production, pushing farmers to employ mechanical methods to reduce the window period between two successive crops. Tractors and implements are important agricultural industry development tools [53]. Due to its interactions with uneven terrain, the increasing use of tractor or tractor-mounted machinery (e.g., soil tillage implements, water tanker, loader, trolley, etc.) is directly associated with whole-body vibrations (WBV) exposure [54–63]. The vibration is transmitted to the driver's body through various source points such as the floor, seat, and steering wheel [64,65]. Working in this environment can lead to fatigue, impacting ride comfort and causing various health issues, including metabolic disorders and cardiovascular and nervous system problems [66]. Tractor vibrations have also been reported to impact driver performance [67]. Previous studies have shown that WBV exposure is more severe in off-road situations than on-road situations [66,68,69]. Consequently, off-road vehicle vibrations are more likely to exceed the recommended health guidance caution zone of 8 h of exposure within 24 h [70]. Increased WBV exposure among tractor drivers is a major occupational hazard often associated with lower back pain [71]. Furthermore, WBV can cause muscles to lengthen and shorten, increasing muscle tension as a stretch reflex [72], which may result in muscle fatigue. Moreover, for a range of tractor-driving applications, the tractor seat often displayed inadequate vibration isolation capabilities [73].

While some studies have explored IoT technology for real-time vibration monitoring focused on evaluating ride comfort within the specific context of rotary tillage operations [49,74]. There is a limited exploration of WBV and SEAT (Seat Effective Amplitude Transmissibility) during cultivation tillage utilizing smart systems. While existing IoT systems primarily focused on on-line data retrieval and computation through web-based applications using specific algorithms to assess ride comfort. The current study presents a novel IoT system that distinguishes its implementation by seamlessly integrating with a dedicated cloud computing platform, i.e., ThingSpeak. This strategic fusion substantially augments the system's data analytics capabilities and empowers it to generate real-time warning alerts when vibration levels exceed recommended thresholds. The implementation of automated alerts assists tractor operators in proactively monitor and managing their vibration exposure, potentially resulting in health benefits and enhanced operator comfort. This system holds the potential for its integration into tractor manufacturing to modernize tractor rides to enhance operator well-being and safety. This smart approach can be extended to diverse agricultural applications by deploying appropriate smart sensors, where real-time alerts play a pivotal role in safeguarding the occupational safety of farmers. These applications encompass crucial areas like heat stress monitoring, exposure to hazardous chemicals, noise levels, ultraviolet radiation exposure, and musculoskeletal health. Moreover, this approach finds applicability in various other agricultural domains, including irrigation management, equipment monitoring, soil erosion prevention, and greenhouse gas emission tracking, enabling timely alert notifications. Ultimately, this technology-driven solution aligns with the principles of Agriculture 4.0 that contribute to societal well-being and promote sustainable agricultural practice.

Research methodology

Participant

To operate the tractor during the experiment, a 32-year-old male participant weighing 88 kg, standing at 1.79 m, and with a body mass index (BMI) of 27.46 kg/m^2 was recruited. The participant was a farm worker with around eight years of experience in tractor driving. Before the start of the tests, the driver was informed about the study's purpose. Participant did not report any sensitivity to vibration exposure. Moreover, the participant confirmed his consent by completing a form for participation in the study.

Test terrain and machinery

This study was conducted at the Punjab Agricultural University (PAU) in Ludhiana, Punjab, on a post-harvest paddy field (India). To measure soil texture's moisture content, soil samples were randomly selected from the surrounding region and placed in sealed containers. Clay made up 26% of the soil's composition, sand made up 65.57%, and silt made up 8.43%. When soil samples were randomly selected from the trial area, the moisture content was discovered to range between 55.7% and 59.9%. Using a digital soil penetrometer, the soil compactness was measured at depths of 0–0.05, 0.05–0.10, and 0.10–0.15 m, and found to be 14, 20, and 28 kPa, respectively. A Farmtrac tractor with two-wheel drive and 55 horsepower was chosen for this study. A manufacturer-supplied original seat was included with the tractor. According to the recommendations of the manufacturer, the tyre pressure was set. A 500 kg, 13-toothed, mild steel cultivator tool fitted to a tractor was used for the experiment.

Ride conditions

The three input parameters for the ride are average speed (m/s), average depth (m), and pulling force (kN). Participant was instructed to keep the tractor in first-low, or 1-L gear, and keep speed between 1.6 and 2.1 m/s, which is the optimal range for cultivator operation (Bureau of Indian Standards, 1998). This procedure needed a normal pulling power of 2, 4, or 6 kN during tilling, depending on the field conditions. Furthermore, the pulling force was measured with a dynamometer attached to the drawbar and the cultivator [60]. The three levels of tillage depth were set at 0.10, 0.12, and 0.14 m, respectively. These conditions were made explicit to the participant. In addition, the participant was asked to take a series of test rides to familiarise himself with the ride conditions. Data from the pilot trials were not included in this study.

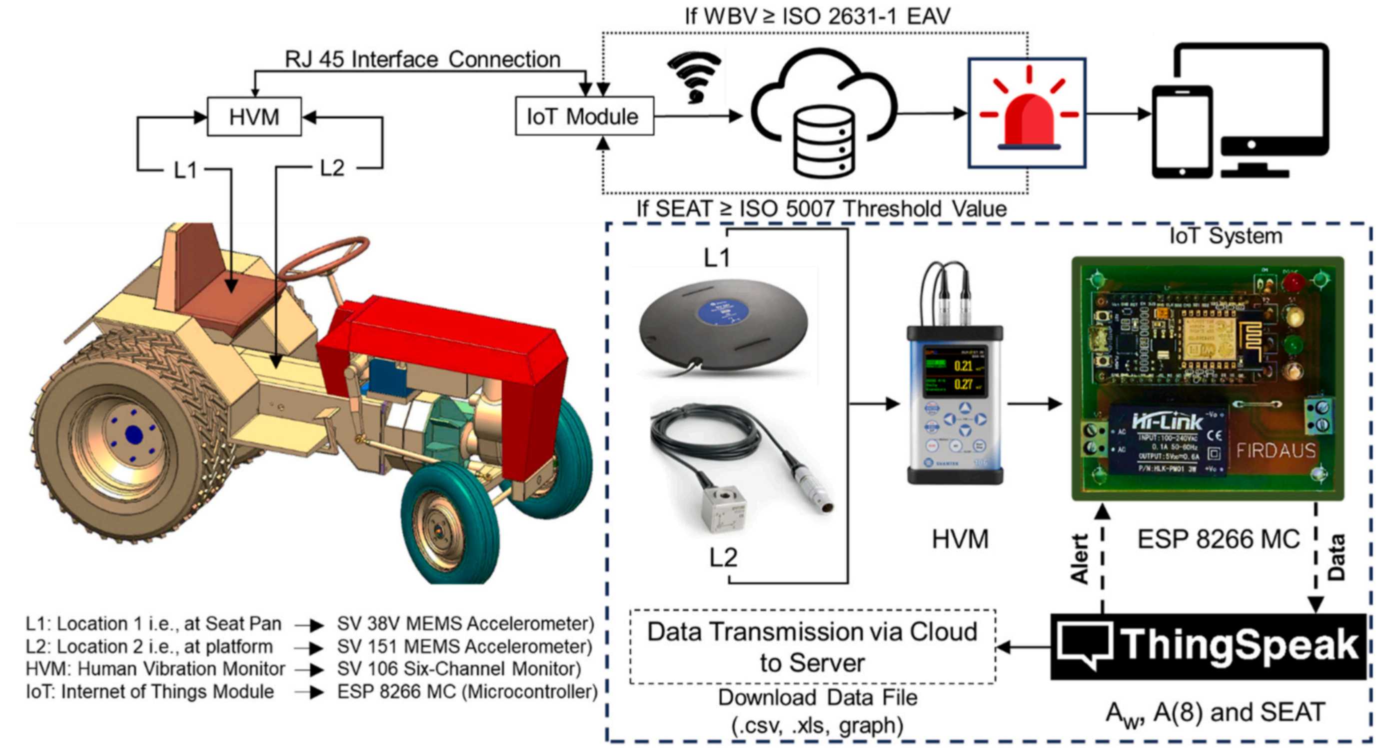

Fig. 1. Schematic Representation of Experimental Setup.

Experimental set-up

The vibration was measured at the two locations (at the seat pan and platform) in time-domain raw acceleration data along the three translational axes based on Taguchi's L_{27} orthogonal array. Hence, the raw acceleration data was pre-processed to remove the dc effect (or signal shifts) by removing the mean from the signals. Then, the data was processed to get the statistical measure of the signals, i.e., weighted root means square acceleration (RMS) [70]. Further, the A (8), i.e., the quantity of WBV to which an individual is exposed during a working day, normalized to an 8-hour reference period, is calculated as [70]:

$$A(8) = a_w \sqrt{\frac{T}{T_0}}$$

Where, a_w: Vibration magnitude (in m/s^2) on the axis (longitudinal-x, lateral-y, and vertical-z) which measured highest, including the weighting factor (x = 1.4, y = 1.4 and z = 1) based on ISO 2631–1 [70]; T: Actual duration of exposure to the vibration magnitude aw (i.e., 60 s); T_0: Reference duration of eight hours.

This study considered the vibration dominant axis (i.e., z axis) for SEAT values. It is defined as the ratio of the vibration on the seat pan and the vibration on the platform and accounts for human sensitivity to vibration. SEAT value is defined as [75]:

$$\text{SEAT} = \frac{\text{Vibration exposure at seat}}{\text{Vibration exposure at floor}} \text{x}100$$

This study developed an IoT module for online data transmission to the ThingSpeak cloud platform to enable monitoring, analysis, and the generation of warning alerts. Vibration exposure levels were recorded using SV 38 V MEMS-based seat pad accelerometers mounted at the seat pan and SV 151 MEMS accelerometers at the platform. These were connected to a six-channel SV 106 human vibration monitor and analyzer following ISO 2631–1 weighting filters, with a sampling rate of 6 kHz. The data logger was equipped with RJ45 interfaces, which formed input units controlled by the ESP 8266 microcontroller unit. This chip comprises a two-core central processing unit (CPU) on the PCB, serving as the electronic components' core. An 8 GB micro-SD unit was integrated to store input data. The ESP32 module's operating range is 2.2–3.6 V, but a Micro-USB connector was utilized for 5 V delivery, supported by an LDO voltage regulator to maintain a constant 3.3 V. This IoT module is connected to the cloud via a Wi-Fi network to transmit data. Output data was programmed to transmit to the ThingSpeak cloud platform, where processing and analysis occurred using embedded MATLAB functions. Before transmitting data, a TCP/IP protocol connection was established. Data transfer was executed using the built-in Arduino Integrated Development Environment (IDE). MATLAB processed data using equations to evaluate A (8) and mean SEAT response. The logic was formulated (A (8) $\geq$ 0.5 m/s^2 and SEAT $\geq$ 100) for real-time monitoring, and if values exceeded recommendations, ThingSpeak triggered warning alerts via text, email, and red LED flashing. The output data is downloadable in CSV and Excel formats. Furthermore, the experimental setup is visually represented in Fig. 1, and the workflow of data transmission and alert generation is illustrated in Fig. 2.

Results and discussion

Assessment of vibration exposure levels

The vibration response assessment was carried out by acquiring raw acceleration data at distinct points: the seat pan and the platform as illustrated in Fig. 3 (A & B). The response of Aw, which encapsulates the weighted root mean square acceleration, was meticulously analyzed at both the seat pan and platform locations. The results revealed variations in the A_w response, from 0.40 to 0.55 m/s^2 at the seat pan and 0.36–0.51 m/s^2 at the platform, along the vertical axis, as visually represented in Fig. 3 (C & D). This thorough examination provided critical insights into the dynamic nature of vibration exposure across these two distinct points, offering a comprehensive perspective on vibration distribution. Furthermore, evaluating the A (8) response, a crucial parameter that quantifies the daily vibration exposure normalized to an 8-hour reference period, showcased a range extending from 0.43 m/s^2 to 0.87 m/s^2 as shown in Fig. 3 (E). Impressively, the calculated mean A (8)

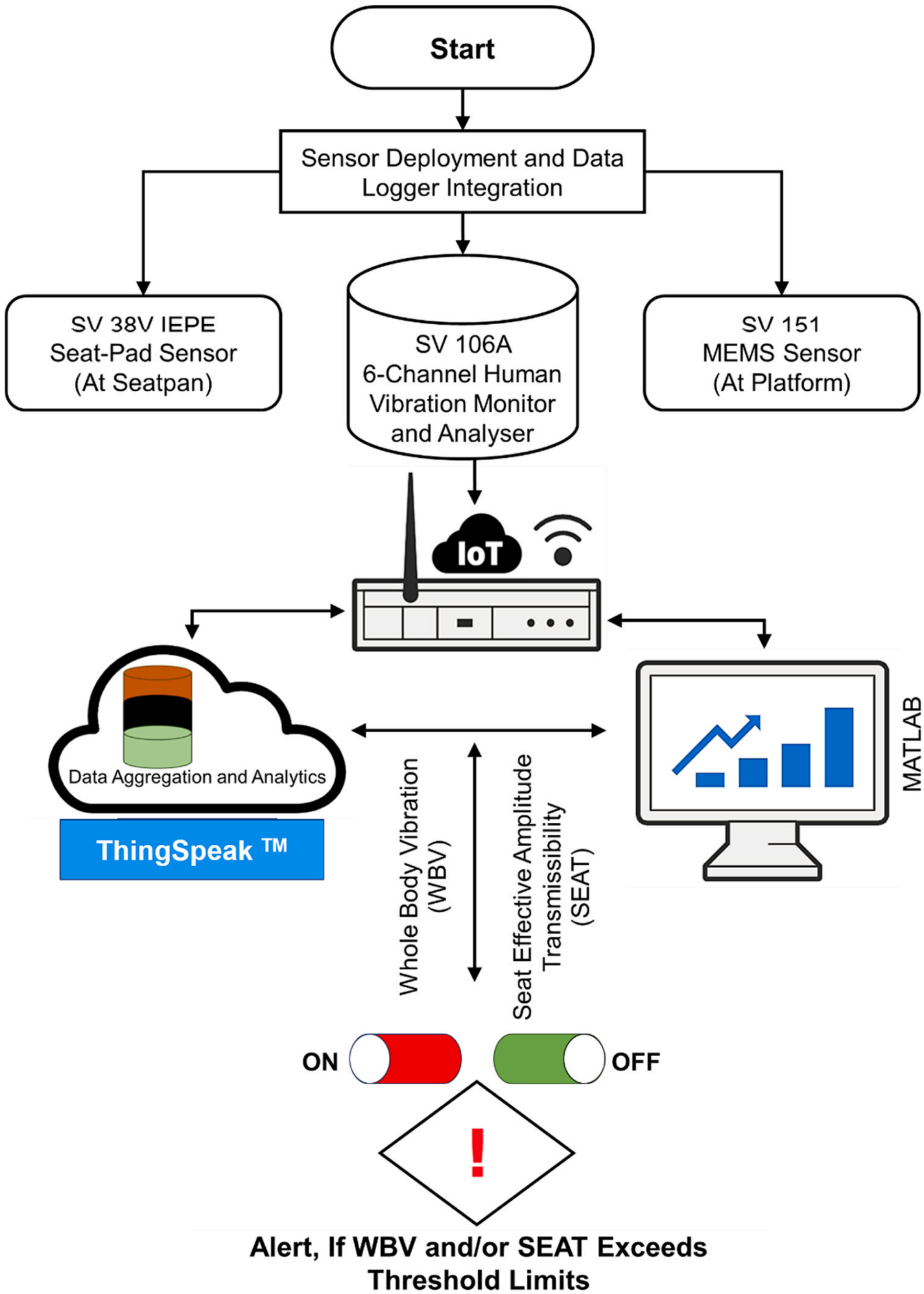

Fig. 2. Process Flow for Data Transmission and Alert Generation.

value was determined to be 0.64 m/s^2. Notably, this mean value exceeded the prescribed exposure action value (EAV) limit set at 0.5 m/s^2. This observation reinforces the significance of addressing the existing vibration levels to ensure tractor operators' well-being and occupational safety.

Notably, the recorded Aw values were found to align within the scope of the weighted acceleration values documented in various tractor-related research studies [65,69]. However, it's imperative to recognize the contextual variations inherent in these studies, as they predominantly encompass controlled test tracks or diverse terrain conditions for tractor rides. It often doesn't encompass the dynamic challenges encountered during real-world field operations, particularly those associated with tillage tasks. The findings from a previous study further corroborate these trends by highlighting elevated whole-body vibration exposure levels experienced by tractor operators across different terrains and operating speeds [76]. The implications of these heightened vibration levels cannot be underestimated, as they have the potential to induce discomfort and contribute to increased health risks. The specific vulnerabilities associated with conditions like low back pain [77] and overall discomfort [75] underscore the urgency of addressing vibration management within tractor operations, particularly in tasks involving tillage implementation.

Seat Effective Amplitude Transmissibility (SEAT)

SEAT values were systematically computed to probe the inherent isolation characteristics of the seat in mitigating vibration propagation. The extraction of the SEAT response relied on the detailed analysis of

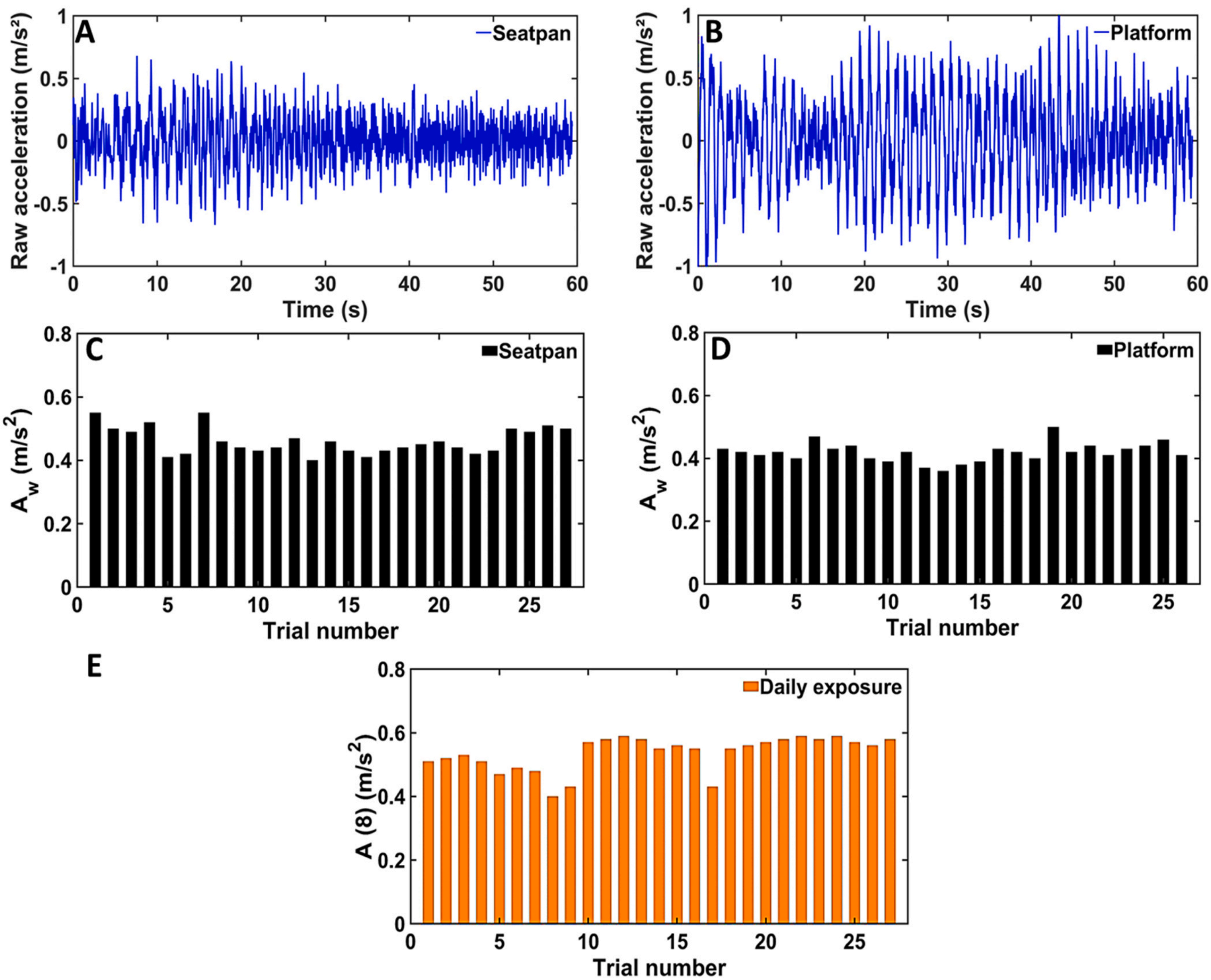

Fig. 3. Comprehensive Vibration Analysis Illustrating Raw Acceleration at Seatpan (A) and Platform (B); Weighted Root Mean Square Acceleration at Seat Pan (C) and Platform (D); Daily Vibration Exposure (E).

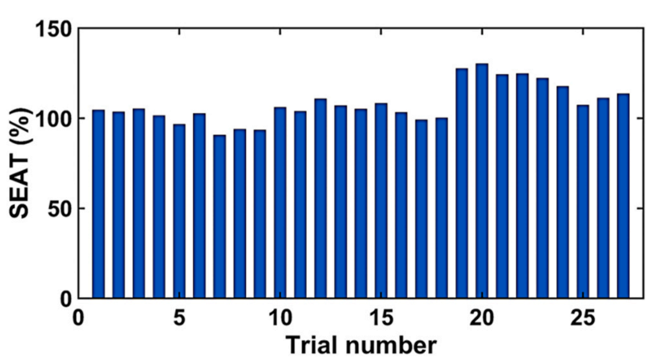

Fig. 4. Visualization of Seat Effective Amplitude Transmissibility (SEAT) Response.

RMS acceleration data acquired from the seat pan and the platform [68]. A SEAT value below the threshold of 100% signifies an effective seat isolation mechanism that attenuates vibrations originating from the platform, leading to diminished discomfort arising from vehicular vibrations. Conversely, a SEAT value surpassing 100% implies a compromised seat isolation capacity, indicating inadequate damping of vibration magnitudes transmitted from the platform. Fig. 4 represents the comprehensive SEAT response, drawing insights from 27 distinct experimental trials. Over this spectrum, SEAT values exhibited a span spanning 91.37–133.08, with an arithmetic mean of 108.35. This mean value surpassing the 100% reference point highlights a conspicuous deficiency in seat isolation performance. Such a characteristic accentuates the heightened transmission of excessive vibration magnitudes from the platform to the seat pan, ultimately impacting the human body. Given the inherent sensitivity of the human body to low-frequency vibrations, the perceptible influence on ride comfort is undeniable [73].

The complex interplay between the human-seat coupling system entails multiple contact points, involving the lower seated body's interaction with the seat pan, the upper body region's connection with the back support, the hands' engagement with the steering apparatus, and the feet's positioning on the foot supports [78,79]. Hence, an adept seat structure with superior isolation traits becomes paramount to curtail the transmission of such vibrations into the seated human body.

Analysis of variance (ANOVA)

The ANOVA method was crucially applied to identify the parameters that significantly influenced the vibration response. This intentional effort was motivated by equipping tractor operators with the ability to

Table 1
Exploring Variance Effects on Vibration Response in Cultivation Operation.

Source	DF	Seq. SS	Adj. SS	Adj. MS	F-value	P-value	P (%)
Average Speed (m/s)	2	4.280	4.280	2.140	76.95	0.013 *	74.16
Average Depth (m)	2	1.355	1.355	0.678	24.37	0.039 *	23.48
Pulling Force (kN)	2	0.080	0.080	0.040	1.43	0.411	1.39
Residual Error	2	0.056	0.056	0.028	-	-	0.97
Total	8	5.771	-	-	-	-	-

carefully adjust these identified parameters, especially in response to alerts indicating high vibration exposure levels. This statistical method aimed to compute essential metrics such as total sum of squares (SST), individual sum of squares (SSI), and the F-test. With a calculated F-value of 3.37 at a 5% significance level and degrees of freedom (DOF) in the denominator (26) and numerator (2), represented as $F_{0.05}$ (2, 26), the analysis evaluated the relative impact of each parameter. A higher F-ratio indicated a more pronounced influence of the input parameters under consideration. This statistical technique originated from agricultural trials, used to explore variance among a group of analyzed items and extract insights from output responses. Additionally, each input parameter's percentage contribution (P%) was quantified [80]. Table 1 illustrated the detailed analysis and identified parameters and the percentage contribution in significantly impacting the vibration response. The statistical significance of average speed and pulling force at the 5% level within the scope of this study. The P% values provided valuable insights, indicating that average speed exerted the most substantial influence, accounting for 74.16% of the contribution to the A (8) response. It was followed by average depth (23.48%) and pulling force (1.39%).

The results underscored a significant finding - an increase in speed correlated directly with a rise in vibration exposure. This relationship can be attributed to the increase of root mean square frequency

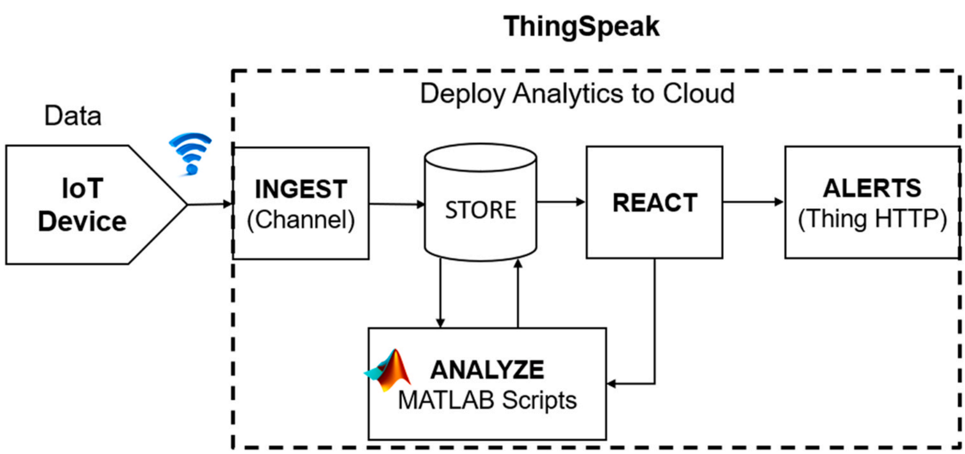

Fig. 5. Schematic Representation of ThingSpeak Framework.

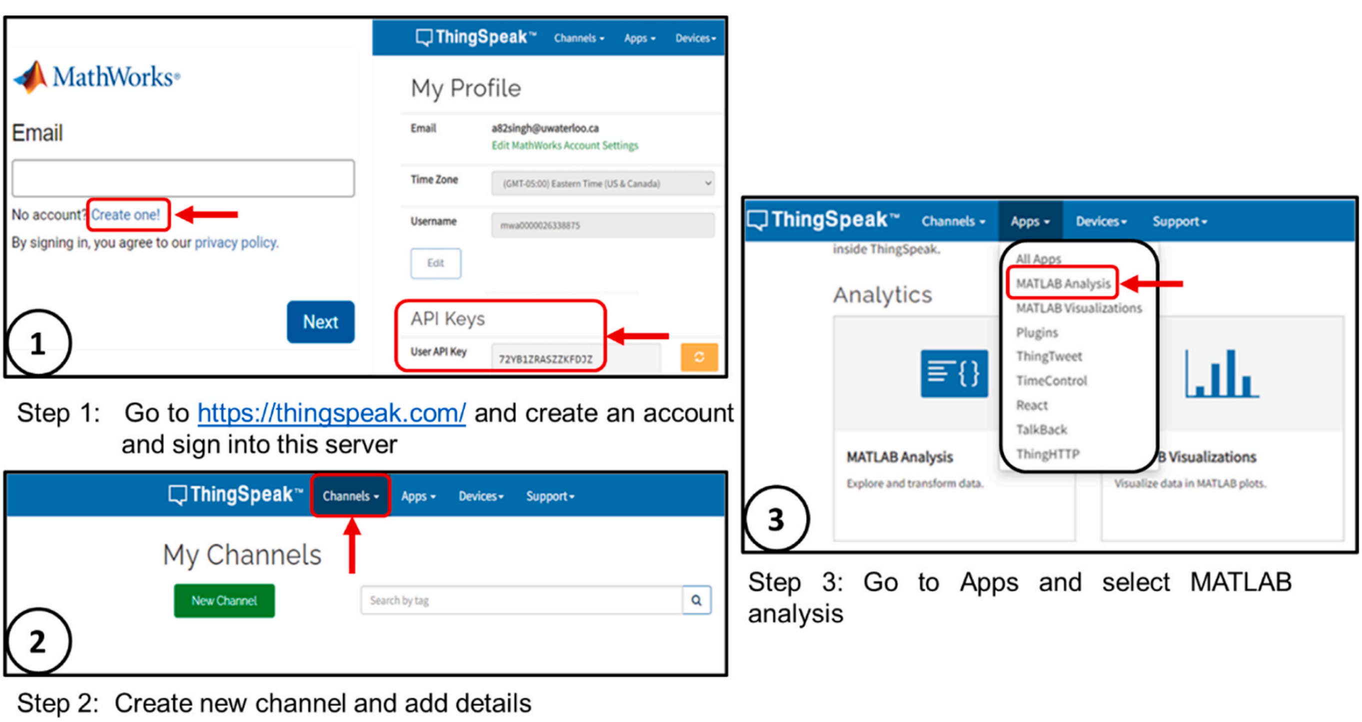

Fig. 6. Sequential Setup Process of ThingSpeak for Data Analysis.

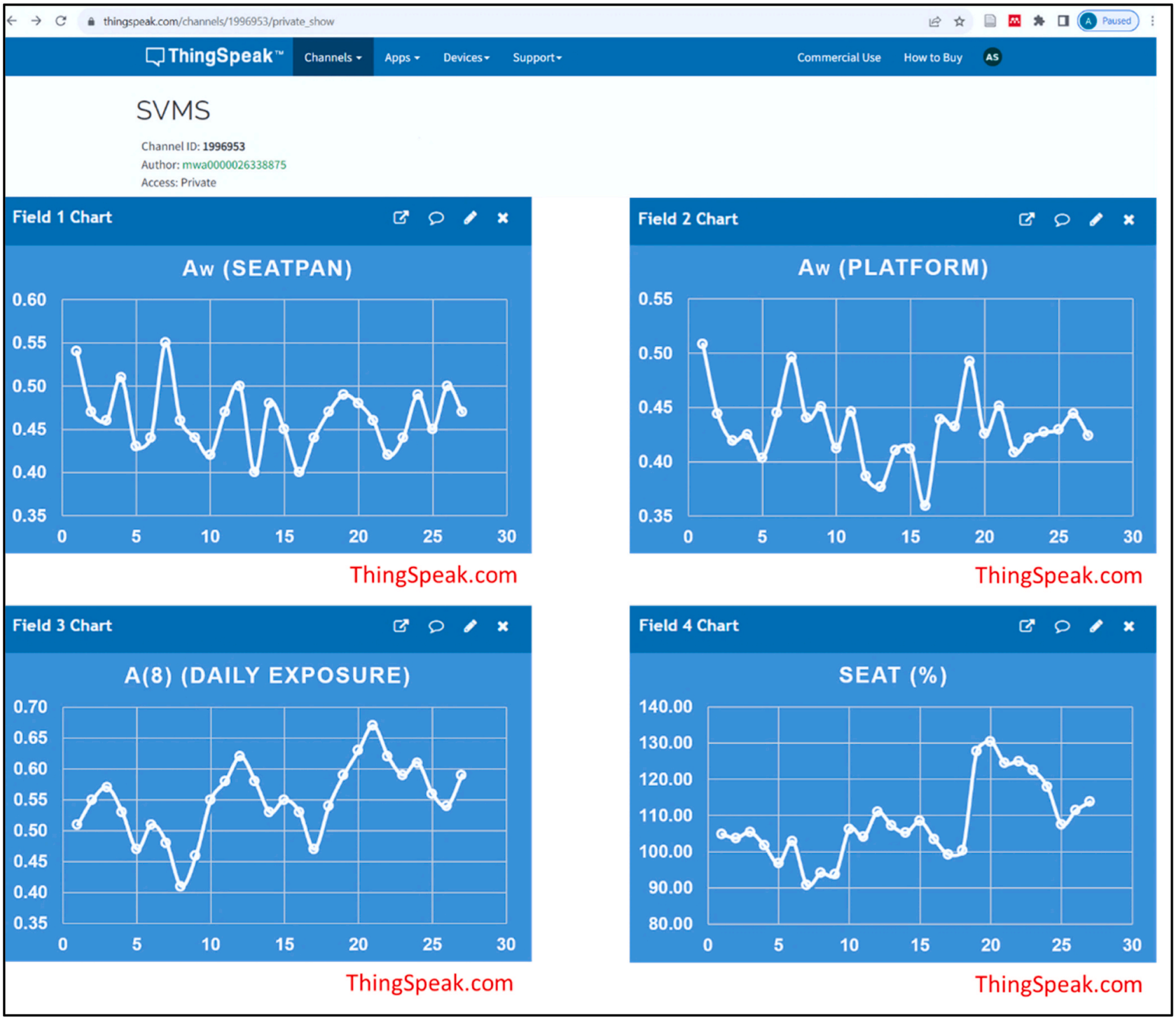

Fig. 7. Visualization of Analyzed Results on ThingSpeak Platform.

weighted acceleration magnitude as speed levels increase [81]. Moreover, the rise in acceleration magnitudes might directly result from uneven terrain conditions. This increase in vibration levels has the potential to adversely affect tractor drivers, necessitating the implementation of preventive measures to limit exposure.

Importantly, the observed trends imply that integrating a warning alert system for tractor operators could effectively support the implementation of vibration reduction measures. This system would promptly notify operators when vibration levels exceed the recommended threshold, contributing to reducing vibration magnitudes. The association between the SEAT response and the RMS acceleration response at both the seat pan and platform supports this strategy. By utilizing warning alerts, the management of SEAT values through vibration level mitigation is attainable. An online monitoring system is indispensable for continuously tracking vibration exposure levels to enact this strategy effectively. Hence, this study integrated the IoT system with a cloud computing platform, i.e., ThingSpeak, with the application of MATLAB programming to achieve online vibration level monitoring and to trigger timely warning alerts. The subsequent sections provide a detailed integration of the ThingSpeak platform, including its architecture, components, and real-time computing capabilities.

Thingspeak set-up for ESP8266

As illustrated in Fig. 5, this study employed the cloud-based capabilities of the ThingSpeak platform to collect, store, analyze, and respond to the acquired data. ThingSpeak is an open-source Internet of Things platform enriched with MATLAB analytics, designed to gather, visualize, and analyze real-time data streams in the cloud. We can seamlessly transfer data from devices like the ESP8266 to ThingSpeak by employing on-line services, enabling instant real-time data visualization and alarm generation. ThingSpeak's integration of MATLAB analytics empowers us to develop and execute MATLAB code for preprocessing, visualization, analysis, and alert generation. To incorporate the ESP8266 into the Arduino Integrated Development Environment (IDE), we added the URL "**https://dl.espressif.com/dl/package_esp8266_index.json**" to the Additional Boards Manager Tab. Once the ESP8266 is successfully identified and installed, the IDE becomes operational.

The configuration process for ThingSpeak in this study entails a structured series of steps to establish a seamless data transmission and analysis framework as illustrated in Fig. 6. Initially, we need to access the ThingSpeak platform by navigating to the URL https://thingspeak.

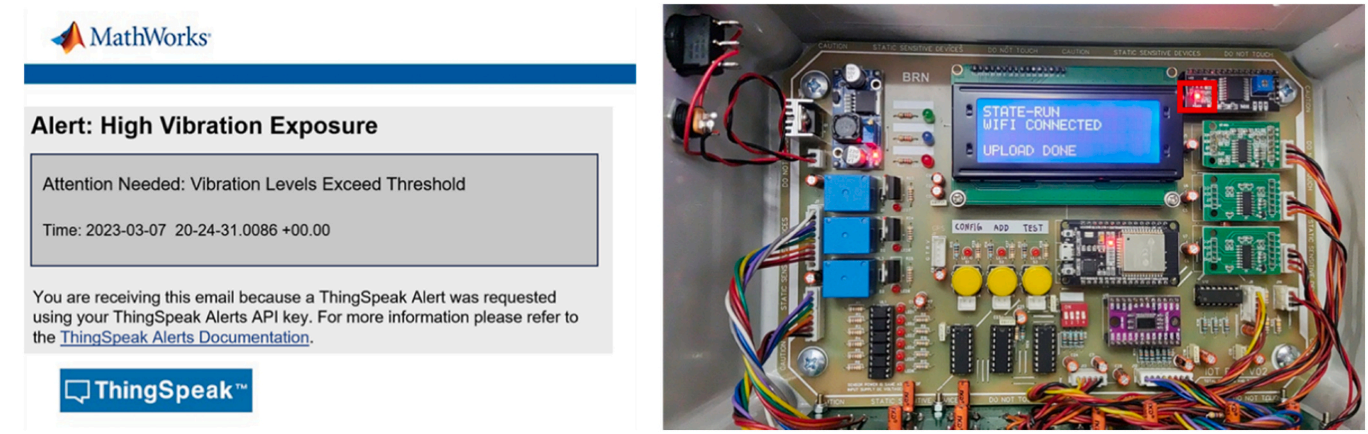

Fig. 8. Illustration of ThingSpeak's Alert Generation.

com/. Upon creating an account and logging in, the next step involves the creation of a new channel, where relevant channel details are input to define the data organization. The next step directed to the 'Apps' section within ThingSpeak, where the 'MATLAB analysis' option is selected. This choice integrates MATLAB analytics into the platform, enhancing data processing capabilities. Fig. 5 illustrates the visualization of these steps.

A critical aspect of the configuration involves the assignment of an API key. This key serves as the communication link between the ESP8266 device and ThingSpeak, enabling the secure and efficient data transmission. This key establishes a secure and streamlined data transmission mechanism, storage, analysis, and response within the developed IoT system.

Display results and trigger alerts

ThingSpeak demonstrated its capability seamlessly by adeptly receiving, analyzing, and visually presenting the weighted RMS acceleration (A_w) at the seatpan and platform, along with the vital A (8) and SEat% responses. These results have been presented in Fig. 6, aligned with the data depicted in Figs. 3 and 4. This coherence underscored ThingSpeak's ability through cloud computing to execute complex calculations. Following the successful demonstration of ThingSpeak's analytical and visualization capabilities, the study delved into refining the alert mechanism. It involved the utilization of ThingSpeak's "React" module, which seamlessly interfaces with the analyzed data on the platform. Through this integration, customized alerts were configured to trigger based on predefined conditions. Specifically, the study employed a "numeric" condition within ThingSpeak's React module, leveraging a range of options that include "greater than"; "greater than or equal to"; "less than"; "less than or equal to"; "equal to"; and "not equal to". These conditions were set to activate when vibration levels exceeded or equaled 0.5 m/s^2, and when SEAT values reached or exceeded 100. These comprehensive conditions ensured a dynamic alert framework catering to various scenarios.

Furthermore, the alert system exhibited a multi-faceted approach by promptly delivering alerts via email and text messages as shown in Fig. 7. In tandem, strategically placed LED pins within the ESP8266 emitted a conspicuous red flashing pattern, reinforcing real-time visual cues whenever vibration levels surpassed safe limits. This seamless integration of alerts across various modalities enhanced the system's responsiveness, providing tractor operators with a comprehensive toolset for swift decision-making and timely intervention.(Fig. 8).

Concluding insights and future implications

In conclusion, this study has successfully demonstrated the implementation of an intelligent IoT solution utilizing ThingSpeak for real-time monitoring and alert generation in tractor operations. The system effectively addresses the challenge of elevated vibration levels by analyzing vibration data and integrating customizable alert mechanisms. The research confirms that adjusting tractor parameters can influence vibration exposure, and the developed system's prompt alerts through email, text messages, and LED indicators empower operators to take immediate action. This research marks a significant step towards enhancing operator well-being, performance, and safety in digital agriculture.

In future implications, this study opens several directions for future research and development. One direction can be the expansion of system's capabilities to include analysis of vibration exposure along different axes and frequencies. Additionally, integrating advanced sensors and wearable devices could allow for collecting more nuanced physiological data from tractor operators. Furthermore, incorporating machine learning algorithms could significantly elevate the system's capabilities. The system could predict potentially hazardous situations by analyzing historical data and operator responses and provide pre-emptive alerts or recommendations to mitigate risks. Overall, the smart system presented in this study lays the foundation for many potential advancements. By fine-tuning parameters, integrating advanced sensors, and harnessing predictive analytics, future iterations of this system could play a pivotal role in ensuring operator well-being and safety in tractor operations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. General Representation of the Taguchi's L27 Orthogonal Array

Experiment No.	Tractor Ride Parameters		
	Average Speed (m/s)	Average Depth (m)	Pulling Force (kN)
1	1.6	0.10	2
2	1.6	0.10	2
3	1.6	0.10	2
4	1.6	0.12	4
5	1.6	0.12	4
6	1.6	0.12	4
7	1.6	0.14	6
8	1.6	0.14	6
9	1.6	0.14	6
10	1.9	0.10	4
11	1.9	0.10	4
12	1.9	0.10	4
13	1.9	0.12	6
14	1.9	0.12	6
15	1.9	0.12	6
16	1.9	0.14	2
17	1.9	0.14	2
18	1.9	0.14	2
19	2.1	0.10	6
20	2.1	0.10	6
21	2.1	0.10	6
22	2.1	0.12	2
23	2.1	0.12	2
24	2.1	0.12	2
25	2.1	0.14	4
26	2.1	0.14	4
27	2.1	0.14	4

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