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DORPER BSI MONITORING WITH LOAD CELLS AND RASPBERRY PI

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Abstract—The paper describes an alternative method to weigh and monitor the health of livestock via BSI. One method is by recording the measured weight for each livestock for daily weight comparison. The farmer needs to manually lift each of the livestock onto the weighing scale, using rope, producing risk of injury to both farmer and livestock. The main purpose of this project is to enhance the existing weight process by developing a weighing scale which is durable, easy to maintain as well as equipped with online database to store the weight of the livestock for monitoring purposes. Hardware consisting of load cell, HX711 and Raspberry Pi while the software will be written using Python programming language and LAMP to create a web server for storing acquired data. The system's prototype takes accurate and stable reading in experiments simulating a livestock walking onto the weighing platform with an error rate of 0.1kg. Finally, the implementation of this system shall increase farmers productivity as well as redusing risk for injury.

Keywords—Dorper, body score index, load cell, python programming, LAMP

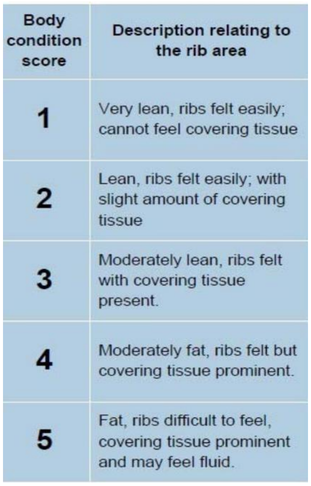
I.INTRODUCTION

Ruminants farming namely the sheep breed Dorpers are getting famous on Malaysia. Usually the farmers have more than 100 pens with each pen fitting about 5 to 10 sheep. The large number in livestock count causes difficulty to the farmers in monitoring the sheep's body score index (BSI). Sheep's weight plays the most crucial role in determining health and pregnancy. Normally the farmers need to manually lift the sheep to the weighing machine using rope then hangs the sheep at the weighing scale to measure the weight as shown in Fig. 1. For every 100 pens at 10 sheep per pen, amounting to 1000 sheeps with a weight range of 20 to 40 Kg each, will need manual lifting for weight recording propose every day. This tedious labor consumes massive energy and time. Thus, the main purpose of this project is to enhanced the existing weight scale and develop a weighing scale that is easy to maintain, equipped with database to experdite the tedious task of storing the sheeps' weight. This project will be equipped with 4 load cell and HX711. Raspberry Pi will be used as the main controller of the system. The main objective of this project is to design the digital weight scale that will replace the existing analog weighing scale. Moreover, develop weighing scale that is easy to maintain, equipped with database to store the sheeps weight. Finally, increasing the farmers productivity by redusing injury risk. Two limitation to this project are, formerly manual execution of the command program, is required upon controller start-up. The latter, is the hardware frame of the weighing scale must be redesign to fit a real sheep as the scale designed in this project is only a prototype for in lab experiments.

Fig. 1. Current Weighing Scale

II. LITERATURE SURVEY

Beside nutrition and Body Condition Score (BCS), live weights of the livestock are also an important factor influencing milk production [1]. Moreover, loss of appetite due to parasitic infestation also affects sheep's weight causing loss of body weight and as well as milk production [2]. Usually goat will drink about 10-15% of their body weight. For example, if the goat is 40kg then the goat needs to drink about 4-6 litters of water each day. Fig. 2 shows the BCS of how the sheep is categorized from 1 to 5, with score 1 of being very thin and score 5 to being fat. A good BCS is around 2 or 3. Fig. 3 show a guideline in BCS measuring [3].



Body condition score	Description relating to the rib area
1	Very lean, ribs felt easily; cannot feel covering tissue
2	Lean, ribs felt easily; with slight amount of covering tissue
3	Moderately lean, ribs felt with covering tissue present.
4	Moderately fat, ribs felt but covering tissue prominent.
5	Fat, ribs difficult to feel, covering tissue prominent and may feel fluid.

Fig. 2. Body Condition Score (BCS) [2]

The template Load cell as a weighing scale sensor with stain gauge technology will be used in this project. A strain gauge is a small wire that holds electrical resistance which responds to changes in resistance as it strains. Positive stress applied to the strain gauge will increase length while decreasing its area of cross section and viceversa. Since the resistance is directly proportional to length and inversely proportional to area of cross section, the resistance of the strain gauge increases with positive strain [4]. Strain gauge also has larger sensitivity coefficients, with smaller mechanical hysteresis, and lower power consumptions [5]. Load cell allow force, pressure, tension, from the weight to be converted into a change in electrical resistance. Wheatstone bridge with four arms at each bridge is applied as amplifier since measuring minute resistance change in a strain gauge (mΩ) with an ohmmeter proves to be difficult [6].

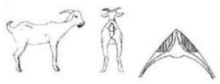
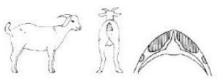
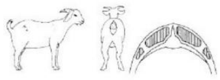
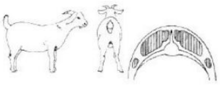
1 **Very lean**		• Body angular, narrow and slab sided. • Backbone raised and sharp. • Ends of short rips sharp and easily felt.
2 **Lean**		• Backbone raised and barely covered. Pin and hip bones obvious and barely covered. • Ends of short ribs smooth but easily felt.
3 **Medium or moderately lean**		• Backbone slightly raised, smooth and rounded over top. Pin and hip bones lightly covered. • Ends of short ribs smooth but can still be felt. • Moderately rounded appearance.
4 **Moderately Fat**		• Smooth, rounded appearance. • Backbone can be only just felt. Pin and hip bones smooth and rounded. Ends of short ribs cannot be felt. • Condition score 5 is very fat.

Fig. 3. Guideline to Measure BCS [3]

This is an Internet of Things (loT) project allowing centralized communication [7]. The project can be monitored via application program on smart phone at convenience, thus saves time and reduces labor [8]. The data will be stored in database using SQL [9]. A web portal is specially designed website created for a particular purpose gathering information from several other public sources. Unlike public website, web portals than can only be accessed by registered user, requires logging into the web portal [10].

III. PROPOSED SYSTEM

In this project, both software and hardware were implemented. The hardware used in this project is Raspberry Pi model 3, load cell and HX711. Raspberry Pi 3 is single onboard computer with 1.2GHz 64-bit quad-core ARMv8 CPU, 802.11n Wireless LAN, Bluetooth 4.1, 4 USB ports, 40 GPIO pins, Ethernet port, Display Interface (DSI) as well as being equipped with a Camera Interface (CSI). Raspberry Pi will act as controller for the system. Load cell using strain gauge as sensors whose resistance varies with applied force, converts weight into change in electrical resistance for measurement. HX711 amplifies the signal from the load cell into the microcontroller, increases the accuracy in reading the changes of the strain gauge resistance. Meanwhile, the software using python to write coding program and LAMP to create web server for data storage.

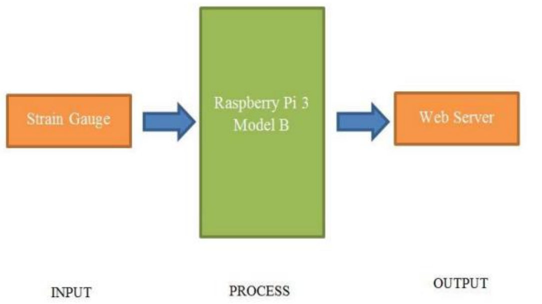


Fig. 4. Block Diagram of the System Fig. 4 shows the functional block diagram of the system. In this project, the input of the system are the load cells. The main controller which is the Raspberry Pi act as the mediator for the input process and communication medium to the output of the system which is the web server storing weight measured into the database.

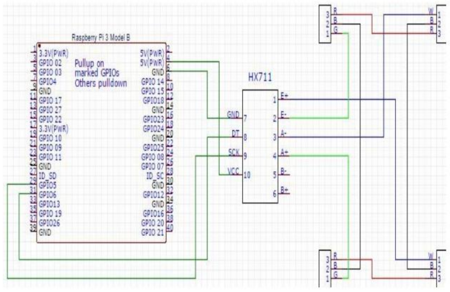


Fig. 5. Schematic Diagram of the System

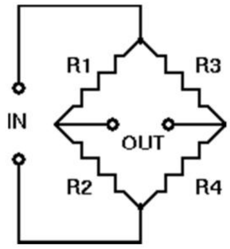


Fig. 6. Wheatstone Bridge

Fig. 5 depicts the schematic diagram of the system is designed based on the functionality of the system. The system utilizes 4 load cells connected using Wheatstone bridge configuration as shown in Fig. 6. The load cell must then be connected to the HX711 which amplifies the voltage for accurate reading by the controller. Fig. 7 show the flow chart of the project. Raspberry Pi will continuously obtain voltage from the load cell and converts the electrical signal to kilogram unit. Next, Raspberry pi will save the converted measurements to database using LAMP. User can view, edit, insert or delete data by accessing to the server using web portals.

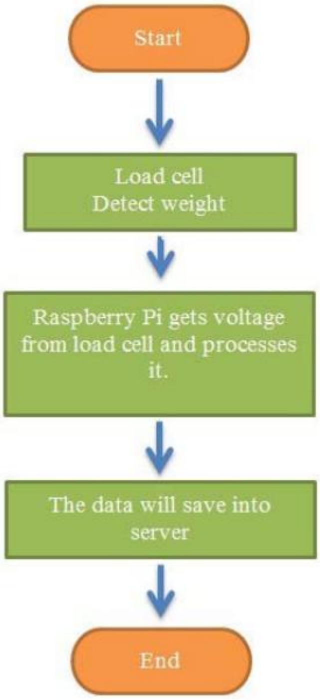
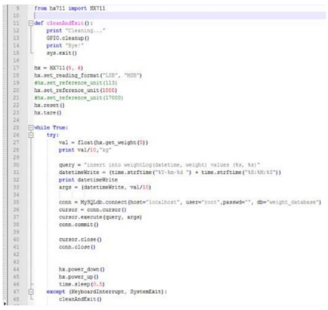


Fig. 7. Flow Chart for the System Load cell as weight sensor will be planted under the weighting scale as in Fig. 8.

Measurement is then recorded as the sheep crosses over the weighting scale. Then, Raspberry Pi will read the signal data and display the output at the designated web portal as Raspberry Pi uploads weigh measured to the database. Farmers can access the database to monitor weight of each livestock. With this system, subsequent time and energy can be saved in the process of measuring the weight of the sheep.

Fig. 8. Prototype of the system

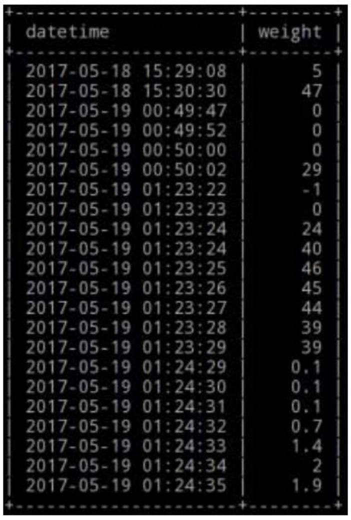


```
from hx711 import HX711

def cleanAndExit():
    print "Cleaning..."
    GPIO.cleanup()
    print "Bye!"
    sys.exit()

hx = HX711(5, 6)
hx.set_reading_format("LSB", "MSB")
#hx.set_reference_unit(113)
hx.set_reference_unit(1000)
#hx.set_reference_unit(17000)
hx.reset()
hx.tare()

while True:
    try:
        val = float(hx.get_weight(5))
        print val/10,"kg"

        query = "insert into weightLog(datetime, weight) values (%s, %s)"
        datetimeWrite = (time.strftime("%Y-%m-%d ") + time.strftime("%H:%M:%S"))
        print datetimeWrite
        args = (datetimeWrite, val/10)

        conn = MySQLdb.connect(host="localhost", user="root",passwd="", db="weight_database")
        cursor = conn.cursor()
        cursor.execute(query, args)
        conn.commit()

        cursor.close()
        conn.close()


        hx.power_down()
        hx.power_up()
        time.sleep(0.5)
    except (KeyboardInterrupt, SystemExit):
        cleanAndExit()
```

Fig. 9. Pseudo Code

IV. RESULTS

Fig. 10 shows table of weight and datetime that have been recorded to database of the systems.

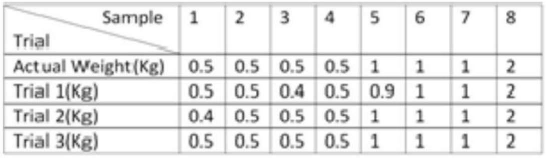


```
+---------------------+--------+
| datetime            | weight |
+---------------------+--------+
| 2017-05-18 15:29:08 |      5 |
| 2017-05-18 15:30:30 |     47 |
| 2017-05-19 00:49:47 |      0 |
| 2017-05-19 00:49:52 |      0 |
| 2017-05-19 00:50:00 |      0 |
| 2017-05-19 00:50:02 |     29 |
| 2017-05-19 01:23:22 |     -1 |
| 2017-05-19 01:23:23 |      0 |
| 2017-05-19 01:23:24 |     24 |
| 2017-05-19 01:23:24 |     40 |
| 2017-05-19 01:23:25 |     46 |
| 2017-05-19 01:23:26 |     45 |
| 2017-05-19 01:23:27 |     44 |
| 2017-05-19 01:23:28 |     39 |
| 2017-05-19 01:23:29 |     39 |
| 2017-05-19 01:24:29 |    0.1 |
| 2017-05-19 01:24:30 |    0.1 |
| 2017-05-19 01:24:31 |    0.1 |
| 2017-05-19 01:24:32 |    0.7 |
| 2017-05-19 01:24:33 |    1.4 |
| 2017-05-19 01:24:34 |      2 |
| 2017-05-19 01:24:35 |    1.9 |
+---------------------+--------+
```

Fig. 10. Database

The weight value and timestamp record are automatically uploaded to the table when the system starts. Eight samples had been selected and filled with water to a certain height corresponding to a selected weigh for experiment. Each sample was tested by placing the weights onto the prototype and the weight reading is recorded.

TABLE I. INITAL SETUP TESTRUN



Sample / Trial	1	2	3	4	5	6	7	8
Actual Weight(Kg)	0.5	0.5	0.5	0.5	1	1	1	2
Trial 1(Kg)	0.5	0.5	0.4	0.5	0.9	1	1	2
Trial 2(Kg)	0.4	0.5	0.5	0.5	1	1	1	2
Trial 3(Kg)	0.5	0.5	0.5	0.5	1	1	1	2

The record was tabulate as shown in Table I and Fig. 11 depicts the graph of table trail. Reading shows that samples 2, 4, 6, 7, and 8 has shown the exact same values with the actual weight with all trial. Sample 1 in the second trial, while sample 3 and 5 shows a slight difference of 0.1 kg in the first trial.

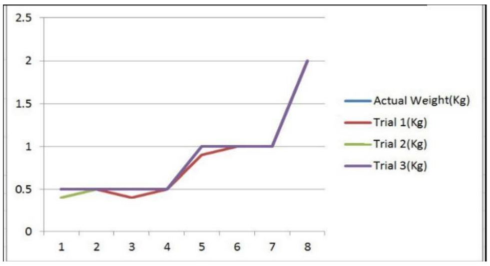


Fig. 11. Graph of Table Trial

Table II tabulates readings from experiments conducted to find the relationship between position placement of the sample on the prototype and actual weight. Five locations were identified which are the upper right, upper left, lower right, lower left, and center of the weighing scale.

TABLE II. WEIGHT PLACEMENT ON PROTOTYPE

Sample Position	1	2	3	4	5	6	7
Actual Weight(Kg)	0.5	0.5	0.5	0.5	1	1	1
Upper Right(Kg)	0.5	0.5	0.5	0.5	1	1	1
Upper Left(Kg)	0.5	0.5	0.5	0.5	1	1	1
Lower Right(Kg)	0.5	0.5	0.5	0.5	1	1	1
Lower left(Kg)	0.5	0.5	0.5	0.5	1	1	1
Center(Kg)	0.5	0.5	0.5	0.5	1	1	1

All weight reading from samples placed at various location on the weighing scale platform, produced same value as actual weight of the samples, proving stability in the weighing by the prototype as depicted by the graph in Fig. 12.

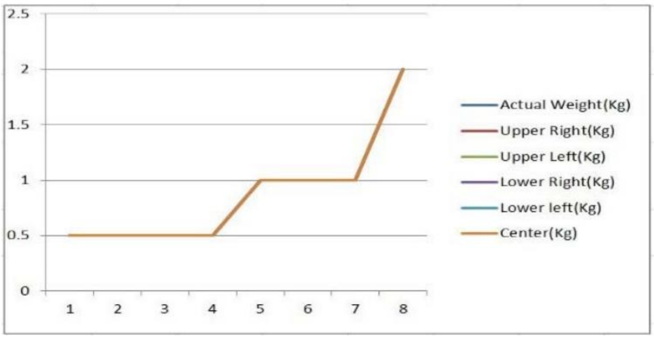


Fig. 12. Graph of Sample Position on Prototype

Further, the shape of bottle was also recorded to determine the relationship between shape of the sample and actual weight as tabulated in Table III. The experiment was that the system shall be tested with 3 different base shape using the same amount of water simulating the weight of half kilogram. Firstly a circular container with a flat-base as shape 1, followed by a square container with flat base as shape 2, and lastly a circular but non-flat base as shape 3.

TABLE III. SAMPLE BASE SHAPE

Sample Trial	Shape 1	Shape 2	Shape 3
Actual Weight(Kg)	0.5	0.5	0.5
Trial 1(Kg)	0.5	0.5	0.5
Trial 2(Kg)	0.5	0.5	0.5
Trial 3(Kg)	0.5	0.5	0.5

Although the base shape of the samples were different, the prototype recoded the right weight for the tested samples as depicted in Fig.13.

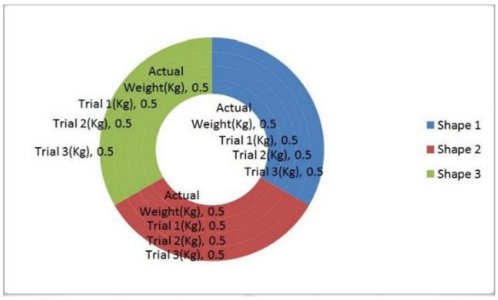


Fig. 13. Graph of Shape

This project exhibits promising result with only one limitation in term of the program needing to be manually executed every time the controller was turned-off. However, results from Table I above expresses accurate reading to an error of + −0.1 Kg by the system. The first two trials then produces accurate reading for all samples in the third trial and henceforth, proving stability of the system's weighing mechanism. The result from Table II and Table III proves the stability of the weighing mechanism even further with the placement of the samples on the prototype as well as the base shape of the sample. Both experiments did not affect the outcome of the measured weight. This is desirable as a simulation of a sheep walking onto the weighting scale in the process of capturing its weight.

V. CONCLUSION

In conclusion, the system was successfully built to measure weight with an efficient method, beneficial to the farmer. Farmers shall save energy and time to measure the weight of the Dorper since heavy lifting and manual recording the readings will no longer be required. Based on the result, the systems were not influenced by the placement of the sample on the prototype which simulates a sheep walking across the platform of the weighing scale. The system also takes accurate reading with error of ±0.1Kg. The second part of the system is the development of the user graphical interface (GUI) for onsite real-time data monitoring. This system can be improved by making ease of access to the database with attractive and interactive web portal. A method of segregating data for each individual Dorper is also to be considered. The weighing mechanism should also cater for more decimal number for accurate reading of the data value, as well as redesigning the hardware frame of the weighing scale to fit an actual livestock.

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