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A Novel Technique for Early Pregnancy Detection of Dairy Cattle

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Abstract

Detecting pregnancy of cattle at an early stage and timely diagnosis of pregnancy problems with minimal hazard to the animal is very essential for profitable animal husbandry. It helps to manage potential disease issues and optimize estrous synchronization and artificial insemination. To minimize fertility-related issues, it is necessary to provide a complete images of a cow's reproduction status in early stages. The correct identification of fertility status of cows will help to improve the reproductive performance in dairy cattle to enhance the farm profitability. Commonly few methods used for the pregnancy diagnosis in cattle are: Transrectal Ultrasound, Transrectal Palpation, and Blood or Milk testing for progesterone levels or Pregnancy Associated Glycoproteins (PAG). All these techniques can be done only by expert veterinarian and costlier. In this paper, we design a novel non-invasive pregnancy detection method with better accuracy that will be managed by the unskilled person.

Keywords: ELISA (enzyme-linked immunosorbent assay), ECG (Electrocardiogram), K-means, latex agglutination (LA), Principle components, RIA (radioimmunoassay) *Author Guide, Article, Camera-Ready Format, Paper Specifications, Paper Submission.*

1. Introduction

Early detection of pregnancy in breeding cattle and diagnosis is very essential for profitable animal husbandry. Identifying pregnant cattle at an early stage and timely diagnosis of pregnancy problems with minimal hazard to the animal helps manage potential disease issues and optimize estrous synchronization and artificial insemination. Transrectal Palpation takes as 35 days, Transrectal Ultrasound takes 28 days, Progesterone level testing using Blood or Milk testing takes 21 - 24 days and Pregnancy Associated Glycoprotein (PAG) testing takes 30 days post breeding [1,9]. All these techniques can be done only by expert veterinarian and costlier [8]. The main objective of this study is to design a novel non-invasive pregnancy detection method with better accuracy that will be operated by any untrained person.

2. Current Methods

Pregnancy testing for cattle are normally of two types which are non-invasive and invasive. Transrectal ultrasonography of the reproductive tract and Rectal palpation of the reproductive tract are the frequently used methods for pregnancy detection of cattle. These two methods belong to the invasive type. The oldest and most commonly used procedure for pregnancy detection in cattle is the transrectal palpation of the uterus, which is in practice even till now. The palpatory should wear a protective plastic sleeve to cover the arm till the shoulder. The pregnancy detection of cow using palpation takes only few seconds [4]. There are several palpable structures that indicate pregnancy. Due to the gathering of fluids within the pregnant uterine horn, one of the indications of pregnancy is a distinction in size of uterine horns. It is possible to feel the slipping of the fetal layer along with the greater curvature within the uterus. This has the advantage of being accurate and cheap, but training is required for the person. The main disadvantage of this method is this cannot be performed until some other time in gestation. This method takes place between fifty to sixty days after the insemination to extend the exactness of the exam. During the gestation, the monitoring of the heart rate is very important factor.

The parameter from the FECG that is FHR can help the early detection of pregnancy. The major problem in fetal monitoring is that difficult to extract the information from the fetus. Presently, ultrasound technique can be used for monitoring the fetal heart rate. The drawback of this method is its sensitivity to the development which can result in moved and reflected waves stronger than the cardiac signal and also it will be harmful to the fetus and even the cost and time taken for this method is bit higher. Hence the ultrasound is not used for the long-term monitoring of the FHR. This technique is inaccurate also it provides relatively low positive value; it is reliable only when the state of the fetus is clearly good or bad. This method takes between fifty-five and seventy-seven days to identify the pregnancy. Another method to detect the cow pregnancy is with milk progesterone test which is normally a non-invasive method. Progesterone is the hormone known as pregnancy hormone. The Pregnancy related glycoproteins which are created by the placenta and trophoblast and it is a direct indication of pregnancypro. Usually these particles appear in the circulation of pregnant bovines from 15 days after conception [13]. Even though this being a non-invasive technique it has many drawbacks like levels of PAG can occur only after the parturition and also this can result in false positive diagnosis. The early rise and occurrence of levels of PAG in circulation of cows are tested within seven days after experiencing the embryonic loss [2].

An ideal pregnancy detection test for cow should have consider the following features: non-invasive, high accuracy (sensitive and specific), easy and fast to predict the results in real time, safe for cow and the operator, no other effects or harm to the pregnancy and should be very easy for farmers to test it by themself. Keeping all these features and drawbacks of other existing methods we have proposed with a feasible method. Here, we shall be using the ECG signals to predict the pregnancy [3,5,7]. The non-invasive detection of heart beat of the cow may allow for the development of real time and early pregnancy detection [6]. The fetus heart usually develops in twenty to twenty-two days and regular beating can be observed by thirty days in embryogenesis. Depolarization of cardiac muscle tissue results in the generation and spreading of electrical signal from the fetus through the maternal tissue. The obtained raw real time signal from the cow to be processed. Here we will find the peak to peak distance which will yield us the heart beats of the cow [10,12].

3. Methodology

Fig.1 shows that the cow ECG signals will be considered as input which will be fed to a LPF.

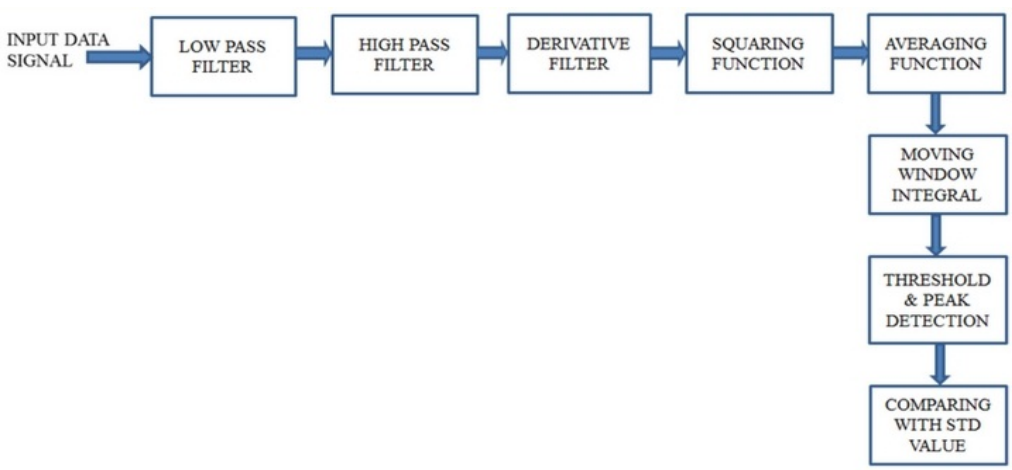

Fig. 1 Proposed Methodology

3.1 LPF

The transfer function of the second-order LPF is given by

$$H(Z) = \frac{(1 - z^{-6})^2}{(1 - z^{-1})^2}.$$

3.2 HPF

The HPF design is based on the subtraction the output of a 1st-order LPF from an all-pass filter. The HPF transfer function is given by

$$H(Z) = z^{-16} - \left[\frac{(1 - z^{-32})}{(1 - z^{-1})}\right] \quad \ldots(1)$$

The combination of the HPF and LPF will help to reduce the false detection which caused by motion of electrode, muscle noise, interference of T wave and power line interference.

3.3 Derivative filter

This helps in finding out the variations in the slope of the signal. It also will help to indicate the peak in the signal. After the filtering process, the signal will be differentiated to indicate the QRS complex slope information [13,14]. 5-point derivative can be used along with the transfer function

$$H(z) = (1/8\ T)\ (-z^{-2} - 2z^{-1} + 2z^{1} + z^{2}) \quad \ldots(2)$$

The amplitude response given below

$$|H(wT)| = (1/4T)\ [\sin(2wT) + 2\sin(cwT)] \quad \ldots(3)$$

The difference equation given below

$$y(nT) = (1/8\ T)\ [-x(nT - 2T) - 2x(nT - T) + 2x(nT + T) + x(nT + 2T)] \quad \ldots(4)$$

3.4 Function for squaring

This is used to obtain the absolute values of the signal to perform the modulus operation. This is used to enhance the signal strength. The equation given below,

$$y(nT) = [x(nt)]^2 \quad \ldots(5)$$

3.5 Function for averaging

The averaging function can be used to find out the mean value.

3.6 Integral of Moving window

This can be performed to find out the features of the waveform along with the slope [11]. This can be calculated

$$y(nT) = (1/N)\ [x(nT - (N - 1)T) + x(nT - (N-2)T) + \ldots + x(nT)] \quad \ldots(6)$$

where N is the number of samples in the integration window width. The moving window summation of earlier N samples of output is considered. This performs the smoothening of the output of the preceding operations along with a moving window integration filter.

3.7 Peak detection and Threshold

The delay created by HPF and LPF to be eliminated before applying the threshold function. The threshold function used to identify the location of the peaks in the QRS signal. The threshold which has been set so that it will automatically adjusts itself. Also floats over the noise while passing through these filters. Heartbeat can be determined with respect to the peak signal.

3.8 Standard value comparison

The cow heartbeat is measured will be compared with the range that is with a pre-defined value which will help in predicting the pregnancy.

4. Results and Discussion

Fig.1 shows the block diagram developed based on the requirement analysis along with the following steps:

Step-1: Taking an ECG signal. i.e., the raw signal of the cow is taken as input.

Step-2: Signal is passed through the designed LPF and the output is recorded as below.

Step-3: Convolute ECG values with the designed LPF

Step-4: Further and HPF is designed and the output is passed through it.

Step-5: Convolute ECG values with the designed HPF

Step-6: Take Mean of the signal after passing it through LPF and HPF.

Step-7: Find out the QRS values using the locations of the signal

Step-8: Apply principle component analysis to find out the principle component.

Step-9: Cluster these principle components using k-means.

Step-10: Calculate the heartbeat using principle component after clustering.

Step-11: Based on the heartbeat obtained we are predicting the pregnancy of the cow.

By utilizing the proposed algorithm test has been conducted with four different signals and in that 2 has been detected as positive and 2 has been detected as negative. The simulations results are presented with Fig.2 to Fig.10.

Data signal

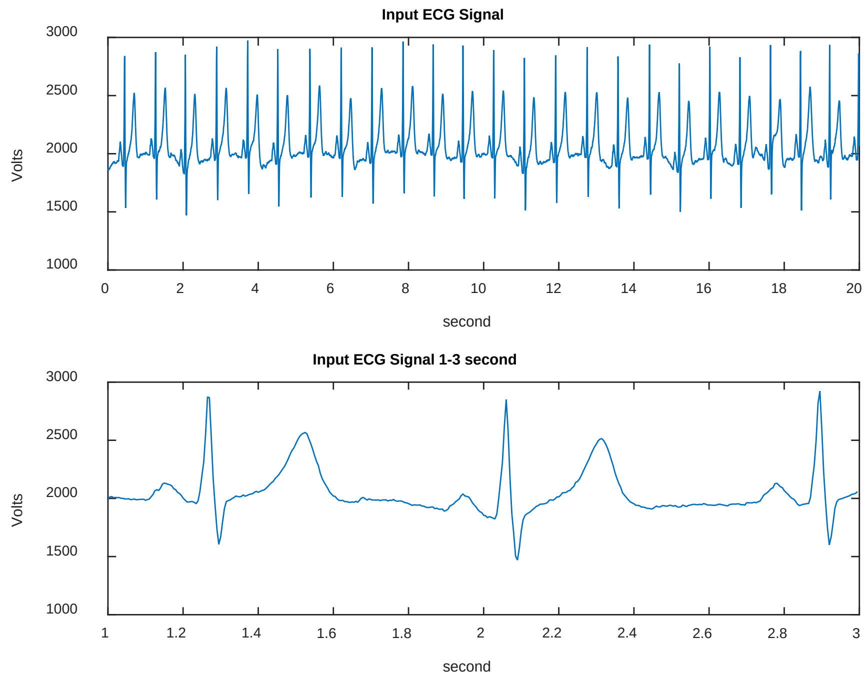

Fig 2: Data signal from ECG

normalization and DC drift cancellation of ECG signal

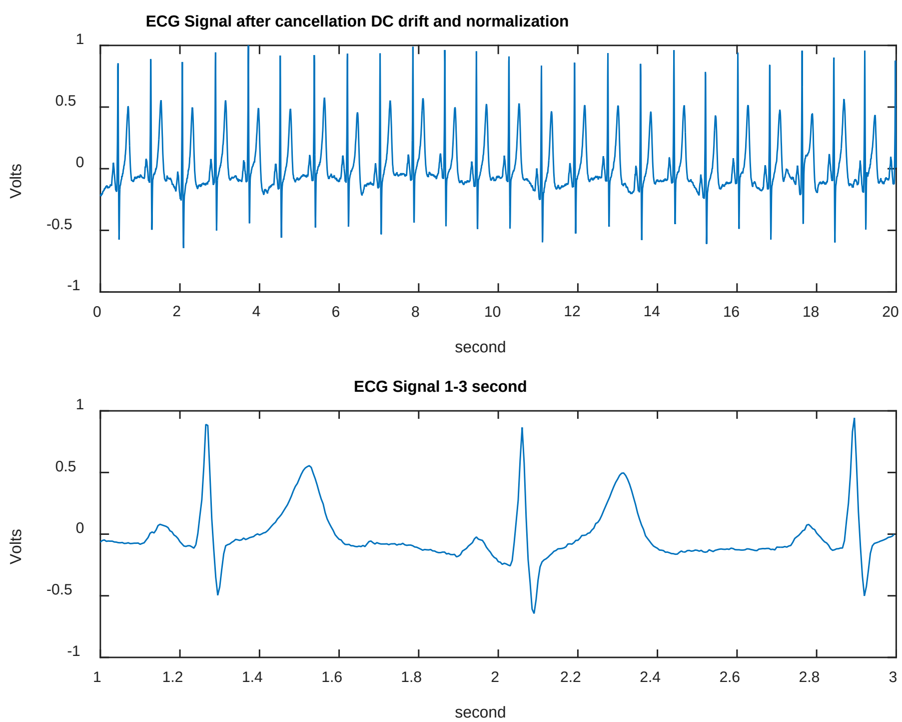

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Fig 3: Drift cancellation

Output of LPF

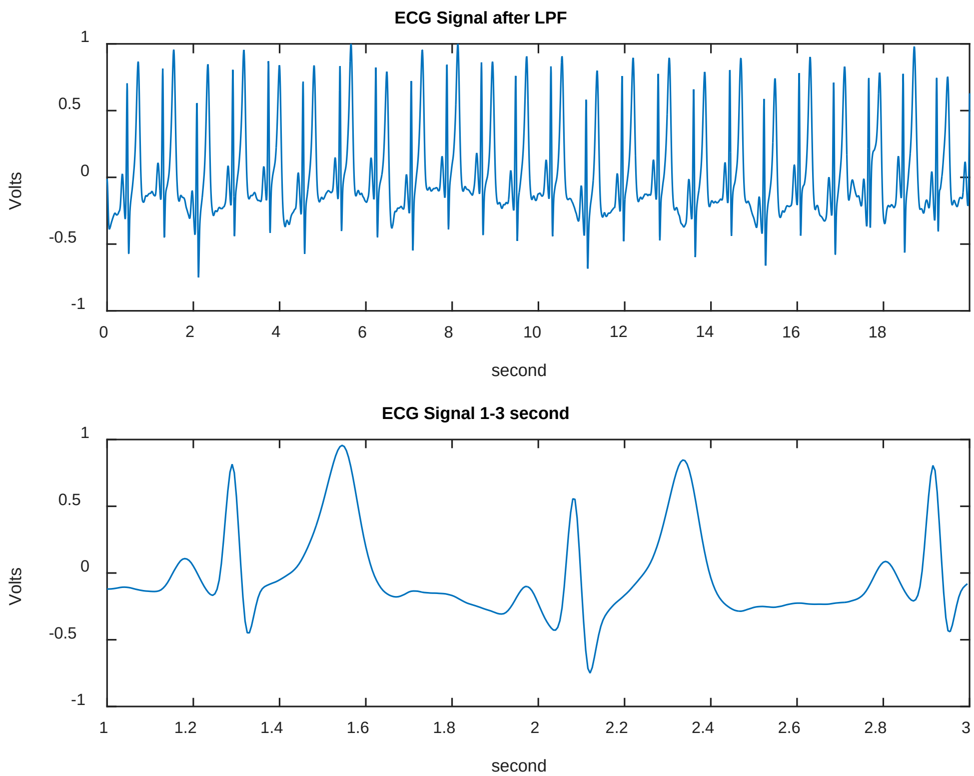

Fig 4: Output of LPF

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Output of HPF

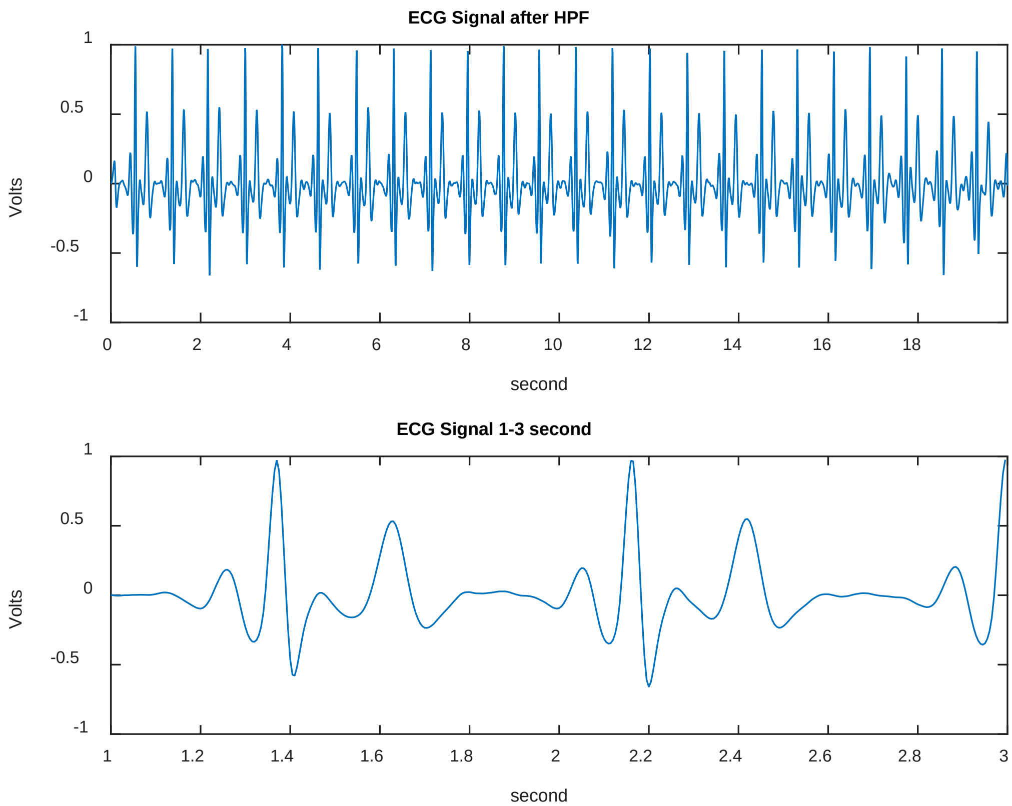

Fig 5: Output of HPF

Derivate filter output

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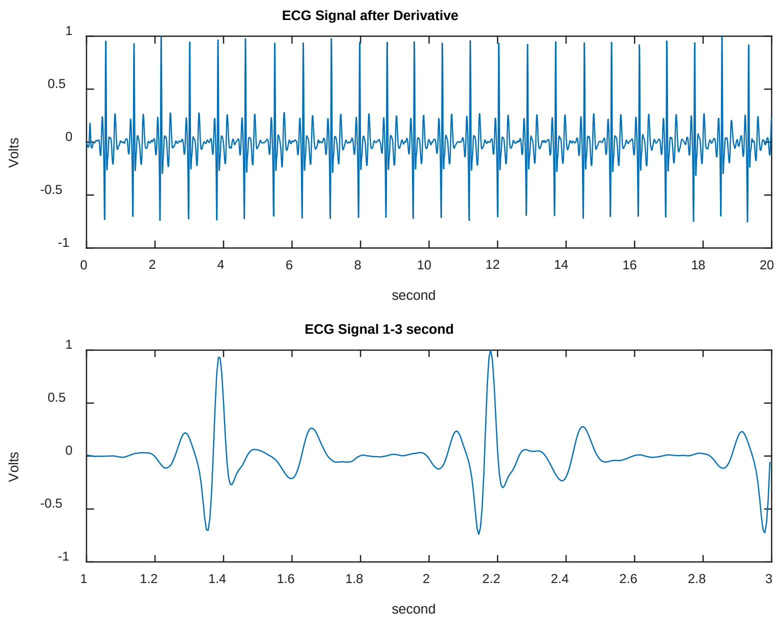

Fig 6: Filter Output

Squaring function

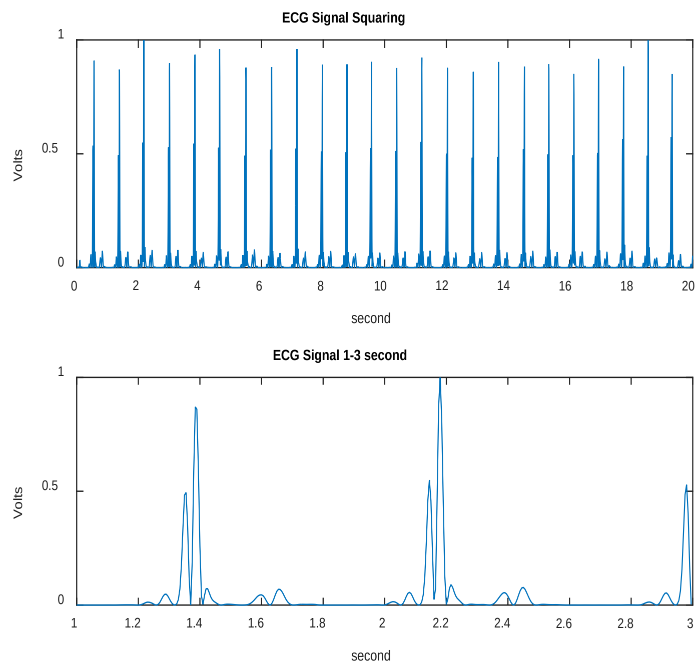

Fig 7: Squaring function signals

Averaging function output

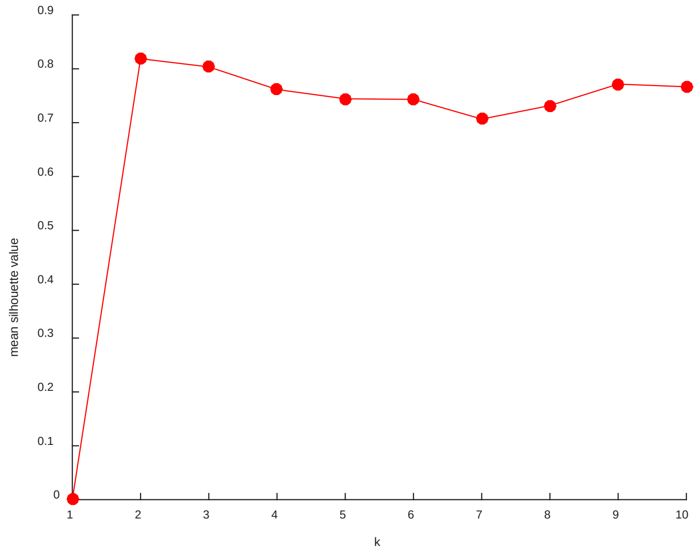

Fig 8: Average function output

Moving window integral

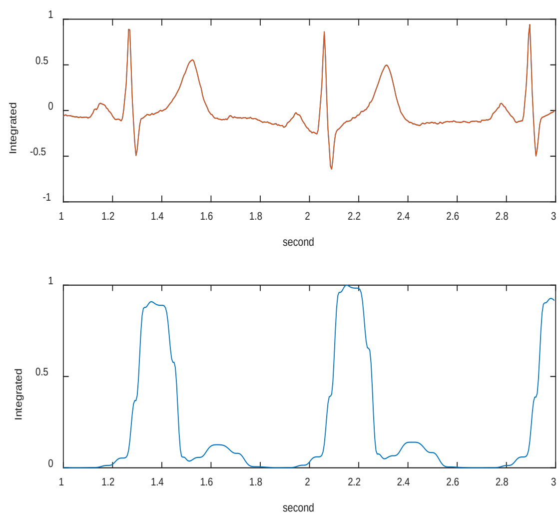

Fig 9: Moving window integral output

Threshold and peak detection

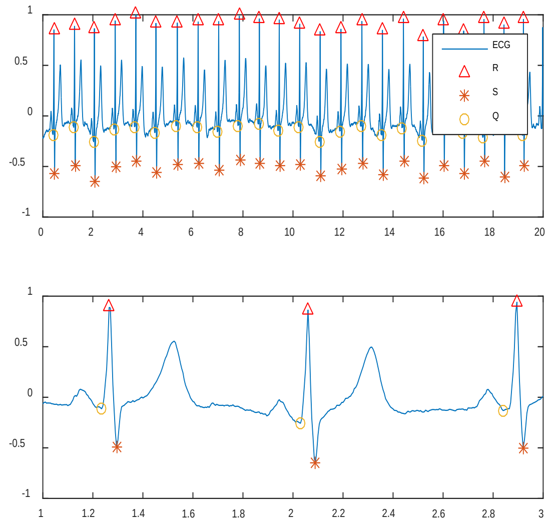

Fig 10: Peak Detection and Threshold

Comparing the standard value and predicting the cow pregnancy.

Here the comparison of the actual heartbeat and with a threshold value that is above one hundred beats per minute then it can be used to predict the cow pregnancy. If the heartbeat is less than one hundred beats per minute then this can be predicted as non pregnant.

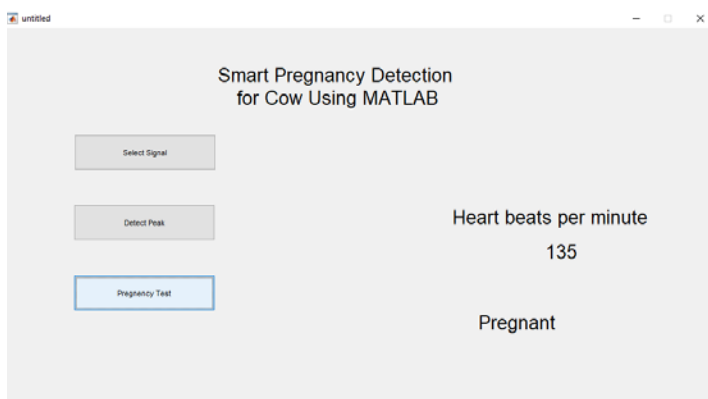

Fig 11: Proposed Output GUI

Following table1 shows the test outcomes:

Table 1: Sample Output

Sl. No.	Heart beats per Minute	Pregnant (P) or Not Pregnant (NP)
Cow A (ECG 1)	135	P
Cow B (ECG 2)	142	P
Cow C (ECG 3)	86	NP
Cow D (ECG 4)	93	NP

5. Conclusion

As the algorithm we designed resulted in low response time, low latency with good accuracy. The results produced for cow pregnancy detection is better and with this method of pregnancy test will be very useful to the Veterinary doctors, its pain free test within 20 days we can identify the cattle pregnancy. This method can be further enhanced with a development of a prototype and used to predict the pregnancy with the device itself.

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