1.1 BACKGROUND AND MOTIVATION

India is an agrarian country. Farmers in India have cattle in addition to their farms at large. India, in spite of rearing 43.6 million cattle (16.5% of the world population), on its conducive land; has lower average yield of 1,155 litre per animal an year(8.4% of the global yield) as compared to other countries like Netherland, New Zealand [1]. Efforts taken by the government like the white revolution led by Dr. Verghese Kurien also proved to be inconsequential with time.

The botches in this sector led to think about the technology penetrations in this field in India; which were found quiet shallower given Illiteracy, unavailability of internet, expensive imported systems, traditional approach, administrative negligence towards rural awareness etc.

1.2 AIM OF THE PROJECT

The project aims to develop an interdisciplinary comprehensive platform to interpret the meaning of the physiological parameters for milking animals corresponding to their average milk yield and establish a relationship between them [2]. An IoT based platform would provide a daily and in-depth analysis of the dairy animal. Data over a specific period of time can be assessed by the monitoring system and suggest improvements to alter the handling of animals, diet, etc.

1.3 PROPOSED SYSTEM AND FEATURES

Milking station where the cattle are milked is used to monitor the parameters. When the cattle are milked, they are stationary. Hence by staging their path to milking stations, their physiological parameters can be assessed through sensors.

Outputs from web cameras fixed at various positions would help to note height, width and breadth of the cow. Lameness can be assessed by the hunch cows get when they stand on a plane surface. Both these parameters can be monitored employing digital image processing.

Temperature can be measured internally as well as superficially. When the cow enters the station, daily locomotion database is logged in system over Wi-Fi interface. A weight sensor beneath the milking platform is used to obtain the weight [3]. The milking machine would automatically provide the data about the quality and quantity of milk [4]. This data obtained by internetworking the sensors is logged into cloud over internet and analyzed by remote server. It suggests the inference about milk yield in correspondence to the health of cow, and proactive solutions to improve further results.

1.4 SCOPE

The project incorporates the combination of sensor interfacing and cloud computing for implementing the Internet of things. Given that system is to be deployed on body of livestock, constraints like weight, electrival isolation, long life for batteries is important. Electronic Product design and base station reliability are major concerns while end to end testing.

2.1 LITERATURE REVIEW

The common problems faced by dairy farmers in India are related to decrease in milk production due to hidden physiological parameters which go unnoticed viz.

2.1.1 Locomotion

Due to sickness, a cow will be motivated to lie down in order to rest and enhance the healing process by minimizing the consumption of body energy reserves [5]. However, lying down may cause uncomfortable or painful feelings because of a painful udder, which can limit the lying time [6].

2.1.2 Temperature

Grazing cows tend to walk around 7-8 km. Though the dairy farm areas are restricted and secured, cows may suffer from partial injuries, fatigue, fever etc. through the day off wandering. In such cases, the databases depicting physical locomotion, body temperature logs prove useful for the management to attend the diseased in time.

2.1.3 Body Weight and physical dimensions

Body dimensions, Weight, moisture contents in excrete vary significantly during estrus, pregnancy, diseases like Bovine anemia, cryptosporidiosis etc. Cows losing more BW in early lactation conceived with greater likelihood than those with a greater BW loss [3].

2.1.4 Lameness

Lameness is the change in cattle posture and gait due to health issues limiting its locomotive capabilities. It is monitored in terms of locomotion score:

Locomotion scoring is a 5-point system based on both gait and posture.

1) Normal: The cow is not lame; the back is flat.
2) Mildly lame: The back is slightly arched when walking.
3) Moderately lame: The back is arched when both standing and walking. The cow walks with short strides in one or more legs.
4) Lame: The truly lame cow will bear some weight on the affected foot.
5) Severely lame: The back is arched; the cow refuses to bear weight on the affected foot and remains recumbent.

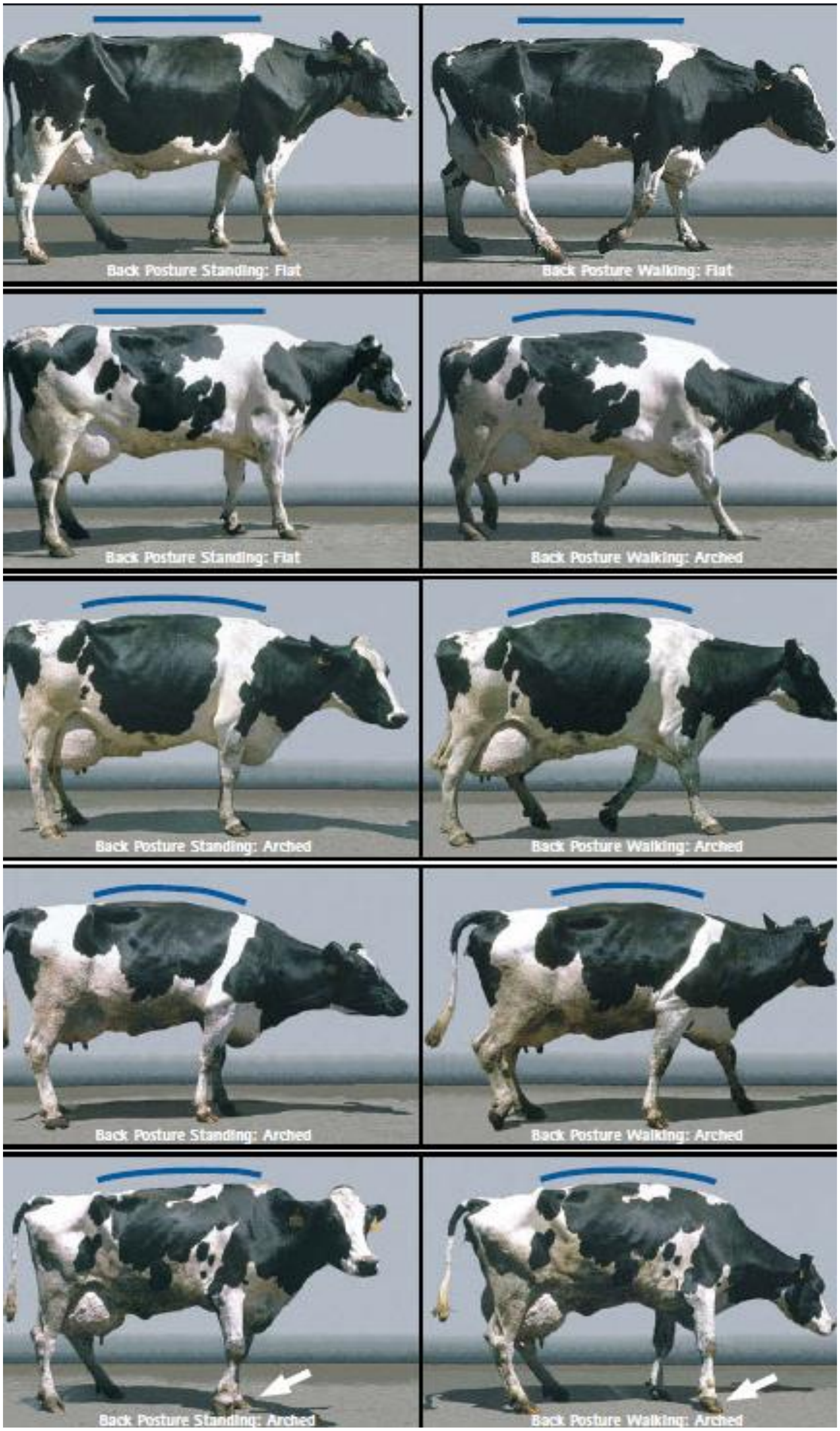

Fig 2.1 Stages of lameness for locomotion scores 1-5[Courtesy: Zinpro]

2.2 CURRENT MARKET REVIEW

- There are various companies which provide cattle monitoring systems. They only track the locomotion and estrus of the cattle. Thus factors like lameness and body weight are left out. Hence, the farmers won't understand the relation between the physiological disorder and the reduction in milk production.
- These systems use GPS trackers and other costly components making the system beyond the reach of the common Indian cattle farmer. The cost of these systems may go upto Rs 500,000 (Consulted to a farming expert).
- The functioning of these systems is complicated and difficult to understand for the workers.
- No relation established between the disorders and production variation.

3.1 BLOCK DIAGRAM

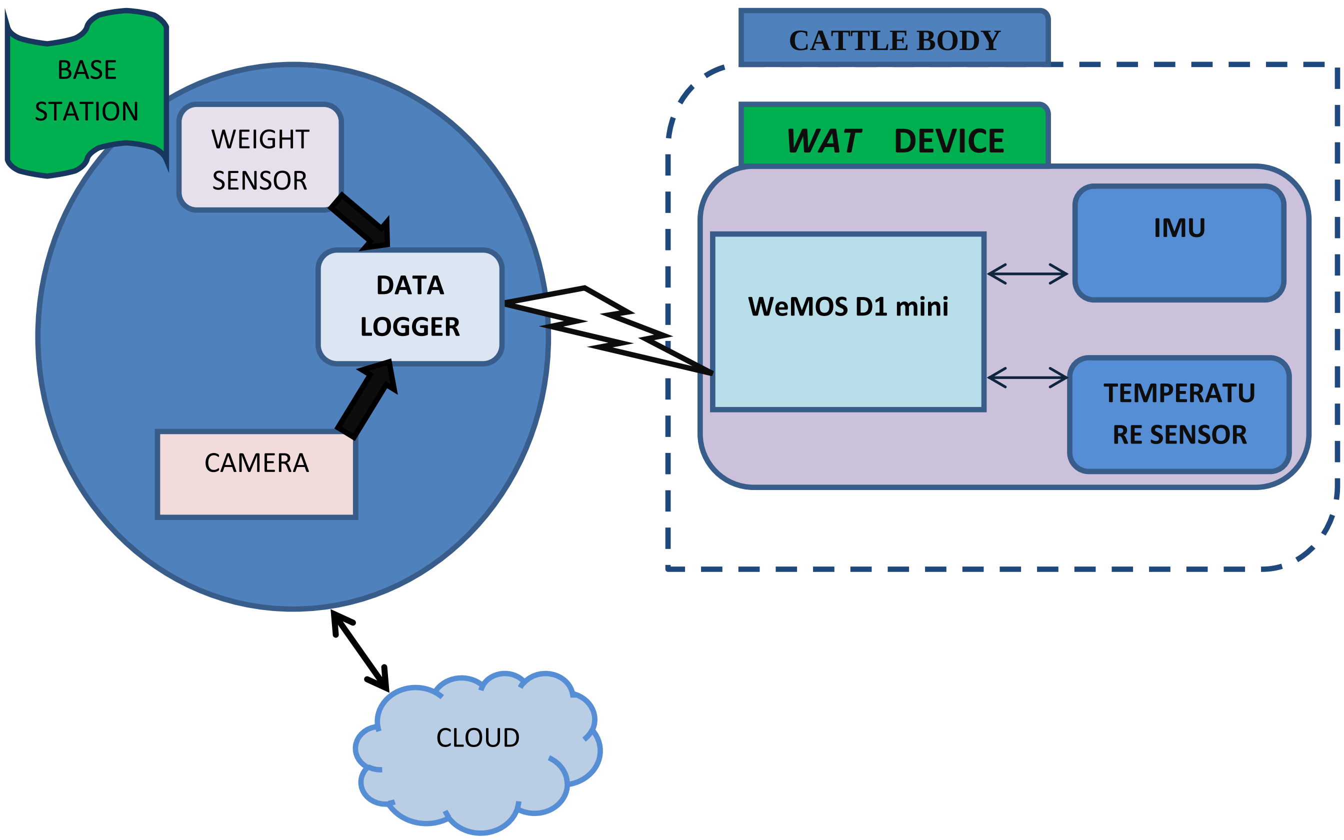

Fig 3.1 Block diagram of IoT Based cattle monitoring system

1. Power Supply Unit: It is a coin cell that provides supply voltage to the WAT device
2. Inertial Measurement Unit (IMU): We are using IMU for detecting motion of cattle. Also we will use IMU as pedometer for counting there walking distance.
3. Temperature sensor: Temperature sensor is used for monitoring body temperature of that cattle so we can get about its diseases.
4. Weighing Sensor: We are using load cell for measuring weight of cattle. This would be helpful at time of keeping its health record.
5. Camera: Camera will be used for image processing for detecting lameness.
6. WeMos D1 Mini: This will be processing unit on WAT device. This is compact in size, less power consuming and it has inbuilt WiFi module.
7. Base Station: Base station has a PC and WiFi module.

3.2 SYSTEM BLOCK DESIGN

3.2.1 IMU

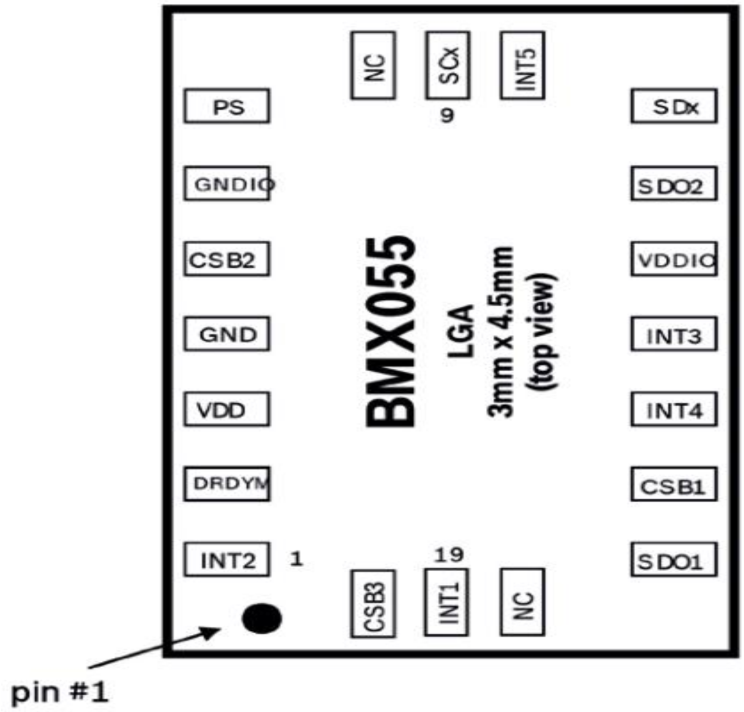

Fig 3.2 BMX055 9 DoF Inertial Measurement Unit

Inertial Measurement Unit (IMU) is device use for determining changes in position of an object. It consists of accerlometer, magnetometer, and gyro meter. It gives co-ordinate in units of roll, pitch and yaw. We can program it and use it as a pedometer.

Specifications

• Digital resolution: Accelerometer (A): 0.98 mg
Gyroscope (G): 0.004 °/s
Magnetometer: (M): 0.3 µT

• Measurement ranges: (A): ±2g, ±4g, ±8g, ±16 g
(G): ±125°/s, ±250°/s, ±500°/s, ±1000°/s,
(M): ±1200µT (x,y),

• Sensitivity: (A): ±2g: 1024LSB/g, ±4g: 512LSB/g ±8g: 256LSB/g ±16g: 128LSB/g
(G): ±125°/s: 262.4 LSB/°/s ±250°/s: 131.2 LSB/°/s ±500°/s: 65.6 LSB/°/s ±1000°/s: 32.8 LSB/°/s
(M): 3.3 LSB/µT

• Supply voltage (VDD) 2.4 … 3.6 V

3.2.2 ESP 8266

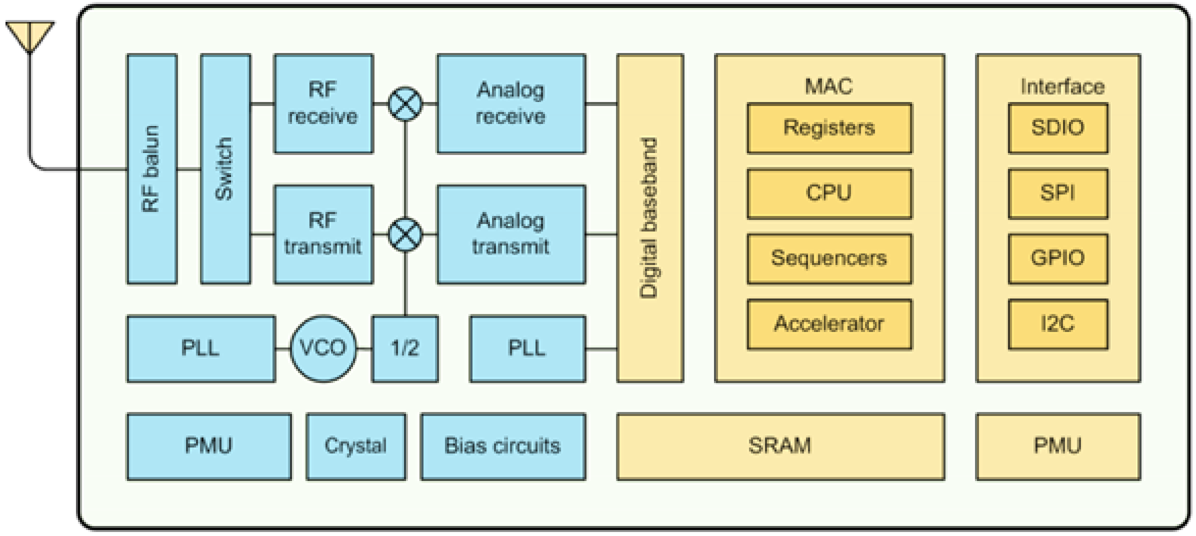

Fig 3.2 BMX055 9 DoF Inertial Measurement Unit

ESP8266EX offers a complete and self-contained WiFi networking solution; it can be used to host the application or to offload WiFi networking functions from another application processor. When ESP8266EX hosts the application, it boots up directly from an external flash. In has integrated cache to improve the performance of the system in such applications. Alternately, serving as a WiFi adapter, wireless internet access can be added to any micro controller based design with simple connectivity (SPI/SDIO or I2C/UART interface). ESP8266EX is among the most integrated WiFi chip in the industry; it integrates the antenna switches, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the WiFi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs.

Specifications

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- WiFi 2.4 GHz, support WPA/WPA2
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO

• Deep sleep power <10uA, Power down leakage current < 5uA
• Wake up and transmit packets in < 2ms
• Standby power consumption of < 1.0mW (DTIM3)
• +20 dBm output power in 802.11b mode
• Operating temperature range -40C ~ 125C
• FCC, CE, TELEC, WiFi Alliance, and SRRC certified

3.2.3 LM 35

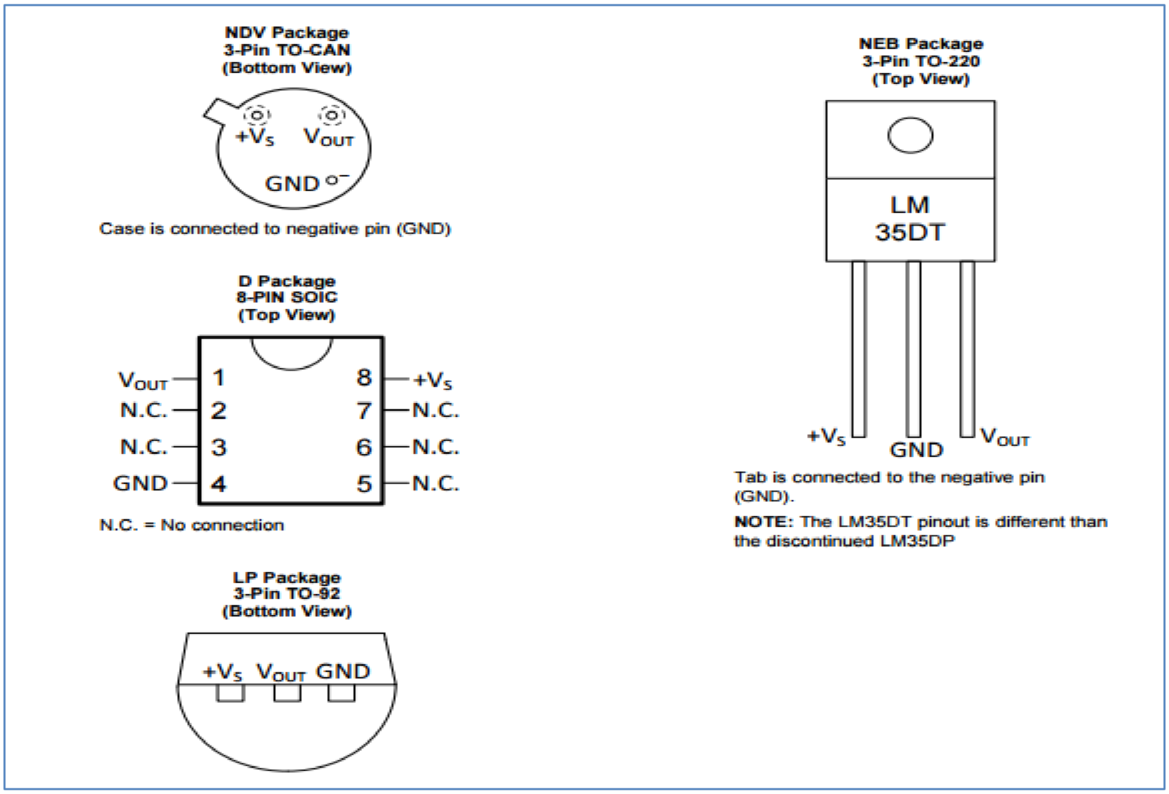

Fig 3.2 LM 35 PACKAGE AND PIN DIAGRAM [Courtesy: Texas Instruments]

Specifications
• Calibrated Directly in Celsius (Centigrade)
• Linear + 10-mV/°C Scale Factor
• 0.5°C Ensured Accuracy (at 25°C)
• Rated for Full −55°C to 150°C Range
• Suitable for Remote Applications
• Low-Cost Due to Wafer-Level Trimming
• Operates from 4 V to 30 V
• Less than 60-µA Current Drain
• Low Self-Heating, 0.08°C in Still Air
• Non-Linearity Only ±¼°C Typical

3.2.4 LOAD CELL

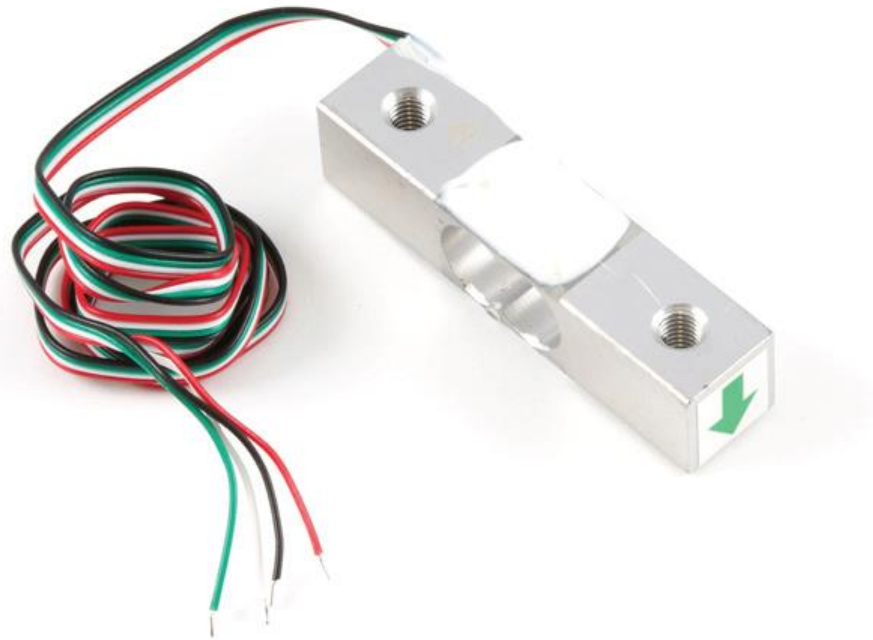

Fig 3.3 LOAD CELL

A load cell is a force sensing module - a carefully designed metal structure, with small elements called strain gauge mounted in precise locations on the structure. Load cells are designed to measure a specific force, and ignore other forces being applied. The electrical signal output by the load cell is very small and requires specialized amplification. Load cells are designed to measure force in one direction. They will often measure force in other directions, but the sensor sensitivity will be different, since parts of the load cell operating under compression are now in tension, and vice versa.

Calibration

A simple formula is usually used to convert the measured mv/V output from the load cell to the measured force:

Measured Force = A * Measured mV/V + B (offset)

It's important to decide what unit your measured force is - grams, kilograms, pounds, etc.

This load cell has a rated output of 1.0±0.15mv/v which corresponds to the sensor's capacity of 20kg.

To find A we use

Capacity = A * Rated Output A = Capacity / Rated Output

Since the Offset is quite variable between individual load cells, it's necessary to calculate the offset for each sensor.

Offset = 0 - 20 * Measured Output

3.2.5 Web Camera

Fig 3.5 QUANTUM QHM 495LM WEBCAM

We use a camera for detecting the lameness of the cow. We take the sideview image of the cow. We need a camera with good resolution to taking good quality images. Images with good resolution will will give accurate iamge processing reults.

Specifications

Brand: QHMPL
Type of sensor: CMOS
Model Id: QHM495LM
Connectivity: USB
Has Night Vision: Yes
Video Sensor Resolution: 0.5 megapixel
Still Image Sensor Resolution: 10 MP

4.1 SYSTEM DESIGN

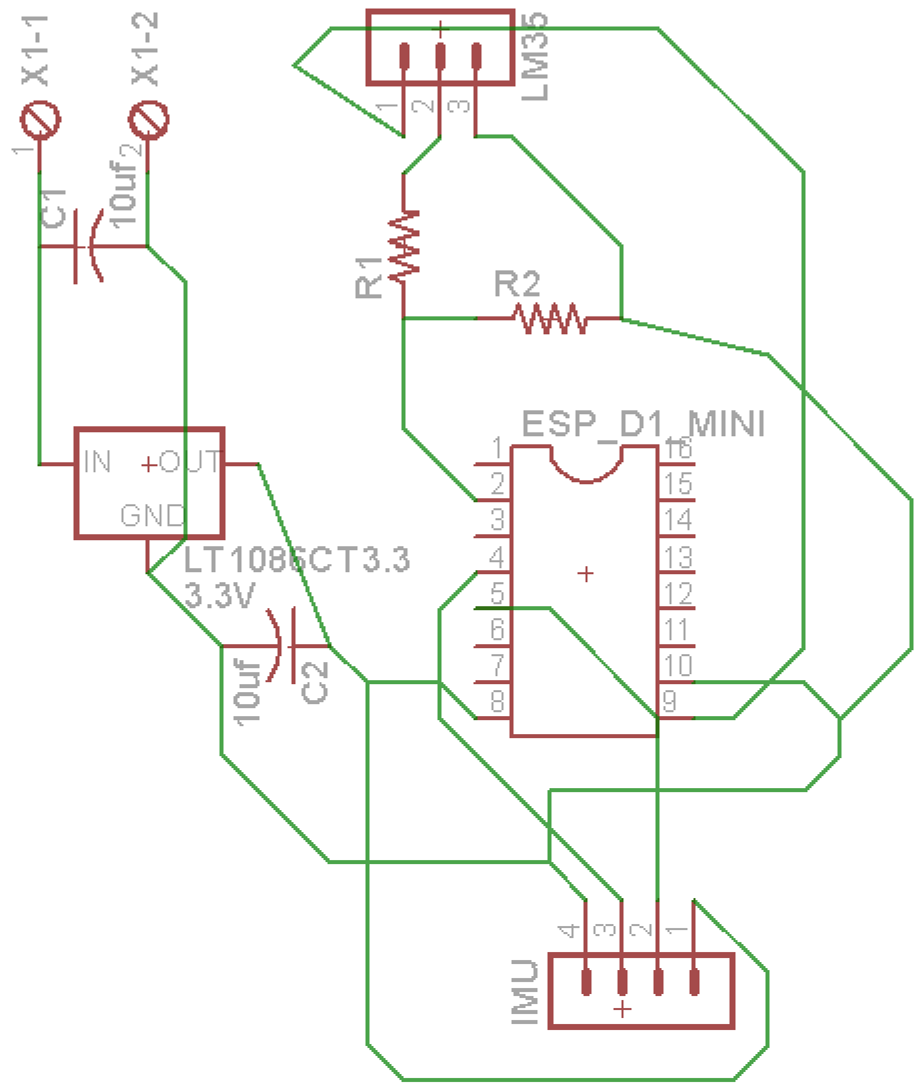

Fig 4.1 Block schematic for ESP 8266 WAT device (EAGLE CAD)

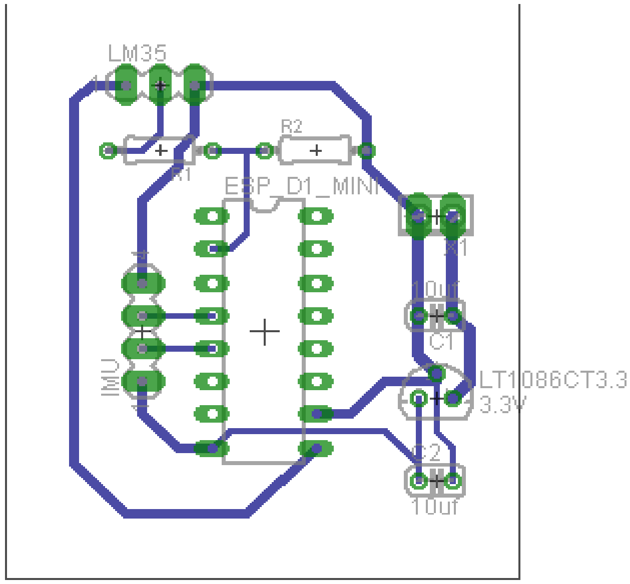

Fig 4.2 PCB layout for ESP 8266 WAT device (EAGLE CAD)

Algorithm for Lameness detection applying DIP

1) Start

2) Acquire image

3) Preprocess image

   i) Convert into gray scale

   ii) Apply median filter for salt and pepper noise removal

   iii) Convert to black and white

   iv) Pad with additional borders

4) Apply angular planning designed mask for HPF action

5) Mask the borders translated as edges

6) Obtain the edge detected image

7) Obtain upper edge of image to represent the back of milking animal

8) Prune the unwanted section and obtain the portion of back depicting the lameness

9) Obtain the equation of the back by using the concept of curve fitting.

10) Obtain the standard deviation parameter from the equation of the back.

11) Compare the obtained standard deviation with the database to obtain the degree of lameness.

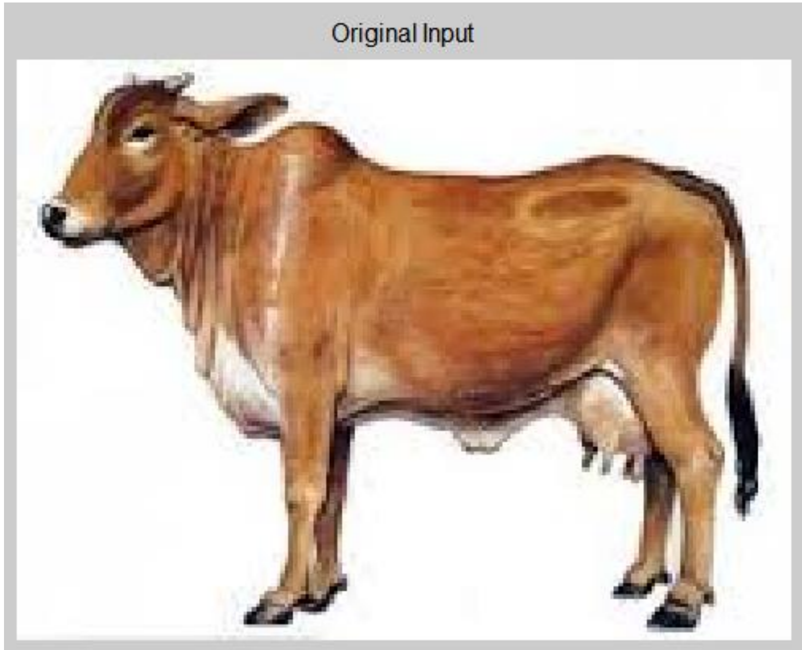

Fig 4.3 Input image

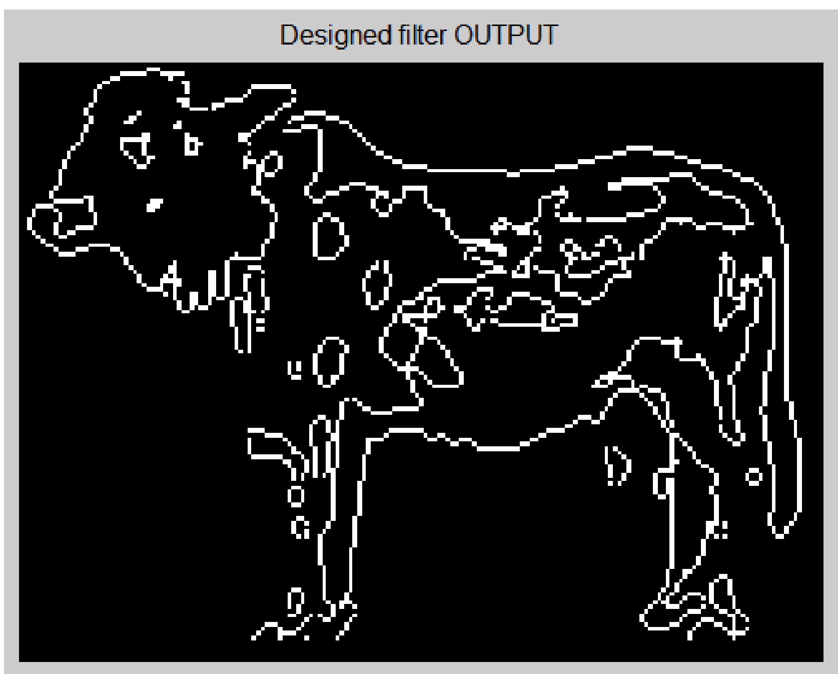

Fig 4.4 Designed planar HPF Edge detection (MATLAB)

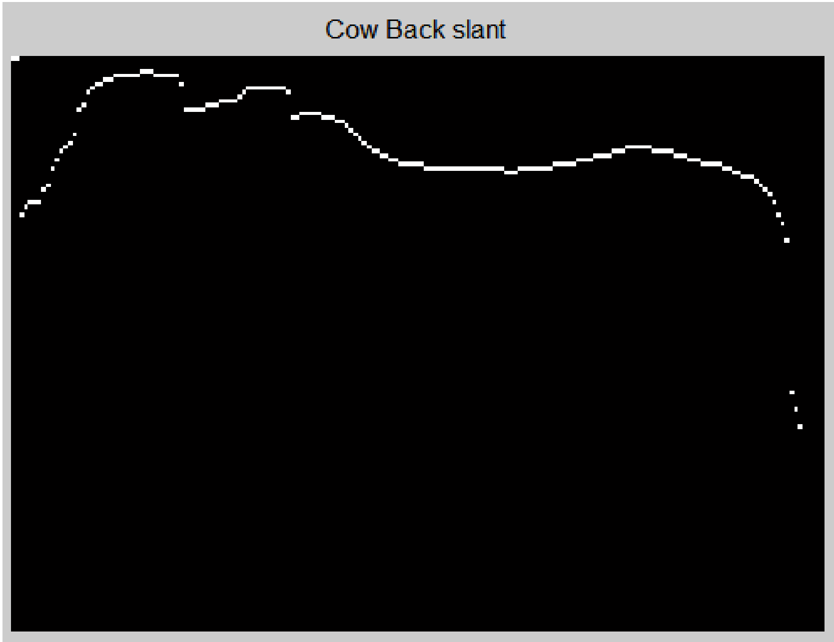

Fig 4.4 Edge retrival for Lameness detection(MATLAB)

4.2 COMPONENT DESIGN

Presented system proposes a solution to the problems faced while monitoring cows. A detailed analysis report can be achieved and the parameters can be analyzed

.

- Locomotion Score: A pedometer is used to track the number of steps taken by the cow. Hence, the total distance covered can be calculated.
- Temperature Sensor: A temperature sensor is used monitor the temperature of the cow from time to time.
- Camera: A camera is used to determine the lameness of the cow. The hump on the back of the cows is calculated by image processing algorithms.
- Load cell: Every bridge can bear certain amount of load thus the solution will measure the weight of the cow.

5.1 CONCLUSION

A detailed study of the Indian cattle farm was conducted. Various parameters like lameness and locomotion are the parameters which affect the cow's milk production. Sensors to analyze these parameters were found out. An IMU is programed as a pedometer to count the number of steps taken and thus the locomotion. A camera is used to take the images of the cow. These images are further analyzed by using Digital image processing techniques to detect the lameness in cows. A temperature sensor implanted in the ear of the cow would provide a continuous database of the cow's temperature measurements. Hardware and software design of the WAT device and station are finalized. This system would provide a complete assessment of the cow on a daily basis and provide the necessary changes that are to be made in the lifestyle of the cow in order to increase the milk production.

5.2 FUTURE SCOPE

- Expand the scope beyond cows to buffalos and goats.
- Use GPS based tracking
- Detetction of Estrus and calving
- Provide the farmer with hourly updates of cellphones via SMS.
- Make the system affordable for a cattle farm with less than 40 cows.

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