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Model of Ubiquitous Precision Livestock System 4.0: A Technological Review

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Abstract

The main objective of this study is to propose a model Ubiquitous Precision Livestock 4.0 system that combines the ability of IoT and drones to monitor livestock biomass and herd cattle, wearable devices on livestock to provide location information and animal health, and utilize data communication networks using Long Range (LoRa) for coverage wider. The methods used in developing this model include collecting data and literature, analyzing technology needs, and developing the model. The results show that the model developed has a huge potential to be implemented to support the 4.0 livestock system which is faster, more accurate and precise in providing information to farmers.

Keywords: IoT, drones, geofence, wearable devices, LoRa, Livestock 4.0.

1. Introduction

Livestock are land animals that are raised in a regular agricultural environment to attract or produce these commodities such as meat, milk, eggs and skin. Livestock contribute to the diversity of the agri-food system globally and have many roles for various community groups (F.A.O, 2018) . IoT is a technology in which devices in an environment can communicate with each other through the internet network. IoT sensors used will facilitate the system in collecting data and will also improve data accuracy (Budiharto, 2019). One of the roles of IoT is widely used in agriculture (Muangprathub et al, 2019; Lakhwani, et al, 2019) and animal husbandry (Mitkari et al, 2019; Pratama et al, 2019). This is because the sensors contained in the IoT system can provide data that is faster, more precise and can be processed at a later stage (Khanna and Kaur, 2019). The application of IoT technology to animal husbandry led to the emergence of the term precision livestock 4.0. The technology used is increasingly developing. The need for extensive land for animal husbandry raises more accurate food, health and livestock monitoring issues. The need for technology that is able to provide data quickly on the condition and environment of livestock is needed.

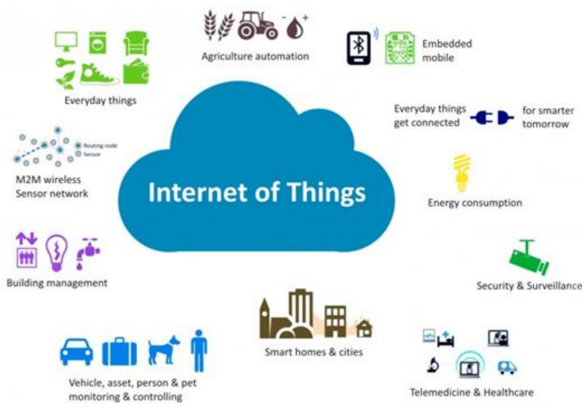


Fig. 1: IoT technology

Drones are unmanned aircraft that are controlled remotely using a radio control or autopilot system that is able to fly them automatically. Drones are very effectively used to carry out airborne monitoring of certain cases (Elliott et al, 2019). Likewise in a precision livestock environment 4.0, drones can be used as a solution to monitor the fertility of shepherds, because they have the ability to remote sensing to process the image of the land to then determine the elements contained in the land [Wahyuni et al, 2016; Yusandi, 2015), and monitor conditions and herding cattle (Barbedo and Koenigkan, 2018). In order to obtain precise data related to the location of livestock, the use of GPS technology installed on livestock and drones is proposed in the model to be developed. GPS is a technology that functions to determine the position on the surface of the earth using satellite signals (Hashim et al, 2011). This technology is supported by 24 satellites that send microwave signals to Earth. This signal serves to determine the position, speed, direction and time (Widyantara et al, 2015), so that it can monitor the location and presence of livestock in real time and precision.

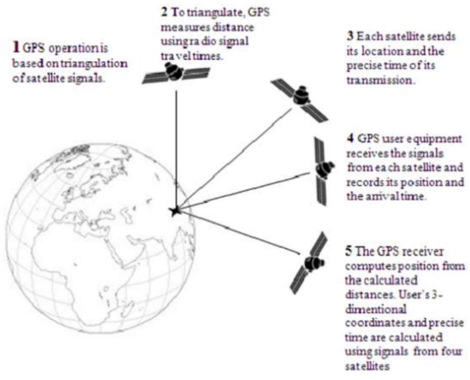


Fig. 2: GPS technology

Wearable devices used in livestock, consisting of sensors to determine the condition (Haladjian et al, 2018) and the location of the livestock (Knight et al, 2018). While the GPS model on the drone was used for flight control (Oktaria et al, 2018), and found the cattle he had to lead. In order to localize large areas, geofencing technology was developed where there is a kind of virtual fence coordinated with GPS technology to monitor cattle inside or outside the fence. Geofencing is a feature in software programs that use a global positioning system (GPS) to determine geographical boundaries. The program that combines geofencing makes it possible to manage triggers, so that if an object using a certain device enters or exits specified limits, a notification will appear that will be sent to the user of the geofencing-featured application (Maiouak and Taleb, 2019; Muminov et al, 2019).

Fig. 3: Geofence technology

Data communication used in precision livestock system 4.0 is LoRa (Long Range) technology. LoRa is proposed because it has the right characteristics for developing an IoT-based system. LoRa is a wireless communication system for the Internet of Things, offering long distance communication (> 15 km in remote areas) and low power (5-10 years). LoRa has advantages compared to other types of communication such as cellular, BLE and WiFi. LoRa has long range communication capabilities such as cellular but low power like BLE, so its use is very suitable for sensor devices that are operated annually with battery resources and on a wide area. However, LoRa has limitations in data transmission speeds in the range of 0.3 -50 kbps (Augustin et al, 2016). However this is not a problem as long as the data sent by the sensor is relatively small (order 10-20 bytes). Such applications are very suitable for transmitting water meter sensor data, electricity meters, river water level sensors, temperature and humidity sensors, and etc (Sinha, et al, 2017).

Fig. 4: LoRa technology

2. Methodology

This research is a preliminary study to produce an architectural model of technology precision livestock system 4.0. The research flow that was developed included the following matters:

- Data collection and literature study: conducting data collection activities derived from studies and scientific articles relating to the research conducted.
- Technology needs analysis and evaluation: initiating and investigating data requirements, running business processes and technological requirements for precision livestock system 4.0, which will be used in the development of system architecture.
- Modeling technological architecture in precision livestock system 4.0., Based on theoretical studies and analysis at an earlier stage.

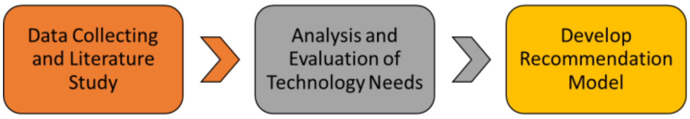


Fig. 5: Research methodology

3. Result and Discussion

The model of precision livestock 4.0. is a Cyber-Physical System (CPS) model that integrates technology and data to produce accurate and fast livestock information. IoT is the basis for the development of the model used because the input-process-output mechanism is carried out by various devices with the help of diverse communication and data networks. Multi-data analysis is performed to obtain information needed by farmers. As for the entities that are used in the model of precision livestock system 4.0 are drone, wearable device in livestock, and LoRa data communication network. While the software developed includes geofencing technology, object detection, location-based services, and data analysis.

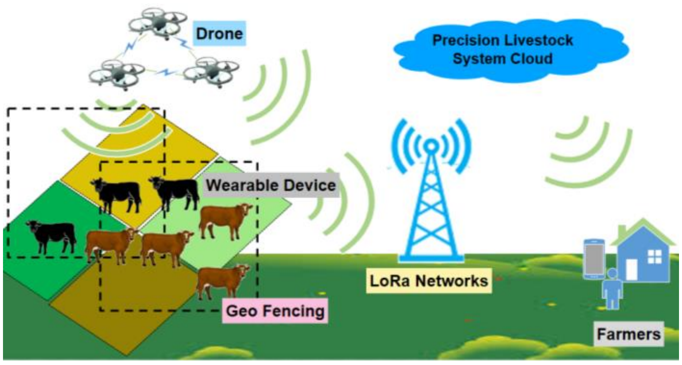


Fig. 6: Model of precision livestock system 4.0.

3.1. LoRa Technology in Precision Livestock Systems 4.0.

LoRa is used in the 4.0 Precision Animal Systems model. because of its wide range of capabilities making it suitable for shepherds and detect cattle at long distances with low power. LoRa is a lightweight protocol suitable for technology that develops IoT, controls drones over long distances and is able to transmit data in the form of data from sensors that are on wearable devices for livestock and drones.

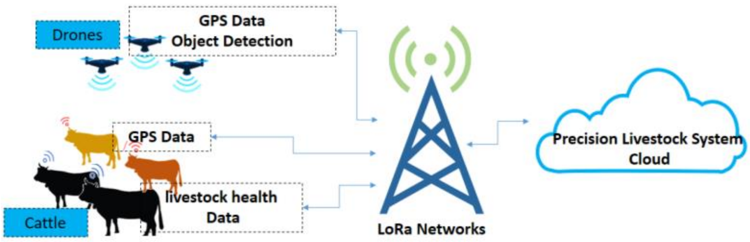


Fig. 7: Data communication for precision livestock systems 4.0 using LoRa.

3.2. Drone Technology in Precision Livestock Systems 4.0.

As an unmanned vehicle that has the ability to explore, the drone is used as a solution on model of precision livestock 4.0 (Figure 8). The role of the drone in the model of precission livestock 4.0, are:

As an entity that conducts surveillance of plant biomass, using image processing technology (Wahyuni et al, 2016; Yusandi, 2015), where the drones will work together / in groups using artificial intelligence (*swarm intelligence*), in order to sensing the shepherd by looking at the color composition of grass on the shepherd and map it in the form of a digital map in accordance with the calculation of biomass. The color composition is indicated as the size of the biomass contained in the land, which will be used to show the potential of grass biomass as feed from livestock in shepherds. The drone used has the intelligence swarm characteristics for speed and accuracy of measurement and detection which is more accurate, and has the ability to be adaptive to the environment. Apart from being a function of surveillance of plant biomass, drones are used to detect the color of objects (Arifin, 2014) and count the number of livestock in shepherds. The object to be tracked and detected is black bulls and brown cows and the system will calculate the number of cattle to be used as a parameter to analyze the availability of grass at a location with the number of cattle in the shepherds.

The drone functions as a shepherd. With the ability to adapt to the environment and the intelligence that is implanted in the drone, the drone can be used to herd cattle to pasture areas that still have a lot of grass. This is certainly based on the results of biomass data analysis and the number of livestock in one area. If the data show that biomass in the area is reduced, while the number of livestock in the area is still very large, the drone will use its function as a herder, to herd cattle to areas that have more grass (higher biomass).

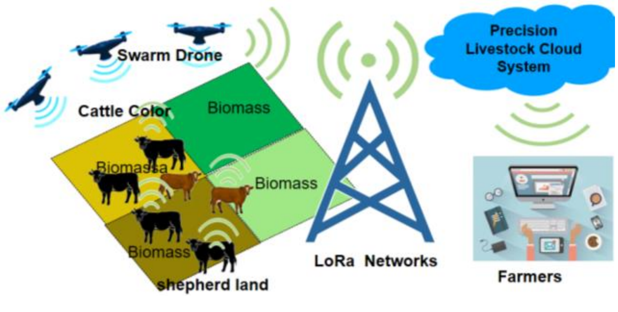


Fig. 8: Drones for grass biomass surveillance, cattle detection and cattle herder

3.3 Wearable Device Technology in Precision Livestock Systems 4.0.

Wearable devices can be interpreted as devices that are applied to an object or creature in order to detect, store data to make decisions from the data obtained. Wearable devices are usually in the form of sensors that have special functions for specific purposes (Haladjian et al, 2018).

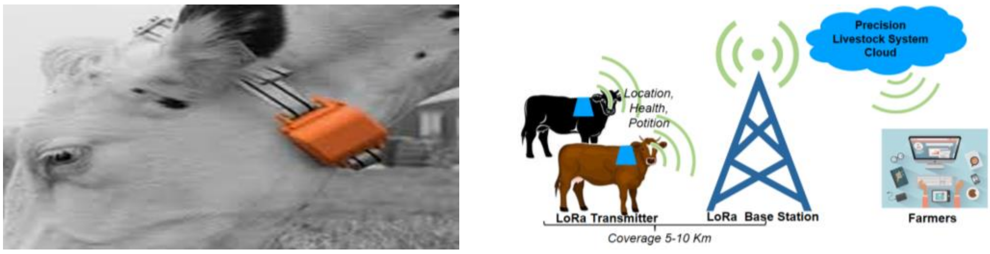
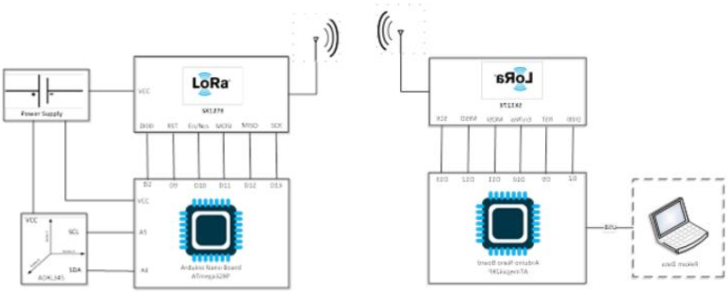


Fig. 10: Wearable devices on model of precision livestock system 4.0.

In the model of precision livestock system 4.0. , livestock in the shepherd fields are fitted with wearable devices, in the form of GPS sensors, temperature sensors and other sensors to monitor the presence and health of these animals. The network used is LoRa, with transmitter mode to transmit data to the precision livestock system 4.0. by utilizing this wearble device, farmers can find out the location, position and health of their animals in real time. For data communication on precision 4.0 animal models, a LoRa network is used with modules placed on objects such as cattle and drones to send data, and modules to receive data (Liandana, 2019).



(a) (b)

Fig. 11: Hardware architecture of the sender (a) and receiver (b) of data wearable devices using LoRa

3.4 GeoFencing Technology in Precision Livestock System 4.0.

The function of geofencing in the model of precision livestock system 4.0. is to ensure that the cattle are still in the herd (in geofence area). If the cattle leave the geofencing area, the system will notify the farmer that there are cattle outside the geofencing area, so that the farmer can lead them back to the geofencing area using drones to herd the cattle into the geofencing area.

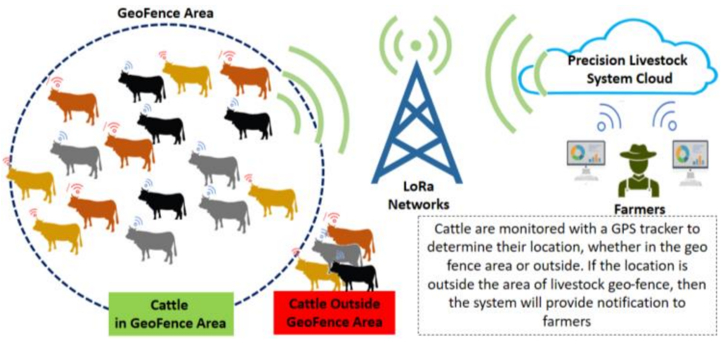


Fig. 12: Geofencing technology in the model of precision livestock system 4.0.

4. **Conclusion**

The results of the Precision Livestock 4.0 system model research show that the integration of input devices, data communication devices, servers to process and analyze data, can provide information easily, quickly and accurately that can be accessed at any time by farmers (ubiquitous system). IoT technology with the integration of drones, wearable devices, geofencing and LoRa can produce an integrated system to improve the quality and sustainability of livestock in the future.

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