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Software Interface to Log High-Speed Data Acquired from a Stress-Strain Measuring System

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Abstract: The jumping performance of a frog is determined by several characteristics of the frog. A system is developed to record the dynamic reaction force response of a striped marsh frog inserted on a platform in the propulsion phase of the jumping cycle. To record dynamic response, simultaneous data acquisition and high-speed data recording is necessary. This research paper discusses how the development of the software interface to log high-speed data is done using C. The primary objective of the system is to collect data simultaneously in a high-speed data rate. ADS1299 Analogue to Digital Converters (ADCs) is used and coupled with three strain gauges attached to the three axes of the platform. The ADC sampling is controlled by a microcontroller, and data is transferred to the PC using the serial port. The Graphical User Interface (GUI) of the software application is capable of reading, saving, retrieving, and plotting data. Besides, the software is capable of static load-based calibration and taring. The developed system is capable of recording the dynamic ground force response of an object inserted on the platform using the developed software interface. The primary objective, collecting data simultaneously at high speed, is achieved with a maximum data rate of 980 SPS. An additional option is given to calculate the jumping angle of the frog using the resultant reaction force.

Keywords: High-speed data Acquisition, Simultaneous sampling, Force platform

Introductıon

Observing animal behaviors is interesting and modeling those leads to new knowledge. This project is based on measuring dynamic performance of a striped marsh frog. A jumping cycle of a frog can be divided into four sub-phases: propulsion, flight, landing and recovery. Variables characteriz- ing the propulsive phase are take-off velocity, ground reaction forces, and jumping distance. The average weight of a stripped marsh frog is ranging in from 2.9 g to 38.4 g. Stripped marsh frogs take off by extending their hindlimbs and use forelimbs for landing [1].

A force platform design for measuring jumping performance is consisted of a circular acrylic top mounted on a L-shaped double-cantilever brass beam which is fixed to an acrylic bottom plate [2]. The frog extending its hindlimbs on the force platform while take off and vertical, horizontal and lateral ground reaction forces exerted on the platform is measured simultaneously.

Methodology

The designed platform is capable of measuring the vertical, horizontal and lateral ground reaction forces of a jumping frog in propulsion phase. The data rate of the designed system is sufficient to capture dynamic performance of the frog. A high-speed cinematography camera is only capable of capturing at a rate of 500 frames per second [2]. So better results can be obtained by the developed system. One main objective of the system is to interface three strain gauges for high speed, simultaneous data acquisition.

An Analogue to Digital Converter (ADC) ADS1229 is used in order to achieve high speed data acquisition. Characteristics of the ADC are data rate of 250 SPS to 16 kSPS, 8 chan- nelled, simultaneous data acquisition with high resolution (24 Bits) and offered with built-in oscillator and I2C-compatible serial interface. This ADC (ADS1299) is used in applications like Electroencephalogram (EEG), sleep study monitoring and evoked audio potential studies [3]. ATMega 32u4 microcon- troller clocked at 16 MHz was used as the main controller of the system.

The interface software application is written using Microsoft Visual C# with the use of Visual Studio Integrated Develop- ment Environment (IDE). The software application comprises of two windows. One is to display and control data acquisition and the other is to retrieve gathered data in graphical format. A base of an electronics balance and a bubble level was used for the experimental setup for calibration. Precision weights were used for the calibration process. Any additional weight

on the loading setup has been tare by using the software. The capabilities of high speed data logging was demon- strated with the use of free fall ping-pong ball under gravity. The primary objective, collecting data simultaneously in high speed is achieved with a maximum data rate of 980 SPS.

Software Interface and Features

The software interface is developed in order to facilitate the user with several options for logging data and viewing logged data. Visual studio C# IDE is used to develop the interface. There are two main basic interface designs for data logging and viewing.

The developed software is used to communicate with the microcontroller using serial communication, which transmits data captured by ADS1299 simultaneous sampling ADC unit.

Software is designed to communicate with the microcontroller at baud rate of 230400. Hence it is capable of getting a maximum sample rate of 1000 samples per second from all three channels.

A. Data Logging Interface

Data logging interface is given by Figure 1. The following features in Table 1 were enabled by using several productivity features available in Visual Studio C# IDE.

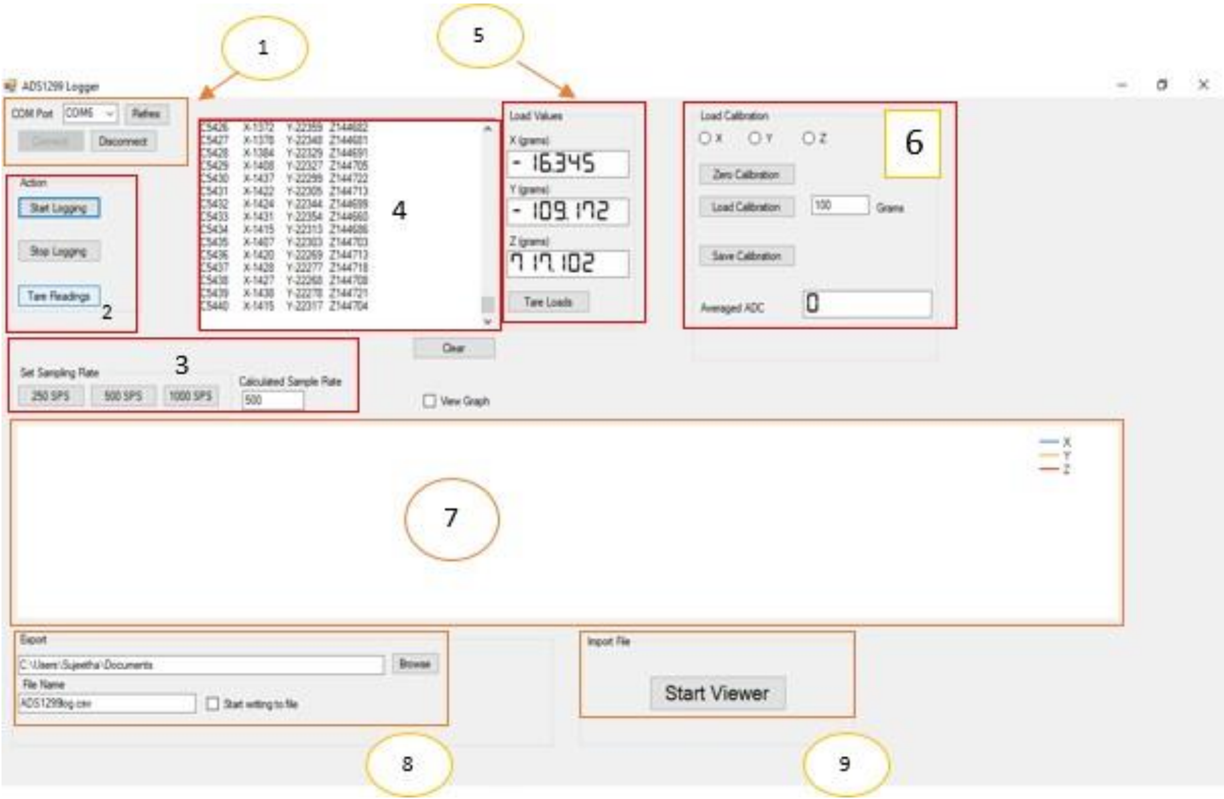


Fig. 1. Data logging software interface including the available features for the user..

The description of indicated numbers are included in Table 1

Table 1. Features/Elements Of The Software Interface

Feature/ Element	Description
1	Select the serial port and enable commutation
2	Start/stop reading data and tare input readings
3	Select sample rate and display actual sample rate
4	Display raw input data
5	Display the calibrated load values of x,y,z channels
6	Tools for calibrating the load values
7	View sampled x,y,z data graph
8	Exporting captured data
9	View saved data

Once the COM port which microcontroller is connected and selected from the software application, data acquisition is started. Start logging and stop logging buttons controls the data recording in the computer.

The microcontroller reads samples of x, y and z channels captured by the ADS1299 ADC and sends to the computer software with a sample count number. The software reads this string of data and separates the count x, y and z channels to separate variables. The sample count is used to calculate the actual sample rate and it is shown on the interface. The x, y, z variables are then used to calculate the load values using calibration curves of each channel. There is a separate section in the interface for calibration and using a known weight on each load cell axis, the calibration data can be acquired and stored in the software.

Calculated load values are shown on the interface and those can be tared at any point to adjust zero position. And these loads can be viewed on a graph for better understanding of motion. The angle of the force and the absolute value of the force on xy plane is also calculated and shown on the interface. Three buttons are given to change sample rates between 250, 500 and 1000 SPS. When these buttons are pressed, it will send commands to the microcontroller and it will change

the sampling rate of the ADS1299 chip.

All logged data is saved as a Comma Separated Value (CSV) file and a separate viewer window is given to view and analyze these saved data.

The resultant force (F) was calculated using horizontal force

(x) and vertical force (y) and given by ,

$$F = \sqrt{X^2} + Y^2 \qquad (1)$$

The angle of the resultant force (Θ) is also calculated using horizontal force (x) and vertical force (y) and given by

$$\Theta = tan^{-1} \frac{y/x}{\pi/180^{\circ}} \qquad (2)$$

The angle of the resultant force is displayed in a direction chart.

Data Viewing Interface

The data viewing window of the software application is shown in Figure 2 and it facilitates user to view data in graphical format.

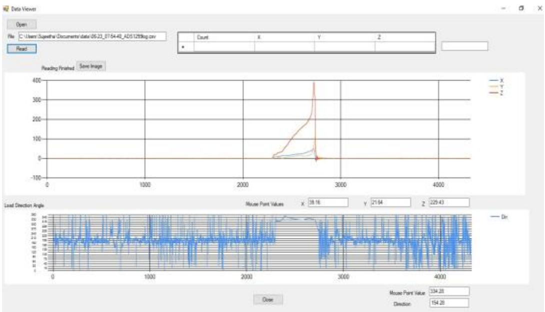


Fig. 2. Data viewing interface includes the loads in horizontal, vertical, lateral directions and load direction angel in y axis and the sample number in x axis

Calculating the instantaneous resultant force at exact point of jump is a semi-automated process. First the maximum force point is found using the saved data. It is done manually by displaying the data graphically. The point with the maximum lateral force is found first and the horizontal and vertical force reading is taken using the mouse point reading option. The data sample number at the same point is considered as the exact point of jump and the direction is taken from the load direction angle graph. The interactive graph can be zoomed in or out depending on the requirements. The graphs can also be saved as images for future references.

Results and Discussion

The system is calibrated for statistic weights using precision weights and calibration curves were observed. The Figure 2 shows the response of the developed system using the data

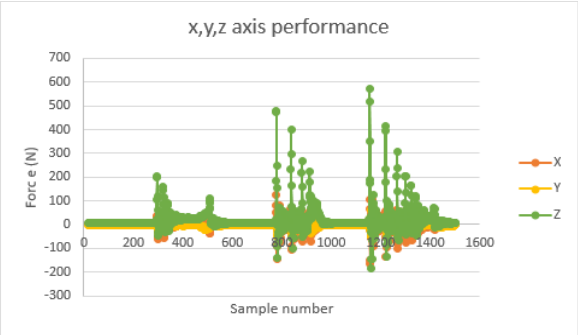


Fig. 3. Performance of x,y,z axis (free fall from height of 100mm), Force (N) in y axis and sample number in y axis

Viewing interface.

The angle of the resultant force is demonstrated by applying a force in different angles and as shown in Figure 4.The predicted angle and the angle calculated by the software was observed and Root Mean Square Error (RMSE) which is a measure of the accuracy of predictions made with a regression line was calculated for the data set as 0.52.However, the actual system is yet to be test with a frog.

Figure 3 shows the quick response observed with the data retrieved using the developed software.

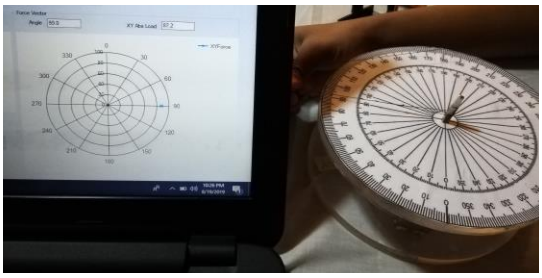
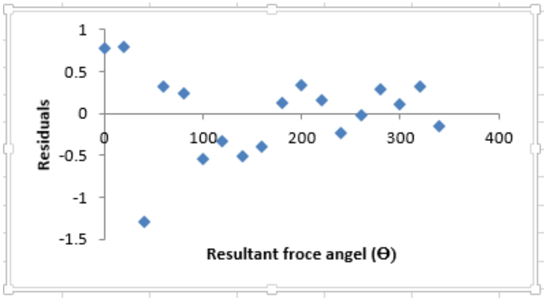


Fig. 4. Direction Chart, Response when applying a force from a known angel

Fig. 5. Resultant force angle, Residual Plot. By



using a data analysis software R Squared was calculated as 0.99 and RMSE was calculated as 0.52

Conclusion

The developed system is capable of recording dynamic ground force response of an object inserted on the platform. The primary objective, collecting data simultaneously in high speed is achieved with a maximum data rate of 980 SPS. The RMSE was found by considering calibration data with data obtained after calibration. The RMSE values for x axis was 1.05, y axis 0.84 and z axis was 1.10.

The developed system can be used to find the direction of the resultant force with RMSE of 0.52. But the system is not tested with real stripped mash frog at this stage. The data with this application will be collected and the possibility of determining the direction of jump will be considered as the next step of the project.

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Author Biographies

Sujeetha Gaspe received the Bache- lor degree in Science and Technology specialized in Mechatroncs from Uva Wellassa University of Sri Lanka in 2013. Then, she completed Masters in Applied Electronics at the University of Colombo in 2019. Currently, she is working at Gen- eral Sir John Kotelawala Defence Univer- sity. Her current research areas includes Intelligent Control Systems, Hyper_ spec-tral Imaging and etc.

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