Correction of Non-Linearity of Load Cell using Adaptive Technique with Mathematical Approximation

Ramkrishna Rakshit, Angshuman Majumdar, Rajesh Dey

Abstract*: *Load Cell is used to evaluate unknown objects ' weight. It presents noise at the output due to different inner and external variables. The output deviates from the required response. This project's primary goal is to use Adaptive and Approximation methods to rectify a load cell's output reaction. Approximation is used to generate the reference or training signal at first using Approximation techniques. To generate the training signal, Least Square Approximation (LSA) and Particle Swarm Optimization (PSO) techniques are used and optimized to the desired value. This training signal is later used in an adaptive scheme as a reference signal. Adaptive methods are used to correct the load cell's output reaction. In the adaptive filter, Least Means Square Algorithms are used to remove the noisy load cell output with the adaptive filter. The noise is primarily caused by the creeping and drifting mistake at the output. The Adaptive Filter utilizes the reference signal produced by approximation methods to eliminate both creeping and drifting errors and to produce a load cell's required reaction.

Keywords: LSA, PSO,

I. INTRODUCTION

All the practical systems are non-linear in the actual globe. The real-world environment shifts seamlessly, so the system needed to adapt and react appropriately as well. Because of this, the system reaction introduces nonlinearities. The reaction deviates from the required one because of this non-linearity. The efficiency of the sensor-based scheme is generally influenced by different kindsnonlinearities. Due to parametric differences and internal parameters, the non-linearity happens primarily. It is probable that sensor based systems will deviate from the required reaction. The Load cell will be used as a sensor-based scheme in this job. A load cell is a transducer used to produce an electrical signal that is directly proportional to the power measured[1,2].

II. APPROXIMATION TECHNIQUES:

In particular, among other answers, an approximate answer must be chosen which carefully matches the target answer in a task-specific manner. Non-linear adaptive control's basic issue is to solve the target reaction. In approximation theory, it is to be assumed that the values applied to the target reaction are known for certain easy linear answers.

Revised Manuscript Received on April 01, 2020.

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Then this data is used to build an approximate. There are different methods / techniques for achieving the required target reaction. Two approximation methods are discussed below in this chapter: Least Square Approximation (LSA) and Particle Swarm Optimization(PSO).[11].

A. Least Square Approximation (LSA) Method:

Least Square Approximation also referred to as the Least Squares Method is a technique for estimating the true value of a certain amount based on considering mistakes in observations or measurements[3,4] LSA is a conventional method for approximating the solution from the sets of the unknown equation in regression analysis. "Last squares" implies the general solution minimizes the squares ' amount of the residuals produced in each equation's outcomes. In general, issues with lesser squares can be split primarily into two classifications: lesser squares linear and nonlinear. The issue of linear minimum squares has a closed-form solution and happens in the study of statistical regression[5,6]

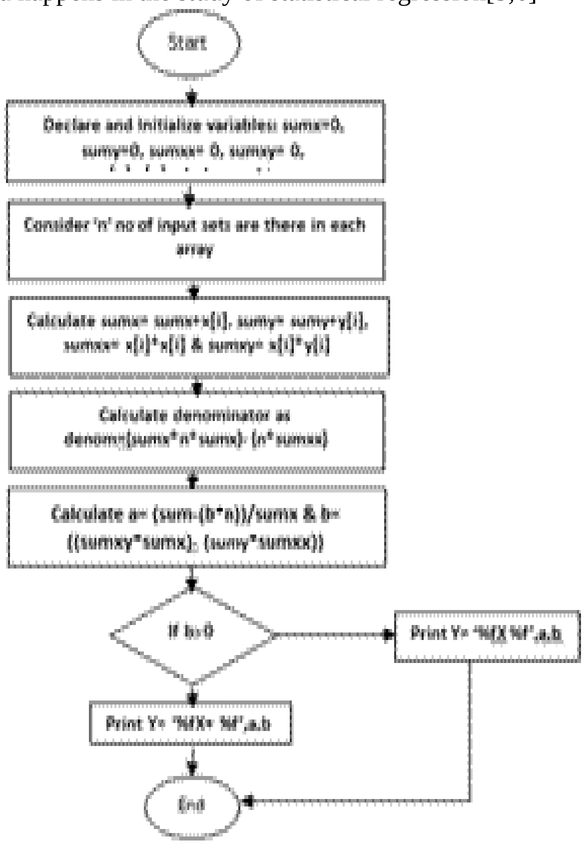


Fig 1.1: Noise optimization technique using LSA method

B. Particle Swarm Optimization:

Particle Swarm Optimization is a method that attempts to enhance the solution iteratively to optimize a issue. By a population notion, the PSO algorithm also operates called a swarm of particles or candidate solutions. These particles are shifted in the search space according to the algorithm. The particles are constantly moving around the search space until it reaches the best-wanted place also known as the best-known place of the swarm. Iterative approach-based PSO methods. The process is repeated and the velocity and position of the particle is updated for each iteration. If the present required outcome is better than the past one, it will set the present one as the best answer and iterate the method again. It is repeated until the required outcome has been achieved.

The Algorithm of the procedure is as follows:

Step 1: START

Step 2: Initialize the particle parameters for each matrix

Step 3: Calculate the highest fitness or particle value for each particle.

Step 3.1: Set present fitness value= best particle fitness value if the present fitness value > prior fitness value.

Step 4: END

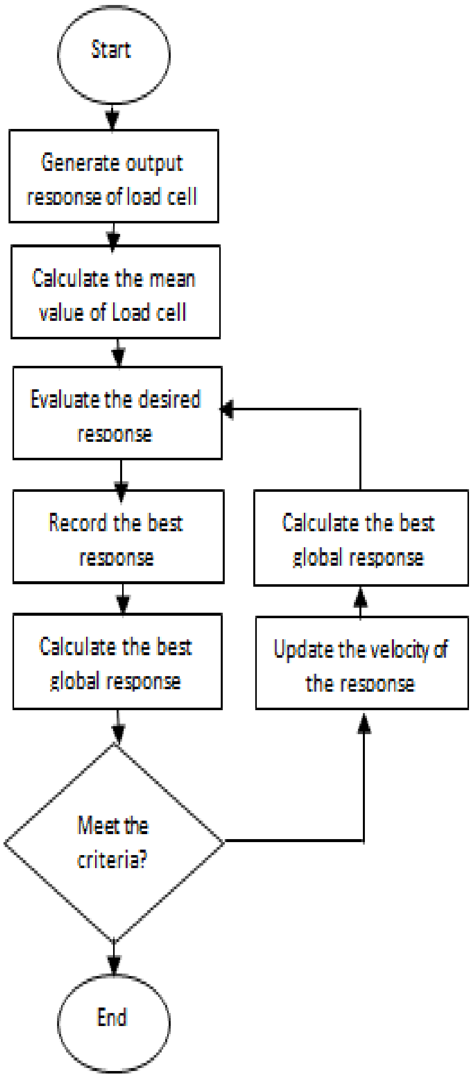


Fig 1.2: Flow diagram of the PSO method

III. ADAPTIVE TECHNIQUE WITH LEAST SQUARE APPROXIMATION (LSA):

The reference signal i.e. training signal is produced using the method of Least Square Approximation (LSA) in the block diagram below. Using the Least Mean Square (LMS) algorithm, the training signal is then introduced to the adaptive filter. The noisy Load Cell sampled output is adjusted by the training signal and the Adaptive LMS Algorithm[7,8]

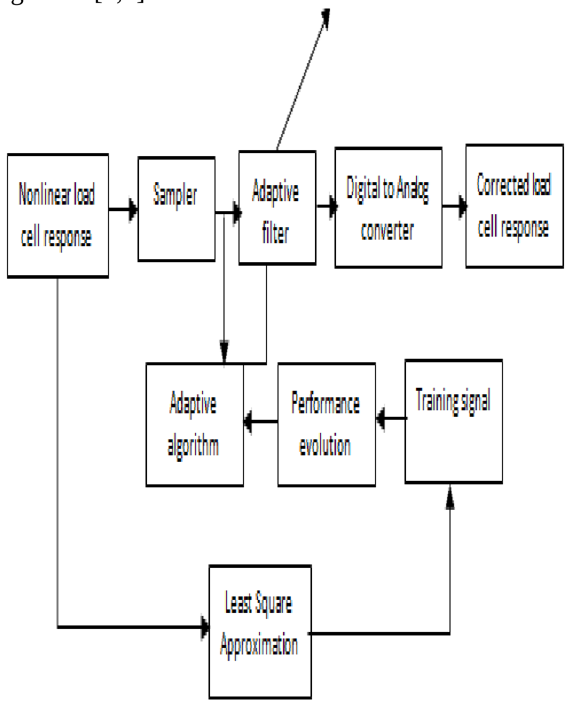


Fig 1.3: Block diagram of Adaptive algorithm using Mathematical Approximation

A. Resultant Waveform:

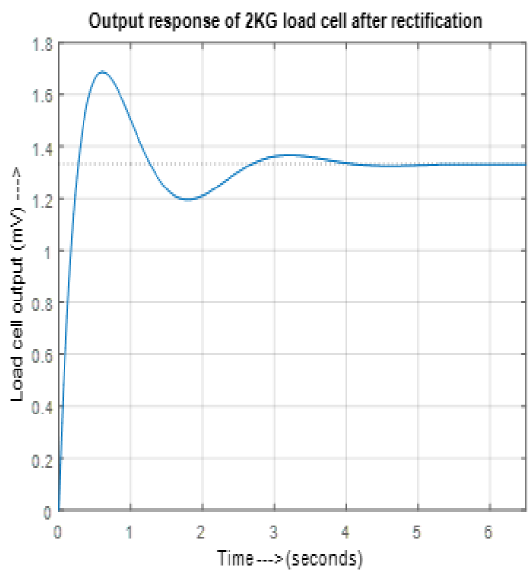
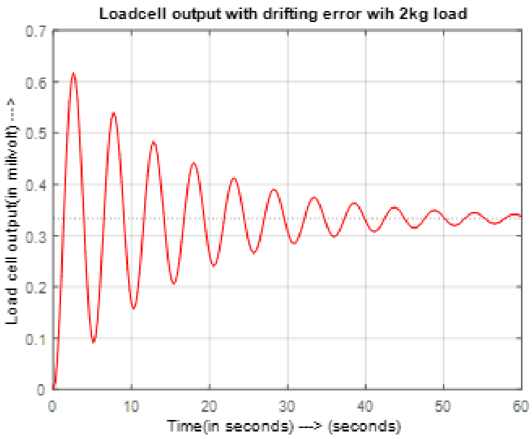


FIG 1.4: Load Cell Response with drifting



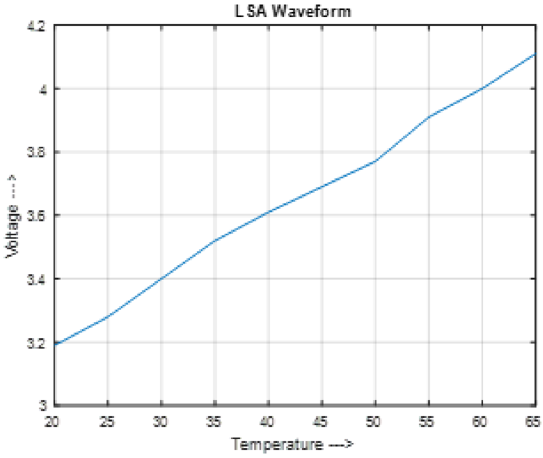


Fig 1.5: Load cell Training signal

IV. COMPARATIVE DISCUSSION BETWEEN LEAST SQUARE APPROXIMATION AND PARTICLE SWARM OPTIMIZATION:

The reference signal also recognized as the training signal is generated by both LSA and PSO. In the adaptive system, this training signal is used to rectify the output of a 2KG load cell. According to the consequence, it can be obviously noted that the production of the load cell becomes constant after 4s in the event of the training signal produced by the LSA method. On the other side, the output of the load cell becomes constant a few seconds later when the PSO method is used to produce a training signal.

According to this observation, in this experiment on the 2KG load cell, the following points can be regarded: • Least Square Approximation effectiveness is better than Particle Swarm Optimization. The number of working data sets here in this work is small in quantity, so the LSA technique performs better to generate training signal and the output response of the load cell reaches a steady state faster than the PSO technique.

• However, this does not imply that PSO effectiveness is much lower. When there is a big amount of information collection, PSO works quite well. But for studies that have a smaller amount of data sets LSA performs better.

V. CONCLUSION AND FUTURE SCOPE

In conclusion, Mathematical Approximation Techniques (LSA & PSO) are used to produce the required reference signal and an Adaptive Technique (LSA) is used to minimize the nonlinearity of the load cell reaction using the reference signal. The results of the simulation are satisfactory. It has been shown here that efficient reaction compensation of the sensor output can be performed using the adaptive blocks. It was shown in the load cell with creep and drifts mistake. It is also possible to implement this method on other sensors. It was shown how the digital adaptive method can compensate for non-linearity in the sensor. Simulation and experimental outcomes have demonstrated the feasibility of the suggested method. Future study subjects on theoretical and experimental innovations of high-performance digital adaptive methods for non-linearity control and methods of approximation include:

Nowadays, a big set of information or Big Data is used for sensors. Big information technology has a wonderful future, so it would be best to apply the PSO as a mathematical approximation method when there are enormous quantities of information. One signal conditioning scheme may be intended to minimize a specific nonlinearity that may reinforce another form of nonlinearity. Assume that the case of a load cell signal conditioning system is intended to overcome only parametric nonlinearity, but other forms of nonlinearity are either enhanced or not minimized. There is therefore scope for further studies to be developed in the future.

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