

A DATA LOGGING DEVICE AND SYSTEM THEREOF

FIELD OF INVENTION

The invention relates to the field of data logging. More particularly, the invention relates to a data logging device and a system for monitoring work activities via data collected by the data logging device.

BACKGROUND OF THE INVENTION

A data logging device is an electronic device that collects data over time or at a specific location with the aid of instruments or sensors. Over the years, data logging devices have become increasingly common in the agricultural industry to achieve precision agriculture. For example, when in use, a data logging device can be held by an agricultural worker while performing an agricultural activity in an agricultural field to record the agricultural activity performed by the agricultural worker. This ensures that various aspects of agricultural management, such as quality of the agricultural activity performed and condition of the agricultural field, can be monitored to improve yield. Additionally, data logging devices can be linked to a server for further improving agricultural management.

Throughout the years, various data logging devices have been developed. For instance, US Patent Application Publication No. US20130275187A1 discloses a work measurement system comprising a handheld electronic device and a server that are communicatively coupled to each other. Accordingly, the handheld electronic device is designed to receive an asset record and input data related to a worker's various activity readings, which are collected through sensors such as a global positioning system sensor, a camera, or an accelerometer. Meanwhile, the server is responsible for receiving the asset record and activity readings from the handheld electronic device for

subsequent review and analysis.

However, the work measurement system relies on the handheld electronic device to receive the activity readings from the sensors, which can be unreliable in event where the sensors malfunction or failed to register the work activity. Consequently, this affects the review and analysis performed by the server. Therefore, it is desirable to provide a data logging device that can overcome the aforementioned problem. The invention provides a solution to the problem.

SUMMARY OF INVENTION

In a first aspect of the invention, there is provided a data logging device for collecting data related to work activity comprising a mechanical actuator which is triggerable by a worker in various ways, each corresponding to a different type of input data that is related to a specific work activity performed by the worker; a geographical position sensing component for collecting location data of the data logging device; a processing module in communication with the mechanical actuator and the geographical position sensing component for processing the input data and the location data; and a transceiver operably connected to the processing module for transmitting the processed data to a server over a wireless network communication at a predetermined time interval.

Preferably, the mechanical actuator takes the form of a button that can be pressed by the worker in different ways to collect the various types of input data.

Preferably, the data logging device comprising at least one sensor for collecting further input data based on parameters detected by the sensor.

Preferably, the sensor is an accelerometer or a gyroscope, or a combination thereof.

Preferably, the processing module is configured to encrypt and/or compress the input data and location data into processed data for storage or transmission.

Preferably, the server is configured to analyse the processed data using one or more algorithms to determine a pathway travelled by the worker and information of the work activity performed by the worker along the pathway.

Preferably, the server is further configured to predict a location of the data logging device along the pathway when registering input data that is between two previously collected location data points.

Preferably, the wireless network communication is a long-range wireless network communication which comprises a plurality of gateways that are connected to one another via a long-range wireless protocol.

Preferably, the server is further configured to centre the data logging device with respect to the gateways such that the input data and the location data are not collected by the data logging device when the data logging device is not within a coverage of the wireless network communication.

Preferably, the data logging device further comprising a power management module that includes a rechargeable battery for supplying electricity to the components of the data logging device and a wireless charging receiver for converting energy received from a wireless charging platform into electricity to charge the rechargeable battery.

Preferably, the processing module is further configured to identify the input data and the location data which are missing from the server and then upload the missing input data and the missing location data to the server via a data synchronisation algorithm when the data logging device is being charged at the wireless charging platform.

Preferably, the processing module is further configured to initiate a new data logging session when the data logging device is removed from the wireless charging platform.

Preferably, the data logging device further comprising a device management module configured to switch the data logging device between sleep mode after a predetermined period of inactivity and active mode when the data logging device is in use.

In a second aspect of the invention, there is provided a data logging system for monitoring work activity comprising a data logging device having a mechanical actuator which is triggerable by a worker in various ways, each corresponding to a different type of input data that is related to a specific work activity performed by the worker; a geographical position sensing component for collecting location data of the data logging device; a processing module in communication with the mechanical actuator and the geographical position sensing component for processing the input data and the location data; and a transceiver operably connected to the processing module for transmitting the processed data over a wireless network communication at a predetermined time interval; a server configured to receive the processed data from the transceiver over the wireless network communication and analyse the processed data using one or more algorithms to determine a pathway travelled by the worker and information of the work activity performed by the worker along the pathway; and a wireless charging platform for charging a rechargeable battery of the data logging device, wherein the processing module is further configured to synchronise the processed data with the server by transmitting the processed data to the server when the data logging device is being charged at the wireless charging platform.

One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope

of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawings the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

Fig. 1 is a schematic diagram illustrating a system for monitoring work activities.

Fig. 2 is a block diagram illustrating components of a data logging device of the system.

Fig. 3 is a block diagram illustrating components of a server of the system.

Fig. 4 is a block diagram illustrating a secondary gateway of the system.

Fig. 5 is a schematic diagram illustrating a primary gateway of the system.

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in greater detail, by way of example, with reference to the drawings.

Fig. 1 illustrates a preferred embodiment of a data logging system (100) for monitoring work activities. In general, the data logging system (100) comprises one or more data

logging device (200) connected to a server (300) over a wireless network communication formed by a plurality of gateways (400, 500).

Fig. 2 illustrates a preferred embodiment of the data logging device (200) for collecting data related to work activity of a worker. The data logging device (200) is preferably a handheld electronic device held by the worker such that the work activity performed by the worker within a work location (101) can be monitored by a management team. Although the data logging device (200) is presented as an example of its use in the agricultural industry to monitor worker activity in a field, it is important to note that the data logging device (200) can have many versatile applications and can be utilized in various other industries. Preferably, the data logging device (200) generally comprises a mechanical actuator (201), a geographical position sensing component (202), a processing module (203), and a transceiver (204).

The mechanical actuator (201) can be designed to be triggered by the worker in various ways that correspond to different types of input data related to a specific work activity performed by the worker. Preferably, the mechanical actuator (201) takes the form of a button that can be pressed by the worker in different ways to collect different types of input data. To record a particular work activity, the worker triggers the mechanical actuator (201) in a manner that corresponds to an assigned work such as a single press, double press, short press, long press, or press and hold for at least a predetermined period of time for activities like crops harvesting, crops collection, and weed removal. Furthermore, the data logging device (200) includes an audio signal module (205) that provides the worker with an audio notification when the mechanical actuator (201) is triggered to register the input data. Additionally, the audio signal module (205) provides the worker with the audio notification when the data logging device (200) is connected or disconnected from the wireless network communication. The audio signal module (205) may consist of a buzzer or other similar device. Alternatively, the data logging device (200) may feature a vibration motor that provides the worker with a vibration

notification to indicate that the mechanical actuator (201) has been triggered.

The data logging device (200) further comprises at least one sensor (206) for collecting further input data based on parameters detected by the sensor (206). The sensor (206) can be but is not limited to an accelerometer, a gyroscope, or a combination thereof. The sensor (206) in the data logging device (200) is designed to collect further input data based on motion and movement of the data logging device (200), such as tilting and shaking, during use. Additionally, the sensor (206) works in conjunction with the mechanical actuator (201) to collect the further input data. When in use, the worker can trigger the mechanical actuator (201) while simultaneously shaking the data logging device (200) such that a different type of input data is collected by the data logging device (200). Alternatively, the sensor (206) can be configured in a way such that specific motion and/or movement can automate collection of the input data instead of manually triggering the mechanical actuator (201).

The data logging device (200) is equipped with the geographical position sensing component (202) that is responsible for collecting location data of the data logging device (200). For instance, the geographical position sensing component (202) may comprise a global positioning system sensor that can be configured by the management team to periodically or continuously collect the location data of the data logging device (200) within the work location (101). An example of this is setting the geographical position sensing component (202) to collect the location data every 5 seconds. This feature is particularly advantageous in reducing power consumption of the data logging device (200) or the workload of the processing module (203) when performing work activities that do not require continuous location tracking, such as tree cutting, whereby the worker remains at the same location for a significant period of time.

The processing module (203) communicates with both the mechanical actuator (201) and the geographical position sensing component (202) to process the collected input

data and location data collected. For example, the processing module (203) can be a microcontroller. Ideally, the processing module (203) is designed to encrypt and/or compress the input data and the location data to ensure data confidentiality and security and/or to reduce size of the input data and the location data. The processing module (203) also performs error correction on the input data and the location data during the encryption and/or compression processes to guarantee the integrity of the processed data. The data logging device (200) also has a memory module (207), and is responsible for storing the processed data.

The transceiver (204) is an essential component that enables the data logging device (200) to transmit the processed data to the server (300) over the network connection. The transceiver (204) is connected to the processing module (203) to prepare for the transmission of the processed data to the server (300). The data transmission interval is an important aspect of the data logging device's (200) operation. Preferably, the data transmission interval can be set to 5 minutes or any other interval that is deemed suitable for the particular application. This ensures that the server (300) receives the data in a timely manner and is updated on a regular basis.

Additionally, the data logging device (200) further comprises a device management module (208) configured to switch the data logging device (200) between sleep mode and active mode. Preferably, the device management module (208) switches the data logging device (200) to the sleep mode after a predetermined period of inactivity. Preferably, the predetermined period of inactivity refers to a duration in which the sensor (206) does not detect motion of the data logging device (200) and/or the mechanical actuator (201) is not triggered for registering the input data by the worker. The predetermined period of inactivity is preferably configurable by the management team. By way of example, the predetermined period of inactivity can be 5 minutes. In addition, the geographical position sensing component (202) can continuously collect the location data of the data logging device (200) in the sleep mode. On the other hand,

the device management module (208) preferably switches the data logging device (200) to the active mode from the sleep mode when the data logging device (200) is in use. Preferably, upon detecting motion of the data logging device (200) by the sensor (206) during the sleep mode and/or when the mechanical actuator (201) is triggered for registering the input data by the worker, the device management module (208) switches the data logging device (200) to the active mode from the sleep mode. Advantageously, the device management module (208) conserves battery usage of the data logging device (200). In addition, the audio signal module (205) provides audio notifications to the worker when the data logging device (200) is switched between the sleep mode and the active mode.

The server (300) can be a local based or a cloud-based portal service, operated by one or more heavy duty computers and any known devices or group of devices to provide sufficient capacity for storing data. The server (300) is preferably stored with plurality sets of computer-implementable instructions to perform and automate the different operations, and the different sets of instructions are performed by software or hardware-based modules of the server (300). As illustrated in Fig. 3, such modules may include a data receiving and filtering module (301), an incoming data frame processing module (302), a time-stamping module (303), an analytics module (304), a database (305), and an application programming interface (API) module (306).

Upon receiving the processed data from the data logging device (200), the data receiving and filtering module (301) performs a deduplication process to remove duplicated or redundant data. Then, the incoming data frame processing module (302) decodes and decompresses the processed data. Preferably, the server (300) is configured to analyse the processed data via the time-stamping module (303) after the decoding process and decompression process to determine a pathway travelled by the worker and information of the work activity performed by the worker along the pathway. By way of example, the information of the work activity can be counts of the work activity

performed by the worker for countable work activity such as crop harvesting. Alternatively, the information of the work activity can be markings or indications of the work activity performed by the worker for uncountable work activity such as weed removal. In addition to the analysis, the time-stamping module (303) is further configured to predict a location of the data logging device (200) along the pathway when registering input data that is between two previously collected location data points. For example, when the geographical position sensing component (202) collects the location data of the data logging device (200) at $t_1 = 5$ s and $t_2 = 10$ s, the server (300) can predict the location of the data logging device (200) when the mechanical actuator (201) is triggered at any time between t_1 and t_2 . By way of example, the time-stamping module (303) in the server (300) calculates the location of the data logging device (200) when the mechanical actuator (201) is triggered at any time between t_1 and t_2 by interpolating the data between t_1 and t_2 with reference to time spent between two consecutive location data collected and historical data.

The analytics module (304) reviews the analysed processed data. Particularly, the analytics module (304) can be configured to generate a report of the analysis, alert the management team in event of detecting anomalies during analysis, and monitoring the transmission of the processed data. Furthermore, the database (305) is provided for storing the processed data received from the data logging device (200), the report generated by the analytics module (304), analysed processed data obtained from the analytics module (304), and the historical data. Additionally, the database (305) can also store staffs and customers information. Moreover, the API module (306) allows authorized devices to communicate with the server (300) to retrieve information from the databases (305).

Preferably, the wireless network communication comprises a plurality of gateway (400, 500) that are connected to one another via a long-range (LoRa) wireless protocol. Nonetheless, the LoRa wireless protocol can be replaced by other wireless protocols

such as Long-Term Evolution (LTE) cloud, Code Division Multiple Access (CDMA) and its derivatives, Enhanced Data Rates for GSM Evolution (EDGE), 3G protocol, High Speed Packet Access (HSPA), 4G protocol, 5G protocol and the like, in accordance to the advancement of wireless technology with time. Preferably, the LoRa wireless protocol may include long range radio, Bluetooth Low Energy (BLE), or radio frequency identification. More preferably, the LoRa wireless protocol is long range radio.

In one embodiment, the gateways (400, 500) can be categorised into two groups, namely primary gateways (500) and secondary gateways (400). The roles of the primary gateways (500) and the secondary gateways (400) are interchangeable so that the wireless network communication can continue to function optimally even if one set of the gateways (400, 500) malfunctions or requires maintenance. Preferably, the primary gateways (500) can be located closer to a base station whereas the secondary gateways (400) can be located further from the base station and scattered across the work location (101). The secondary gateways (400) receive the processed data from nearby data logging devices (200) and communicate with the primary gateways (500). Alternatively, the gateways (400, 500) can be powered by renewable energy sources such as solar energy, biomass, hydro power, geothermal, wind energy, and etc. By way of example, the gateways (400, 500) are connected to solar panels.

Referring to Fig. 4, each of the secondary gateways (400) preferably comprises a secondary data frame database (401), which temporarily stores the processed data received from nearby data logging devices (200). Furthermore, each of the secondary gateways (400) is equipped with a secondary packet forwarder module (402) for forwarding the processed data to the primary gateways (500) or other secondary gateways (400). In order to increase the communication range, the processed data is transmitted from the secondary gateways (400) to the primary gateways (500) or other secondary gateways (400) at an increased spreading factor. The secondary gateways

(400) can also take over the role of the primary gateways (500) and communicate directly with the server (300) in an event of primary gateway (500) failure.

On the other hand, the primary gateways (500) receive the processed data from the nearby data logging devices (200) and the secondary gateways (400), and subsequently communicates with the server (300) to transmit the processed data to the server (300). The primary gateway (500) can be wiredly or wirelessly connected to the server (300).

Referring to Fig. 5, each of the primary gateways (500) preferably comprises an in-memory database (501), a gateway server module (502), a device communication module (503), a primary packet forwarder module (504), and a primary data frame database (505). Preferably, the in-memory database (501) stores data cache, whereas the gateway server module (502) acts as an intermediary that allows the primary gateways (500) to receive the processed data from nearby data logging devices (200) and the secondary gateways (400) and communicate with the server (300). By way of example, the gateway server module (502) may employ ChirpStack to allow it to act as a LoRaWAN network server. The ChirpStack can be used to manage and monitor LoRaWAN devices, gateways, and applications, providing real-time data insights and analytics to help users optimize the wireless network communication. Preferably, the primary data frame database (505) temporarily stores the processed data received from nearby data logging devices (200) and the secondary gateways (400). Additionally, the primary packet forwarder (504) module forwards the processed data to the secondary gateways (400) or other primary gateways (500) in the event of primary gateway (500) failure to ensure that the processed data can be transmitted to the server (300). Furthermore, the device communication module (503) allows the primary gateway (500) to communicate with the data logging device (200) to ensure integrity of the processed data received and transmits the processed data to the server (300). Preferably, the processed data is transmitted from the primary gateway (500) to other primary gateway (500) or other secondary gateway (400) or the server (300) at an increased

spreading factor for an increased communication range.

Preferably, the device communication module (503) employs an exponential backoff algorithm in transmitting the processed data from the primary gateway (500) to the server (300), whereby priority frames of the processed data are prioritized during transmission to the server (300) to improve data transmission rate. Advantageously, the exponential backoff algorithm increases likelihood of the processed data being received by the server (300). Furthermore, the exponential backoff algorithm reduces likelihood of data loss during transmission in an event of communication error.

Alternatively, the server (300) is further configured to centre the data logging device (200) with respect to the gateways (400, 500) such that the input data and the location data are not collected by the data logging device (200) when the data logging device (200) is not within a coverage of the wireless network communication. This ensures that the data logging device (200) is only operable in the work location (101) that is within the coverage of the wireless network communication. Advantageously, this prevents collection of irrelevant input data and location data outside the work location (101) that is not related to the work activity. The presence irrelevant input data and location data increases the size of the processed data, which adversely affects the data transmission from the gateways (400, 500) to the server (300) and the analysis performed by the server (300).

In another embodiment of the invention, the data logging device (200) further comprises a power management module (209) that includes a rechargeable battery and a wireless charging receiver. The rechargeable battery supplies electricity to the components of the data logging device (200), whereas the wireless charging receiver converts energy received from a wireless charging platform (102) into electricity to charge the rechargeable battery. Preferably, the rechargeable battery can be a rechargeable alkaline battery or a lithium-ion battery. In addition, the audio signal

module (205) provides notifications to the worker when the battery is low or when the data logging device (200) is connected to the wireless charging platform (102) for charging.

In the other embodiment of the invention, the processing module (203) is further configured to perform data synchronization when the data logging device (200) is being charged at the wireless charging platform (102). Particularly, the processing module (203) identifies the input data and the location data which are missing from the server (300) and then uploads the missing input data and the missing location data to the server (300) via a data synchronization algorithm when the data logging device (200) is being charged at the wireless charging platform (102). Packet loss may occur during data transmission from the gateways (400, 500) to the server (300) over the wireless network communication, which leads to the missing input data and the missing location data. Consequently, the missing input data and the missing location data can adversely affect the analysis performed by the server (300). Advantageously, the data synchronization algorithm ensures that the server (300) receives the entirety of the processed data for analysis. During the data synchronization process, the processed data is transmitted from the memory module (207) to the server (300) over the wireless network communication at a decreased spreading factor for an increased transmission rate. Preferably, the processing module (203) is further configured to initiate a new data logging session when the data logging device (200) is removed from the wireless charging platform (102). Additionally, the memory module (207) is further configured to temporarily store the processed data of previous data logging sessions. In addition, the audio signal module (205) provides notifications when the data synchronization process is initiated.

Preferably, the wireless charging platform (102) further comprises a backup gateway that functions as per the gateways (400, 500) mentioned earlier to transmit the processed data to the server (300) when the data logging device (200) is docked in the

wireless charging platform (102) for charging. Additionally, the wireless charging platform (102) further comprises a solar power generation assembly for powering the wireless charging platform (102) to charge the data logging device (200). Advantageously, the solar power generation assembly serves as a secondary power supply of the wireless charging platform (102) in the event of power outage.

Preferably, the analytics module (304) in the server (300) is configured to monitor health statuses of the data logging device (200), the backup gateways, and the wireless charging platform (102). Additionally, the analytics module (304) is configured to generate a report of the health statuses.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A data logging device (200) for collecting data related to work activity comprising:
a mechanical actuator (201) which is triggerable by a worker in various ways based on motion and movement of the data logging device (200), each corresponding to a different type of input data that is related to an assigned work of a specific work activity performed by the worker to provide information about the type of assigned work;
a geographical position sensing component (202) for collecting location data of the data logging device (200);
a processing module (203) in communication with the mechanical actuator (201) and the geographical position sensing component (202) for processing the input data and the location data; and
a transceiver (204) operably connected to the processing module (203) for transmitting the processed data to a server (300) over a wireless network communication at a predetermined time interval,
wherein the mechanical actuator (201) is triggered to record the work activity performed by the worker within a work location (101).
2. The data logging device (200) according to claim 1, wherein the mechanical actuator (201) takes the form of a button that can be pressed by the worker in different ways to collect the various types of input data.
3. The data logging device (200) according to claim 2, wherein the different ways of pressing the button includes single press, double press, short press, long press, or press and hold for at least a predetermined period of time.
4. The data logging device (200) according to claim 1, further comprising at least one sensor (206) for collecting further input data based on parameters detected by the sensor

(206).

5. The data logging device (200) according to claim 4, wherein the sensor (206) is an accelerometer or a gyroscope, or a combination thereof.

6. The data logging device (200) according to claim 1, wherein the processing module (203) is configured to encrypt and/or compress the input data and location data into processed data for storage or transmission.

7. The data logging device (200) according to claim 1, wherein the server (300) is configured to analyse the processed data using one or more algorithms to determine a pathway travelled by the worker and information of the work activity performed by the worker along the pathway.

8. The data logging device (200) according to claim 7, wherein the server (300) is further configured to predict a location of the data logging device (200) along the pathway when registering input data that is between two previously collected location data points.

9. The data logging device (200) according to claim 1, wherein the wireless network communication is a long-range wireless network communication which comprises a plurality of gateways (400, 500) that are connected to one another via a long-range wireless protocol.

10. The data logging device (200) according to claim 9, wherein the server (300) is further configured to centre the data logging device (200) with respect to the gateways (400, 500) such that the input data and the location data are not collected by the data logging device (200) when the data logging device (200) is not within a coverage of the wireless network communication.

11. The data logging device (200) according to claim 1, further comprising a power management module (209) that includes a rechargeable battery for supplying electricity to the components of the data logging device (200) and a wireless charging receiver for converting energy received from a wireless charging platform (102) into electricity to charge the rechargeable battery.

12. The data logging device (200) according to claim 11, wherein the processing module (203) is further configured to identify the input data and the location data which are missing from the server (300) and then upload the missing input data and the missing location data to the server (300) via a data synchronisation algorithm when the data logging device (100) is being charged at the wireless charging platform (102).

13. The data logging device (200) according to claim 11, wherein the processing module (203) is further configured to initiate a new data logging session when the data logging device (200) is removed from the wireless charging platform (102).

14. The data logging device (200) according to claim 1, further comprising a device management module (208) configured to switch the data logging device (200) between sleep mode after a predetermined period of inactivity and active mode when the data logging device (200) is in use.

15. A data logging system (100) for monitoring work activity comprising:
a data logging device (200) having

- a mechanical actuator (201) which is triggerable by a worker in various ways based on motion and movement of the data logging device (200), each corresponding to a different type of input data that is related to an assigned work of a specific work activity performed by the worker to provide information about the type of assigned work;

a geographical position sensing component (202) for collecting location data of the data logging device (201);

a processing module (203) in communication with the mechanical actuator (201) and the geographical position sensing component (202) for processing the input data and the location data; and

a transceiver (204) operably connected to the processing module (203) for transmitting the processed data over a wireless network communication at a predetermined time interval;

a server (300) configured to receive the processed data from the transceiver (204) over the wireless network communication and analyse the processed data using one or more algorithms to determine a pathway travelled by the worker and information of the work activity performed by the worker along the pathway; and

a wireless charging platform (102) for charging a rechargeable battery of the data logging device (100), wherein the processing module (203) is further configured to synchronise the processed data with the server (300) by transmitting the processed data to the server (300) when the data logging device (100) is being charged at the wireless charging platform (102),

wherein the mechanical actuator (201) is triggered to record the work activity performed by the worker within a work location (101).