Integration of animal tracking and health monitoring systems

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Abstract. Animal temperature monitoring system and location tracking system based on Global Positioning System (GPS) and Short Messages Services (SMS) gateway is one of the effective solutions to solve problems in detecting the health level of pets and decrease the amount of pet-loss cases. The system using GPS technology installed on the animal’s body. The system uses the Arduino Pro Mini microcontroller that is connected to the GSM module as a communication channel between the user and the system. The system is designed to display the temperature and location data based on user requests sent via SMS. Tests show the system can work according to the initial scenario using the MLX 90614 sensor, Arduino Pro Mini AT Mega 328, GSM Module, and GPS module. The system has an accuracy of 99.62% compared to conventional thermometers. The system also has accuracy at 98.7% compared to the location accuracy on Google Maps.

1. Introduction

Caring for animals is a big responsibility, including even the most experienced animal lovers. When someone decides to have a pet, there are many things to consider before raising the animal. One of which must be considered is a pet health problem that must be highly considered. Pet health that must be considered includes physical health and psychological health. Usually, to check the health of a pet, someone will use a manual method such as checking the health of the animal or taking the pet to the veterinary, but this activity required a special time and is quite expensive. The ability to detect animal health is not always possessed by pet owners, so pet owners need an animal health detection system that can monitor and report the condition of their animals automatically wherever and whenever the owner needs that information. Physical activity must also be carried out by pets to make the animal feel relaxed and not stressed. If the animal is only kept indoors without taking him for a walk and playing outside, this will make the animal feel stressed. But activities outside the home can cause animal loss if not properly guarded. Animal tracker is a necessity for the community as more and more pets are lost either due to being lost or because of animal theft.

Research on animal detection systems and animal health monitoring is an important area in the development of control systems. Several systems have been developed to facilitate animal health and tracking. The use of RFID is a technology that has been applied in animal tracking. The International Standards Organization (ISO) has established two standards, ISO-11784 Radio Frequency Identification for Animals Code Structure and ISO-11785 Radio Frequency Identification for Animals Technical Concepts, as standards for RFID use in analog tracking. In farm animals, RFID tags can be inserted under the skin of animals or can be clamped to the ear. Installation of RFID tags can be affixed attached or inserted depending on the type of animal being tagged. In most cases, dogs and cats have chips
implanted between the front shoulder. The horse has a chip implanted on the left side of the neck, just below the mane. Birds are usually marked on the chest [1]. The RFID technology-based health monitoring system can be used to detect various parameters of animal health such as heart rate, body temperature, and animal ECG. The use of RFID has high accuracy and long operating time compared to other existing systems [2].

The use of GPS technology is a technology commonly used to detect the presence of animals or humans. GPS technology has been widely used for animal tracking [3] and its application in the animal conservation field [4]. In addition to the use of GPS to detect the presence of animals, animal health monitoring is a complement to the animal detection system. To determine the health condition of animals, a parameter commonly used is the observed animal temperature value. The sensors that have been used include IR MLX90614 sensor [5], electrocardiogram (ECG), photo plethysmogram (PPG), and inertial measurement units (IMU) to remotely and continuously monitor the vital signs of dogs [6], Temperature Sensor - DS18b20, Pulse Sensor [7], Thermistor (TTC051022), DHT11 sensor, the polar equine T56H transmitter device for the cattle heart rate measurement and Rumination Sensor Module [8].

The monitoring system for detecting the pet condition had used several technologies. The Zigbee technology has several advantages for data transmission because of its low power consumption, but have lacked at a distance of data sending [7,8]. The Use of IoT technology makes it easy for users because the user can access the information from anywhere using the internet and an android application [9,10]. Notification of the condition of animals using SMS is one of the best solutions because it makes it easy for breeders or animal owners to get the latest data about their pets but is not obstructed by the problem of internet quota restrictions [3].

Some previous studies have created systems to detect the presence of animals and pet health separately, even though these two systems are automatic animal guarding systems that are needed by pet owners. This paper discusses the integration of monitoring systems for the presence of animals and their quality of health based on animal body temperature. The results of animal monitoring will be sent to the owner's SMS according to the user's request.

2. Material and methods
The design of an animal body temperature monitoring system and GPS and SMS gateway based location tracker is shown in Figure 1. In the system that has been designed as shown in Figure 1, the Arduino Pro Mini functions as a microcontroller to receive measurement data from MLX 90614. NEO 6M sends temperature measurement data and GPS coordinate data via 800 L SIM from BTS to be sent to the user's mobile phone as requested. MLX 90614 and NEO 6M in this system function as sensors to measure animal temperature and receive position coordinate data then send temperature data and GPS data to Arduino pro mini. Data sent by Arduino Pro Mini through BTS will be received by an 800 L SIM and then forwarded to the user. The data is then displayed in a message to be known by the user of the device through an SMS gateway.

![Figure 1. System design.](image)

If the user wants to monitor temperature, track the position of animals or want both of them then the user needs to do is make an SMS request with the text format "Temp", "Position" or "Track" using a mobile phone then the signal will be transmitted by the BTS to the 800L SIM module on the system.
The MLX 90614 sensor and the NEO 6M module will process temperature and location data and are sent to the Arduino pro mini microcontroller. The requested data will be sent by the 800L SIM module which is transmitted by the BTS to the user’s mobile phone.

3. Implementation

There are 2 types of modules used, the SIM 800 L module to send and receive messages based on user requests, and the 6M NEO module that is used to read longitude and latitude coordinates of pets from GPS. MLX 90614 is used as a sensor to measure the body temperature of pets in a contactless manner and the Arduino Pro Mini is used as a microcontroller to receive data from SIM modules 800 L, NEO 6M and MLX 90614. Application of SIM 800 L modules, NEO 6M modules, and temperature sensors MLX 90614 with The Arduino pro mini used is shown in Figure 2 and Figure 3.

![Figure 2. Application of modules and sensors (front section).](image1)

![Figure 3. Application of modules and sensors (rear section).](image2)

Based on Figure 2. Arduino Pro Mini functions as a microcontroller shown in number 1. Furthermore, in number 2 is the NEO 6M module, this module is a GPS module that has the function to track the location and capture signals from satellites so that GPS has latitude and longitude data corresponding to GPS module location. Shown by number 3 is a diode which serves to stabilize the voltage in the system. Then number 4 is a switch that functions to activate the step-up module when it is filled with resources when the switch is shifted it will activate all components in the system. The last number 5 is a battery that serves as a voltage power source for the system. Figure 3 is the back of the system. Number 6 is a step-up module that functions to increase the battery voltage up to 5 volts, then what is shown by number 7 is the 800L SIM module which functions as sending and receiving messages from users. Component number 8 is a temperature sensor namely MLX 90614 which functions to measure temperature and finally number 9 is a series of whole component paths so that they can function simultaneously.

4. Results and discussion

MLX 90614 sensor testing is done by measuring the temperature with the sensor and also the measuring instrument simultaneously. The temperature measured in this test is the temperature of the cat. The measuring instrument used in this test is a contactless thermometer. The cats tested were purebred cats and Persians aged 2 years 3 months with normal conditions. The purpose of this test is to show the measurement value obtained by the MLX 90614 sensor can be a measurement reference value that is close to measurement with a measuring instrument. Testing the temperature of a pet using an infrared thermometer is to take measurements simultaneously. In this test, the temperature is measured using an
infrared thermometer by shooting infrared rays into the body of the cat, at the same time the temperature is measured using an MLX 90614 sensor which is brought near the body of the cat by sending an SMS "Temp". Furthermore, the value of the temperature monitoring results will be displayed on the LCD infrared thermometer and on SMS on mobile phones.

**Figure 4.** Measurement of the body temperature of cats using the system via SMS.

The value of the measurement results with the MLX 90614 sensor and the Infrared Thermometer has an average measurement difference of 0.14 degrees Celsius, meaning that the MLX 90614 sensor has an error value of 0.38%. The temperature measurement value using MLX 90614 is not much different from the infrared thermometer which has a measurement difference of 0.19 degrees Celsius. So it can be concluded that the use of the MLX 90614 sensor in measuring the body temperature of cats has an accuracy of 99.62%.

The testing of the NEO 6M module is carried out by tracking the location with the NEO 6M module and measuring devices simultaneously. The location tracked by NEO 6M is the location of cats. The measuring instrument used in this test is a mobile phone that supports global positioning system features. The purpose of this test is to show the level of location accuracy obtained from the NEO 6M module can be a tracking accuracy level that is close to measurement with the iPhone 6s mobile phone using the google maps application. The testing of the 6M NEO module is shown in Figure 5.

**Figure 5.** Location tracking using SMS.

The first test for the user is outside the room and sends a "Position" message to find out the location of the cat to the GSM contained in the system, so the system can send the location of the cat to the user's handphone. After the message is received by the user, the user can click on the SMS data of the location that has been received so that it will be automatically directed to the Google Maps application, as in Figure 5.4. The user is able to find out how many meters the user is from his pet. After conducting experiments in 10 different places, it is known that the error occurred reached a value of 1.7% with the distance of the position of the animal to the position of Google Maps. Then the accuracy of location tracking is known to be 98.3%.
5. Conclusion
The animal body temperature monitoring system and GPS and SMS gateway-based location tracker were successfully built using the 800 L, MLX 90614, and NEO 6M SIM modules. The testing of the system showed the accuracy of the temperature sensor is 99.62% and the accuracy of location is 98.3%. So, GPS and SMS Gateway technology is possible to trace pets and monitor their health subjects. The next research is to add the other sensor for detecting the health parameters such as heart rate, stress detection and combine with an alarm system that can notify the pet owner when the system finds an unusual health condition with the pets.

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