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Using Telecommunication Sensor Network to Monitor the Velocity of Cattle in Southern Nigeria

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Abstract
Due to the adverse effect of various ailing health issues of cattle supply in southern Nigeria, farmers become eager to adopt efficient technical methods for its health monitoring. This study has documented various automated wireless sensor network (wsn) health monitoring system which is used to examine and monitor cattle health status. The major objective of this research work uses of telecommunication based system to monitor growth (increase in weight) and the velocity of movement of cattle, hence determine its health status in real time. The network sensor is inserted on the collar of the cattle that records and stores the data which compares the modeled result with the measured data and hence determine the deviation. If the deviation is abnormal, sms alert will be sent to farm owner for necessary action which includes isolation of the affected cattle, treatment and probably recycle. This revolution in advanced technological farm automation will aid in improving the productivity rate with the reduction of human intervention. This review study concludes cattle monitoring systems along with various issues and challenges.

Keywords: *Wireless Sensor Network, Automation, Monitor, Base station*

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I. Introduction

1.1 BACKGROUND STUDY

The importance of cattle rearing in the southern part of Nigeria cannot be overemphasized. It provides meat food, employment opportunity, income; transportation, shelter and so on. Hence, this business increases in geometric progression without a corresponding march in their wellbeing. Consequently, there are lots of challenges faced by farmers which include spread of diseases, lowered yield, infections, etc. which is attributed to poor performance, high cost of treatment, and unavailability of technical knowhow and the required technology. There has always been a need for livestock producers to be able to "observe" their animals as often as possible. In attention to the wellbeing of the animals, whether it be a health or welfare issue can lead to reduced productivity

Physiological variation in parameters like temperature may affect the cattle's health leading to various diseases like foot mouth disease, mad cow disease which can be easily spread into human beings. Variation caused in heart rate leads to myocardial disease lymph sarcoma, tachyarrhythmia, and tachycardia in sinus rhythm disease in cattle. A reduced velocity of a cattle, will reduce the rate of feed search, which may result to malnutrition and causes the cattle overweight. Thus exposes the cattle to other diseases.

In order to minimize these menaces and increase yields, there is need to monitor the wellbeing of the livestock online and real time. The traditional methods to monitor animal health such as (traditional surveillance, single observation, and simple tabular and graphic techniques) are not efficient to achieve high performance in the large herds' management systems. These methods can only provide partial information and introduce a large cost in staffing and physical hardware. Thus, in order to overcome this foresaid draw-back, there is need to using alternative low cost, low power consumption sensor nodes, and providing real-time communications at a sensible hardware cost, a wireless sensor network (wsn), which uses telecommunication technology is to play a significant role in health care systems and in modern farming.

Electronic livestock farming, using an animal health monitoring system is one which is used to monitor the physiological parameters such as body temperature, surrounding temperature like environment, heart rate, rumination, body movement and its velocity, so that anomaly could be detected online. This will enable for either immediate treatment or isolation of affected cattle to prevent diseases from spreading the other animals.

In this research, interest is on the rate of its body movement and the velocity of healthy cattle. Considering also the normal feeding position (pitch angle) and the movement (velocity) of the cattle in search of feed (healthy), comparing it with any anomaly that may be detected by the sensor of the above parameters. This will send an sms and alert the farmer through his mobile phone for an immediate action.

1.2 STATEMENT OF THE PROBLEM

The business of rearing livestock in Nigeria and its attendant ills are increasing in geometric progression day by day. Due to insufficient manpower and resources, it becomes almost impossible for farm owners to effectively monitor and manage the production of livestock and its health status.

There are too many death of cattle recorded. This can be attributed due to climatic and physiological changes like weight loss which results to stunted growth, weak movement, pitch angle of the neck, feeding habit and so on. It becomes dangerous if they are not monitored and detected on time. In most cases it leads to illness and diseases which might result to death of cattle. These have not only increased cost of maintenance but also increased losses incurred by farm owners.

This could be achieved using sensor networks. Hence, the aim of this thesis 'Telecommunication Network as a Vital Tool for Animal Production, Management is timely. It will be used to monitor the activities of the livestock continuously and closely in order to detect any changes which will be used to characterize the health status and well-being of the cattle. An alert message will be sent to the farm owner through his android phone to prompt him for a corresponding action.

1.3 AIMS AND OBJECTIVES OF THE THESIS

The aim of this research is using telecommunication sensor network to monitor the velocity of cattle in southern Nigeria however, in order to achieve this aim, the following goals were set:

i. To determine the parameters which could be used to monitor cattle wellbeing online and in real-time

ii. To design a mathematical Simulink model used to determine the velocity of cattle from the characterized data.

iii. Using MATLAB to develop a software model for proper tracking and monitoring of velocity to determine the health status of cattle.

1.4 SCOPE OF THE STUDY

The scope of this study is restricted to simulation of key parameters (body weight and velocity) so as to monitor the health status of cattle. Using ZigBee communication protocol, data are being collected, processed and transferred to base station for effective communication between the farmers and the farm.

1.5 SIGNIFICANCE OF THE STUDY

The use of wireless sensor network, like zigbee sensor to monitor some parameters, processes the data received and communicate with the farm owners online has much significance. Some of them are:

i. To initiate an effective communication between the farmers, and the cattle velocity of movement.

ii. It eradicates and/or reduces the man power, resources, energy, cost and time that are involve in traditional monitoring of cattle.

iii. It eradicates the chances of loss that would have been incurred by farmers due to inability to detect diseases as a result of excess weight increase.

iv. To enhance a quantity and quality management and production of cattle farm.

II. Literature Review

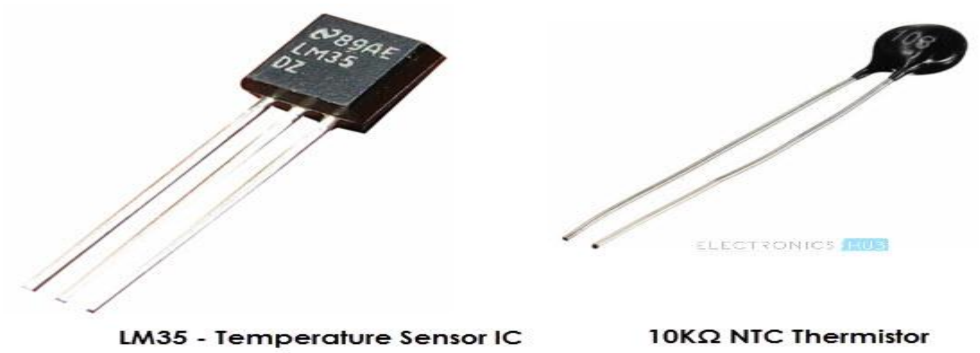
A sensor is a device that measures physical input from its environment and converts it into data that can be interpreted by either a human or a machine. Most sensors are electronic (the data is converted into electronic data), but some are more simple, such as a glass thermometer, which presents visual data. As technology develops, the use of sensors will continue to expand into every aspect of our lives. Engineers and scientists around the world will use sensors to enhance transportation systems, medical procedures, nanotechnology, mobile devices, virtual and augmented reality, and even artificial intelligence (AI).

1.1 TYPES OF SENSORS

There are numerous types of sensors, but in the course of this research, only very few will be considered.

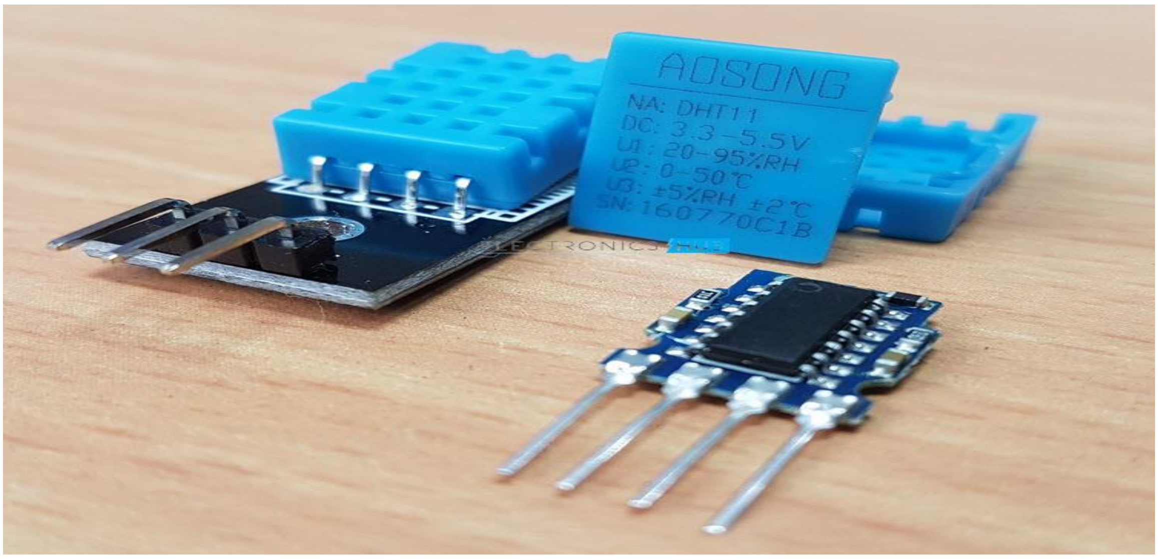
1.1.1 Temperature Sensor

Temperature sensor is that which senses the temperature, measures and records it. It can be used for both environment and body of any animal. For the normal working of any system, temperature should be in constant state. If there is any variation in it, it shows an ill health occurred and also causes certain severity in cattle's health. Temperature sensor is used to monitor the temperature of cattle. Similarly, other temperature sensor is used to determine the environmental temperature surrounding the cattle. Body will work correctly at only specific temperature. Normal body temperature of cattle ranges in 101.5 °F (38.6 °C). Various temperature sensors are thermistors, LM35 which is an IC temperature sensor.



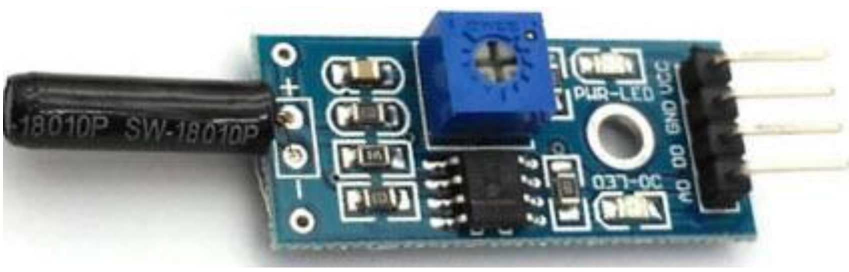
1.1.2 Humidity Sensor

It can be called Hygrometer. Water present in air is nothing but humidity. The quantity of water vapor present in air really affects the human's health as well as cattle's health. Since metabolism and various behavior is affected by humidity, it should be properly monitored. Humidity sensor is used to determine the change occurred in environmental conditions. Relative humidity should be in between 30% to 70%. Various humidity sensors are there. AM1001 is an analog humidity sensor.



1.1.3 Heart Rate Sensor

Heart rate is one of the important parameter when the health is monitored. It indicates stress and irritation occurred upon any animal body. Variation occured in heart normally shows stress, anticipation, movement, exertion and various diseases. Normal heart rate ranges between 48-84 beats per minute in cattle. There are many heart rate sensors such as Polar spot tester (PST), PC-3147.



1.1.4 **Accelerometer Sensor**

An accelerometer is a device that measures the vibration, or acceleration of motion of a structure. The force caused by vibration or a change in motion (acceleration) causes the mass to "squeeze" the piezoelectric material which produces an electrical charge that is proportional to the force exerted upon it. Since the charge is proportional to the force, and the mass is a constant, then the charge is also proportional to the acceleration. These sensors are used in a variety of ways from space stations to handheld devices.

An accelerometer works using an electromechanical sensor that is designed to measure either static or dynamic acceleration. Static acceleration is the constant force acting on a body, like gravity or friction. These forces are predictable and uniform to a large extend. For example, the acceleration due to gravity is constant at 9.8m/s, and the gravitation force is almost the same at every point on earth. The theory behind accelerometers is that they can detect acceleration and convert it into measurable quantities like electrical signals.

There are two types of piezoelectric accelerometers (vibration sensors). The first type is a "high impedance" charge output accelerometer. In this type of accelerometer the piezoelectric crystal produces an electrical charge which is connected directly to the measurement instruments. The charge output requires special accommodations and instrumentation most commonly found in research facilities. This type of accelerometer is also used in high temperature applications (>120C) where low impedance models cannot be used.

The second type of accelerometer is a low impedance output accelerometer. A low impedance accelerometer has a charge accelerometer as its front end but has a tiny built-in micro-circuit and FET transistor that converts that charge into a low impedance voltage that can easily interface with standard instrumentation. This type of accelerometer is commonly used in industry. An accelerometer power supply like the ACC-PS1, provides the proper power to the microcircuit 18 to 24 V @ 2 mA constant current and removes the DC bias level, they typically produces a zero based output signal up to +/- 5V depending upon the mV/g rating of the accelerometer.

1.2 RELATED WORKS

Rajshree S. Thakre, Prof. Vidya Bodhe, and Anuj Kumar and Gerhard P. Hancke, used Zigbee based health monitoring in their research experiment to monitor the health status of cattle and detect any anomaly online and real time. Zigbee has low power consumption with better transmission range. System gives idea to detect various parameters concerned with animal health. Thereby making easy to diagnose various diseases as well as helping farmers to do proper livestock management.

Anushka Patil, Chetana Pawar et al, focused on using Smart health monitoring system using aurdino microcontroller. The system is mounted on animal body to get current status, (healthy/unhealthy). Its merit is that it reduces the waiting time, a farmer may have to undergo to invite a veterinary expertise. This system improves animal's health.

In the work of M. Janzekovic, P. Vindis, he uses a Polar sport tester to monitor the health status of cattle. Since heart rate reflects stress, It is important to monitor that correctly.

Anuj Kumar and G. P. Hancker, monitored animal Health based on IEEE 802.15.4. The System IEEE 802.15.4 has low cost requirement, fast response and low power consumption.

Cattle health monitoring using Thermistor was conducted by B.C.Baker. He noted that variation in temperature leads to diseases. As thermometer can't be used to measure the temperature of cattle, this system uses thermistor to monitor the temperature of cattle.

While experiment on Zigbee based WSN for cattle monitoring was done by J. I. Huircanet al. Bluetooth is the upgraded version of zigbee. Which covers large network for low power wireless LAN's. the LQI-based algorithm is used for cattle health monitoring application.

I.Korhonen, J. Parkka, and M. van Gils, discussed system with technical requirements for health monitoring system that is based on wearable sensors and ambient sensors. These sensors monitor the health status of cattle and E. Lindgren studied the validation of rumination measurement equipment and its role in dairy cow. His research focused on measuring the stress response in cattle in order to estimate the stress by using RuminAct system.

In the previous work of Oborkhole Lawrence and Ogbonnaya Irukwu, it was observed that the usage of internet has so much affected all fields of human endeavor. This led to increased dependence on it, in such a way that even the things that are used in human day to day living are dependent on communication technology. Hence, heralding a new era of Internet of Things (IoT). Their work dealt on the application of telecommunication network as a vital tool for the production and management of livestock. The work majored on the use of Internet of Things (IoT) for monitoring and controlling the development of livestock. To achieve this some of the objectives were, to find out the parameters that could be used to monitor livestock wellbeing online and in real-time and also to design a mathematical model that could be used to determine the weight/health status of a livestock from the characterized data. The research adopted a wireless sensor network based on ZigBee communication protocol with other sensing elements, (like RFID, accelerometer) in order to establish communication link between the livestock and the farmer. Some of the parameters used to estimate the state of well being of the livestock were the height and the size, which were used to compare the weight and the body mass of the livestock. The sensor nodes which were worn as collar by the livestock send signals through a base station about any deviation as it concerns the weight of the livestock. Hence alert in form of a short message signal (SMS) is sent to the farmer's GSM phone, which prompts him for action. The result shows that livestock monitored using IoT performed better because they were well monitored and quickly responded compared to livestock's monitored manually, because challenges were detected early enough and treated.

III. Materials And Methodology

3.1 Materials

Basically three parameters, which include, body temperature, neck pitch angle and the resultant velocity of the cattle are used to characterize their behavior, hence health status.

Like all mammals, cattle are warm blooded animal. They need to maintain a constant core body temperature to be healthy. Normal rectal temperature for cattle is at the average range of 38.6°C (101.5°F). Within a range of environmental temperatures called the "thermo neutral zone," animals do not have to expend any extra energy to maintain their body temperature.

Hot summer temperatures, combined with high dew points can cause significant heat stress to cattle. This heat stress, if prolonged all day and night, increases the temperature, hence heat stress is magnified, thereby affecting the movement and feeding habit of the cattle. The sensing element for this is thermistor, LM35. The effect of heat stress which could increase the body temperature to as high as 50^{o}c has a negative effect on feeding habit of a cow.

For the calibration of the acceleration sensors attached to the neck, acceleration was measured at a standstill at known angles (varying from -90° through 15°) and known positions of the node: top of neck, right side of neck and left side of neck.

The pitch angle can potentially represent the animal behavior in terms of feeding activity. It relies on the fact that when the animal is active (grazing or looking for the grass), the head is down (slanted neck), which is taken at $+15^{o}$ and the translational velocity of the animal is nonzero while in the inactivity mode such as lying down or ruminating, the head is up (horizontal neck) < 15 (10^{o}) and the velocity of the movement is zero. Magnetometer sensory element and accelerometer measure the pitch angle and acceleration. They are part of the collar composition mounted around the neck of the cow.

The result is processed and sent to the owner as alert message with the RFID. Consequently, the pitch angle of the neck and the velocity are the indicators of knowing the health status of cattle activity.

3.2 Pitch Angle of the Neck (Ao) and Temperature (T_P)

(i) Angle of contact (A_0) is inversely proportional to temperature.

$$A_o \,\alpha\, T_P^{-1}$$

$$A_o = K_1/T_P \qquad 3.0$$

Where K_1 is a constant

This means that increase in temperature, decreases the angle of contact. This is due to decrease in cohesive force and if the temperature decreases, angle of contact increases as a result of increase in cohesive force.

(ii) The angle of contact (A_O) is directly proportional to the Force (F)

$$A_O \,\alpha\, F$$

$$A_O = K_2 F \qquad 3.1$$

Comparing the two equations, equation 3.0 and 3.1, we have that

$$A_O = \frac{K_1}{T_p} = K_2 F$$

$$\frac{K_1}{T_p} = K_2 F$$

F = Mass x Acceleration (MA)

$$\frac{K_1}{T_p} = K_2 MA$$

Substituting, we have, $\frac{K_1}{T_p} = K_2 MA$ and assuming that the constants (K_1 and K_2) are equal, the equation becomes,

$$\frac{1}{T_P} = \text{MA},$$

Note that, A is Acceleration, which is change in $\frac{Velocity}{Time}$

$$\frac{1}{T_P} = M\frac{V1 - V_0}{T_m}$$

$$V_1 - V_0 = \frac{T_m}{MT_p}$$

Where,

F = the force of activities of a cattle

M = the mass of a cattle

V_1 = the final velocity of a health cattle

V_0 = the initial velocity of a health cattle, which is equivalent to zero (0)
A_0 = the neck angular velocity of a cattle
T_P = the temperature of a cattle
T_M = the time of operation of a cattle

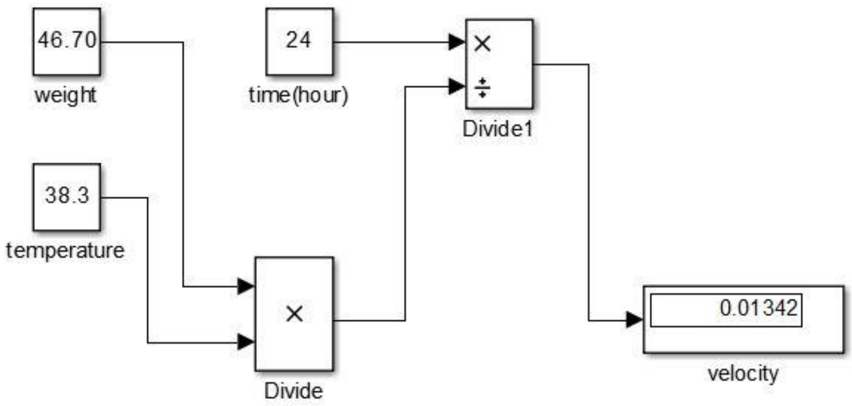
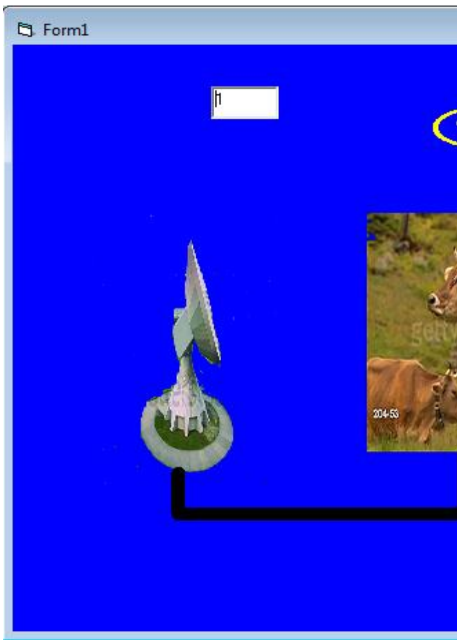


Figure 3.1 Simulink Model for cattle Velocity Monitor



$$V_1 - V_0 = \frac{T_m}{MT_p}$$

Figure 3.2 Designed Visual Basic Model for proper Tracking and Monitoring of unhealthy cattle velocity

The above figure shows a designed visual basic model for proper tracking and monitoring of the velocity of the cattle which is used to determine the health status of cattle. It contains CCTV, search light disc, handset and the area where the cattle are reared. Considering the mass range of cattle, when the velocity deviates from table 3.1.and 3.2, the cattle will be classified as unhealthy and the sensor at the collar will blink red

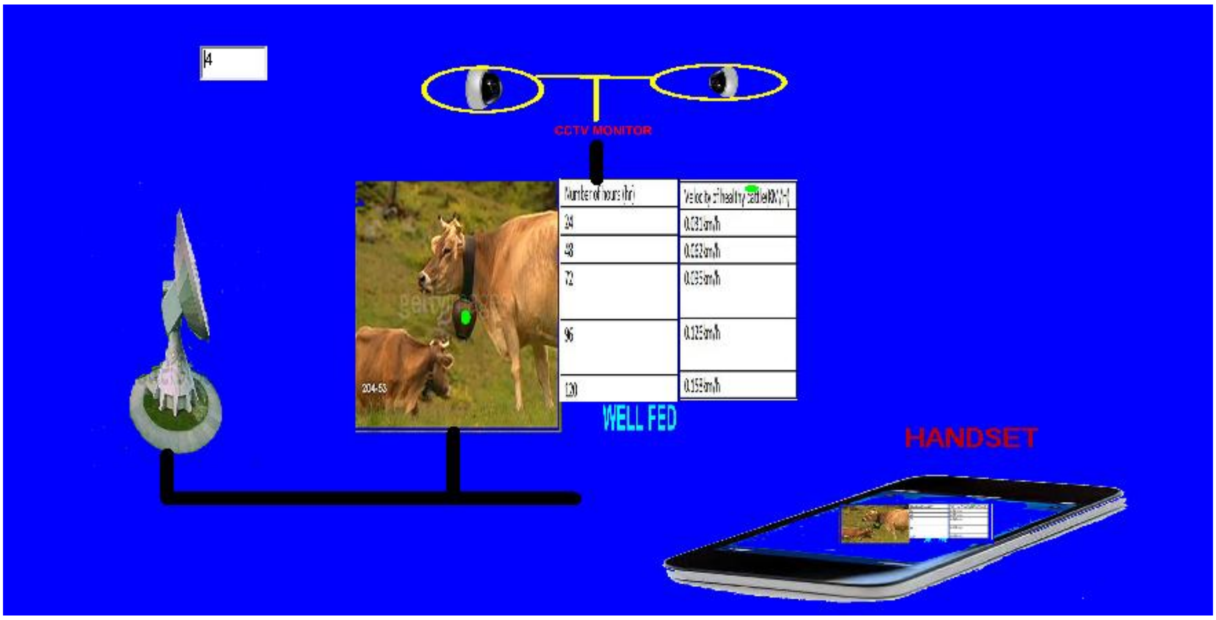
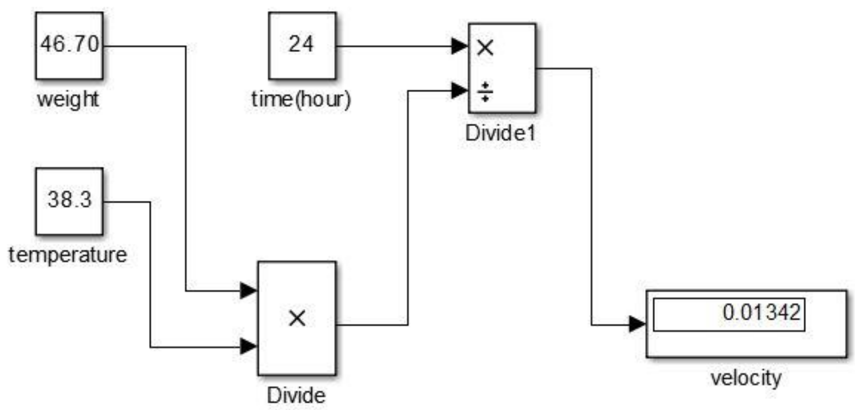


Figure 3.3: Designed Visual Basic Model for proper Tracking and Monitoring of healthy cattle velocity

The above figure shows a designed visual basic model for proper tracking and monitoring of the velocity of healthy cattle which is used to determine the health status of cattle. The cattle is healthy and well fed since the collar shows green light indicator, hence the velocity corresponds to the table 3.1 and 3.2 according to the sampled weight.
In either case, the owner mobile phone is alerted which enables him/her to determine the health status of the cattle in order to take appropriate actions.

IV. Data Collection And Analysis

Like all mammals, cattle are warm blooded animal. They need to maintain a constant core body temperature to be healthy and feed well (about 2.7kg dry grass daily). Normal rectal temperature for cattle is at the average the range of around 38.6°C. Pitch angle of the neck (A_0) is inversely proportional to the temperature of the cattle,(A_o α T^{-1}) and directly proportional to force, hence its acceleration. Conclusively, for healthy cattle the average body temperature and the pitch angle of the neck are constants with normal daily feed and weight gain, whose health status depends on the velocity.



Simulink Model for cattle Velocity Monitor

$$V_1 - V_0 = \frac{T_m}{MT_p}$$

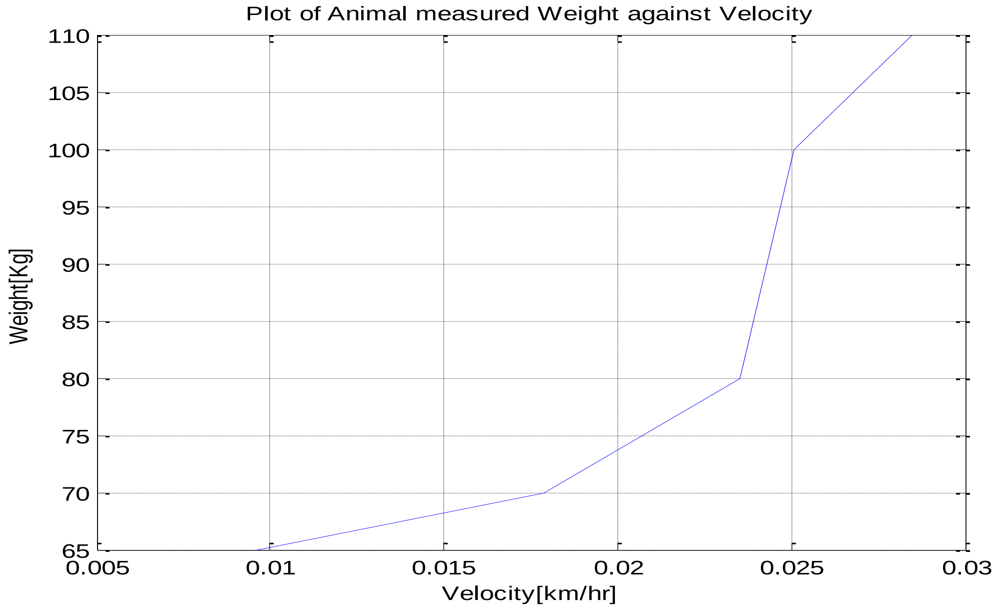
Table 3.1: Velocity (V) of Cattle Using Modeled Weight

MODELED WEIGHT OF A HEALTH CATTLE, Kg	TEMPERATURE OF A HEALTH CATTLE, ^{0}C	TIME (hrs)	VELOCITY km/hr
46.70	38.3	24 hours	0.01342
70.10	38.3	48 hours	0.01788
87.50	38.3	72 hours	0.02148
114.50	38.3	96 hours	0.02189
124.10	38.3	120 hours	0.02525

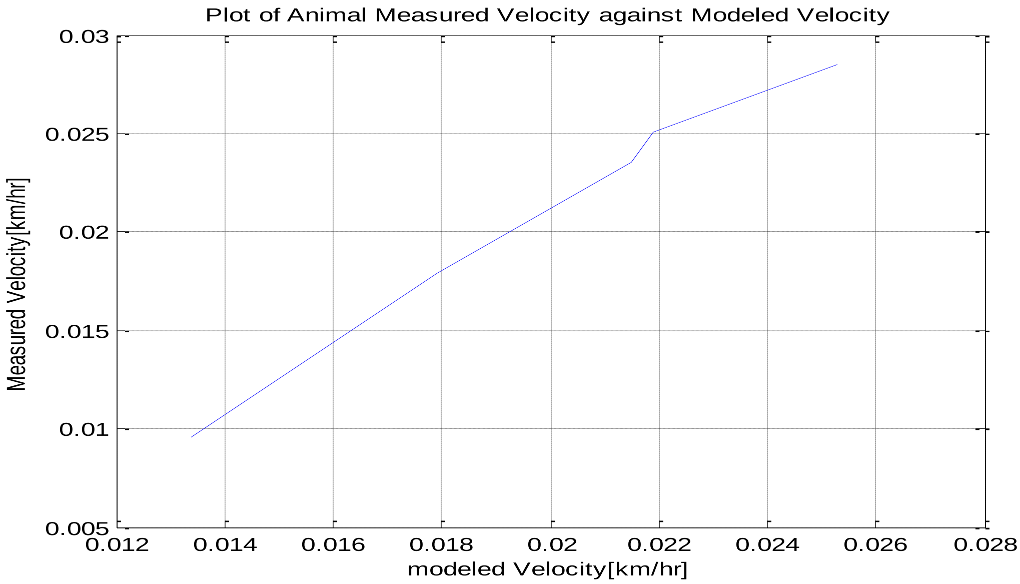
Table 3.2: Velocity (V1) of Cattle Using Measured Weight

MODLED WEIGHT OF A HEALTH CATTLE, Kg	TEMPERATURE OF A HEALTH CATTLE, ^{0}C	TIME (hrs)	VELOCITY km/hr
65.0	38.3	24 hours	0.0096
70.0	38.3	48 hours	0.0179
80.0	38.3	72 hours	0.0235
100.0	38.3	96 hours	0.0251
110.0	38.3	120 hours	0.0285

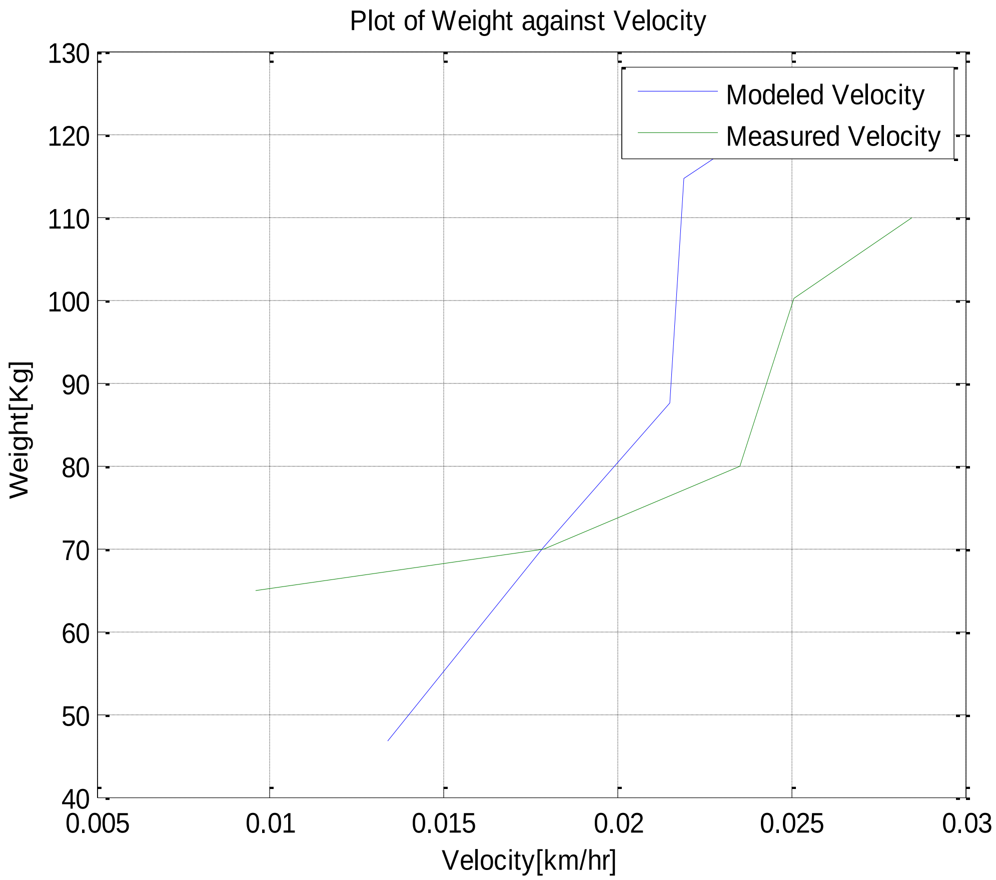
This shows that between the early weight increase i.e 50kg-87kg, there is a sharp increase in the measured velocity of cattle, and deteriotes when the weight increases above the range.



This shows the measured weight and velocity of healthy cattle. The velocity increases as the weight increases to 80kg and above that the velocity deteriotes.



The graph above shows the relationship between the measured and the modeled velocity. It shows that the measured velocity is almost directly proportional to the calculated velocity



The difference in graph if compared with the measured velocity and modeled velocity is as a result error in measurement. However, the result proves the fact that growth of cattle increases the velocity until a point where the velocity deteriotes due to increase in weight.

V. Conclusion And Recommendation

This research has shown that cattle velocity of movement increases within the early growth to a weight of about 80kg-87kg. At that stage, it is deduced that growth (increase in weight) is directly proportional to the velocity of cattle. But increase in weight as a result of growth above the range deteriotes the velocity.

However, some factors like temperature, feeding habit, geographical location, climatic changes etc play important role to affirm this claim. Therefore, it is recommended that different measurement from different locations, geographical area, and climatic condition and under same factors will assist feature researchers to an effective result.

5.1 RECOMMENDATION

In this research, I recommend that new, repeated and consistent researches be made about different species respectively in different locations. Weight loss, reactions to treatment/illness/conditions and other body compositions could be determined in order to overhaul reasons behind why growth varies in different species.

5.2 ACKNOWLEDGEMENT

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