FPGA Implementation of Improved Modified Low Complex Curve Fitting Algorithm, With Appreciable Goodness of Fit

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Abstract

A curve fitting technique has been developed which is destined to automatically provide a fit to any ordered digital data in plane. . A simpler set of rational cubic functions is the basis of this technique. This class of functions involves two controls parameters, which help to generate best possible curve fit. The curve technique has used a variety of ideas for curve design. In one of these ideas, our approach is detection of characteristic points, and parameterization. The final shape is achieved by In this paper, we solved the problem by finding the best possible parameter of quadratic curve and utilize the error minimization between an input curve and a fitting curve by using the tuned approach of low complex curve fitting algorithm .The paper gives sine curve fitting . Simulation result shows that the method has good and stable performance Through VHDL, modelsim simulation, confirms the proposed method based on curve fitting is effective and reliable. From the experiment, the Goodness of fit of the proposed algorithm was 0.06561.

Key word- control parameter, CFA, VHDL, modelsim.

I. INTRODUCTION

The aim of this paper is to return to the curve fitting problem using the consistency of deduction as a primary criterion for the 'fittest' curve. Viewed from this perspective, it is argued that a fundamental concern with the current framework for addressing the curve fitting problem is, on the one hand, the unnecessary influence of the mathematical approximation perspective, and on the other, the insufficient attention paid to the statistical modeling aspects of the problem. Using goodness-of-fit as the primary criterion for 'best', the mathematical approximation perspective undermines. So the goal of this study and work is to implement a system in VHDL module for drawing out frequency of signal. The CFA is processed for measuring the frequency and short out the variation of a demanding signal of required function. This algorithm estimate a frequency which is widely used to examine closely because of their transervarsal presentation .Different fracas detection algorithms are based on fundamental frequency of a signal[1].The CFA permits a small number of samples of a signal comparison then other like CFA with , other fitting algorithm. Due to few samples it takes less computational time with a usual accurateness through the inspection of practical data, the precision of this algorithm is higher[1, 2,19]. CFA allowed extract the quality parameter of signal like harmonic for phase of a fixed length (0, T) window. It is evident the overall system accuracy is link to fundamental frequency evaluation of window(0,T) ,another block are in system use that information to process the sample to evaluate quality parameter [1,2,3,14,17].The study and realization of this type of algorithm is basically implemented with FPGA. The superior programmable circuit with enhance quality and higher integration density, is made better choice of implementation on FPGA. Development of custom design, in different level, with the headwear description language like very high speed integrated circuit language (VHDL), Verilog [4, 20, 21]. FPGA programming was done in VHDL code .to generate VHDL code use the System Generator block set of Xilinx ISE 13.1 environment and simulation result by the modelsim simulator .

II. OVERVIEW OF CURVE FITTING

It is the method of finding equation of a curve from raw data and a function with unknown coefficients. We want to find values for the coefficients such that the function matches the raw data as well as possible. On the basis of this mathematical equation, prediction can be made in many statistical investigations[5]. The simplest case is fitting to a straight line: y= ax+b suppose a theoretical reason to believe that our data should fall on a straight line. We want to find the coefficients a and b that best match our data .For a straight line or polynomial function, we can find the best-fit coefficients in one step. This is noniterative curve fitting, which uses the singular value decomposition algorithm for polynomial fits. [5]Curve fitting capability is one of its strongest analysis features. Here are some of the highlights.

- Linear and nonlinear curve fitting.
- Fit by ordinary least squares, or by least orthogonal distance used for errors-in-variables models.
- Fit to inherent models.
- Built-in functions for ordinary fits.
- Automatic initial guesses for built-in functions.
- Fitting to user-defined functions of any complexity.
- Fitting to functions of any number of independent variables, either gridded data.
- Fitting to a sum of fit functions.
- Fitting to a subset of a waveform or XY pair.

- Produces estimates of error.
- Supports weighting.

The inspiration of curve fitting is to find a mathematical model that fits a data set .assume that has theoretical reasons for preference a function of a certain form. The curve fit finds the specific coefficients which make that function match standard data as closely as possible. Curve fitting is a method to find which of thousands of functions fit a data set. It can also use curve fitting to simply show a smooth curve through their data.

This is fit to three kinds of functions: Built-in functions, User-defined functions, and External functions. The built-in fitting functions are line, polynomial, sine, exponential, double-exponential, Gaussian, Lorentzian,Hill equation, sigmoid, lognormal, two-dimensional Gaussian peak and two dimensional polynomial. A user-defined function by entering the function in the new fit function dialog. Very complicated functions may have to be entered in the procedure window. External functions are written in C or C++. To create an external function need t a C/C++ compiler.

III. IMPROVED MODIFIED CUVE FITTING ALGORITEM

The basic algorithm (CFA) is method to get fundamental frequency of a particular signal. It's developed from Lest Squares method and is tuned to lock and extract the fundamental signal frequency. This algorithm finds the difference between ideal signal sample and the input signal sample of a given frequency. Define an error function by which is sum of the square of the difference of many samples. The fundamental frequency is found minimize the error function.

As mention in [2, 12, 15] basic CFA algorithm allows find out the difference between $\Delta\omega$ from the ideal signal frequency, following equation:

$$a_3(\Delta\omega)^3 + a_2(\Delta\omega)^2 + a_1(\Delta\omega) + a_0$$

Where we put the values,

$$Num = (\int_0^T m(t)\cos\omega t dt)^2 - (\int_0^T m(t)\sin\omega t dt)^2$$

$$Den = (\int_0^T m(t)t\cos\omega t dt)\times(\int_0^T m(t)\sin\omega t dt) - (\int_0^T m(t)t\sin\omega t dt)\times\int_0^T m(t)\cos\omega t dt)$$

The values of "a" (coefficient's) using Taylor series stopped at the second power are:

$$a_0 = 2\omega Den - Num$$

$$a_1 = 2\omega\frac{\partial Den}{\partial\omega} + 2Den - \frac{\partial Num}{\partial\omega}$$

$$a_2 = \omega\frac{\partial^2 Den}{\partial\omega^2} + 2\frac{\partial Den}{\partial\omega} - \frac{1}{2}\frac{\partial^2 Den}{\partial\omega^2}$$

$$a_3 = \frac{\partial^2 Den}{\partial\omega^2}$$

Find $\Delta\omega$ we solve a third order equation, and used Girolamo Cadiano method in different case determined by the discriminator (Δ) sign [5,9,10].The discriminator is defined as:

$$\Delta = \left(\frac{p}{2}\right)^2 + \left(\frac{q}{2}\right)^2$$

Where

$$p = \frac{3b - a^2}{3}$$

$$q = \frac{2a^3 - 9ab + 27c}{27}$$

Case I: for ($\Delta < 0$) we solve: We get three real roots. Where real part are magnitude and phase of the complex number.

$$x_1 = 2r^{\left(\frac{1}{3}\right)}\cos\left(\frac{\phi}{3}\right) - \frac{a}{3}$$

$$x_2 = 2r^{\left(\frac{1}{3}\right)}\cos\left(\frac{\phi + 4\pi}{3}\right) - \frac{a}{3}$$

$$x_3 = 2r^{\left(\frac{1}{3}\right)}\cos\left(\frac{\phi + 2\pi}{3}\right) - \frac{a}{3}$$

$$R = -\frac{q}{2} + \sqrt{(-\Delta)i}$$

While case II for ($\Delta \geq 0$)

$$x_1 = \sqrt[3]{-\frac{q}{2} + \sqrt{\Delta}} - \sqrt[3]{\frac{q}{2} + \sqrt{\Delta}} - \frac{a}{3}$$

$$x_2 = -\frac{1}{2}\left(\sqrt[3]{-\frac{q}{2} + \sqrt{\Delta}} - \sqrt[3]{\frac{q}{2} + \sqrt{\Delta}}\right) + \left(\sqrt[3]{-\frac{q}{2} + \sqrt{\Delta}} + \sqrt[3]{\frac{q}{2} + \sqrt{\Delta}}\right)i - \frac{a}{3}$$

$$x_3 = -\frac{1}{2}\left(\sqrt[3]{-\frac{q}{2} + \sqrt{\Delta}} - \sqrt[3]{\frac{q}{2} + \sqrt{\Delta}}\right) - \left(\sqrt[3]{-\frac{q}{2} + \sqrt{\Delta}} + \sqrt[3]{\frac{q}{2} + \sqrt{\Delta}}\right)i - \frac{a}{3}$$

We improved the CFA algorithm and suppose that $\Delta\omega$ is reasonably less in magnitude so we get as possible the solution smallest magnitude, so obtain the solution with the smallest magnitude. Compared with the other method for frequency evaluation (as seen in algorithm [1]).modified CFA algorithm gives a reliable goodness of fit with smaller evaluation times we see in the next table:

TABLE I. GOODNESS OF FIT.

	Modified CFA			
	*F(x)=a*x* *where a = 7.135X10^{-9} (7.036X10^{-9} , 7.235X10^{-9})*			
Goodness of fit	SSE	0.04305	RMSE	0.06561

Table 1.1 measured goodness of fit

TABLE II MEASURED FREQUANCY AND COFFEICENT

F	Δω	$f_{measured}$	a0	a1	a2	a3
45.10	-31.3531	47.8392 + 0.000i	-6.9258×10^{8}	-3.8812×10^{7}	9.3231×10^{5}	2.3010×10^{3}
46.10	-24.5044	48.1019 +0.000i	-5.5208×10^{8}	-3.6250×10^{7}	8.6909×10^{5}	2.0779×10^{3}
47.10	-18.2212	48.3900 +0.000i	-4.1603×10^{8}	-3.3376×10^{7}	7.9290×10^{5}	1.8269×10^{3}
48.10	-11.9381	48.7647 +0.000i	-2.7497×10^{8}	-3.0092×10^{7}	7.0175×10^{5}	1.5398×10^{3}
49.10	-5.6541	49.2857 +0.000i	-1.3079×10^{8}	-2.6495×10^{7}	5.9855×10^{5}	1.2258×10^{3}
50.10	0.6283	50.1034 +0.000i	1.4529×10^{8}	-2.2689×10^{7}	4.8658×10^{5}	894.7
51.10	6.955	51.7191 +0.000i	1.5903×10^{8}	-1.8783×10^{7}	3.6938×10^{5}	557.266
52.10	13.1947	54.5749 +2.8318i	3.0081×10^{8}	-1.4884×10^{7}	2.5061×10^{5}	223.9136
53.10	19.4779	56.8148 - 6.4722i	4.3808×10^{8}	-1.1095×10^{7}	1.3389×10^{5}	-95.1175
54.10	25.7611	48.8899- 22.6307i	5.920×10^{8}	-7.5121×10^{7}	2.2670×10^{5}	-390.38
55.10	32.0442	35.4467 - 15.2440i	6.9276×10^{8}	-4.2201×10^{7}	-719917×10^{5}	-653.56

Table 1.2 Resultant values of coefficients (a_0, a1, a2, a3) and delta omega(Δω), frequency measured at actual frequency range 45Hz to 55Hz.

IV. ALGORITHM

Step 1: Input the data points or signals.

Step 2: Subdivide the data, in Step 1, by computing the characteristic points using the CFA in section (iii)

Step 3: Compute the derivative values at the characteristic points.

Step 4: Fit the curve by modified method, of Section (iii), to the Characteristic points achieved in Step 2.

Step 5: If the curve, achieved in Step 4, is best possible then GO To Step 6, ELSE enhance the list of characteristic points by incorporating the intermediate points located in Step 4 and GO TO Step 3.

Step 6: STOP.

The above mentioned scheme and the algorithm have been implemented and tested for various data sets. Logically quite elegant results have been observed; see the following section for demonstration

V. DEMONSTRATION

The algorithm has been implemented for the data obtained from improved modified curve fitting algorithm and fitting , see Figure1 (a) and 1(b).

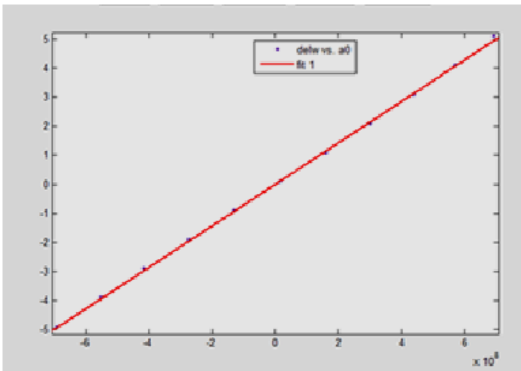

Figure1(a) plot between delta omega and coefficient a_0

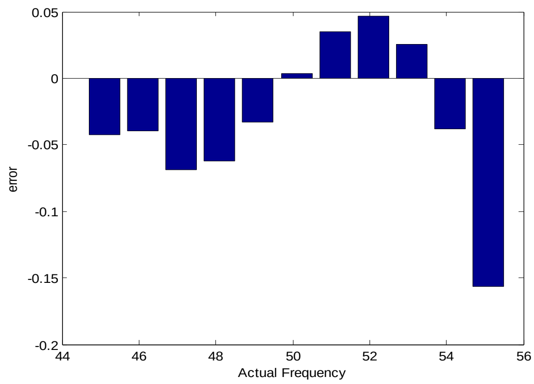

Figure1 (b) plot between error and actual frequency

VI. THE CFA IMPLEMENTATION ON FPGA

The FPGA programming stage has been implemented following the system shown in figure after development of the block diagram in Simulink and the fixed-point tuning, HDL Coder has been used to generate VHDL code of all the subsystems This course of action provides flexibility in the choice of FPGA platform to be used (Xilinx13.1). In addition, the VHDL code is the basis for future development of the mechanism on ASIC technology .In this work the algorithm has been implemented on Xilinx architecture using the software ISE to map all components and manage the I / O of the system.

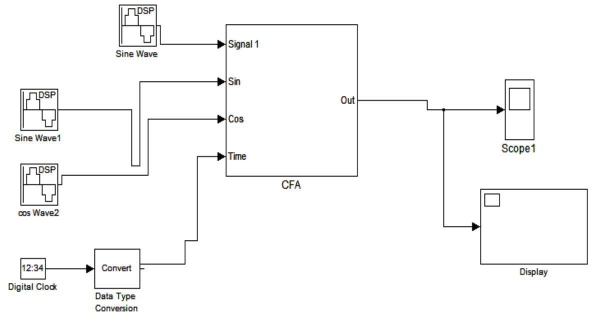

Figure 2(a) basic block diagram of algorithem devlopment

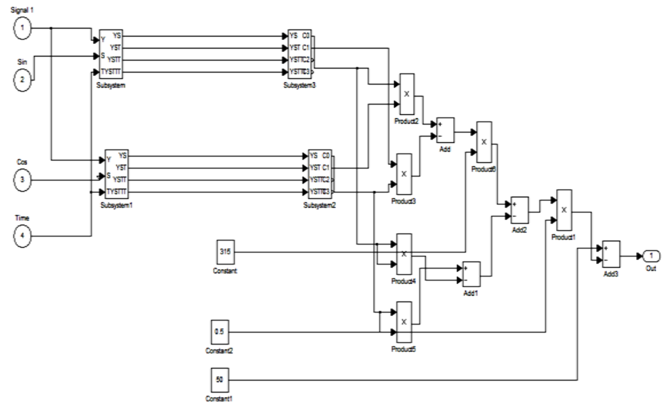

Figure 2(b) subsystem of cfa block .

VII. SIMULATION RESULT

The ModelSim opens and compiles the source files. It simulates and a wave window opens to display the simulation results as shown in figure 3.

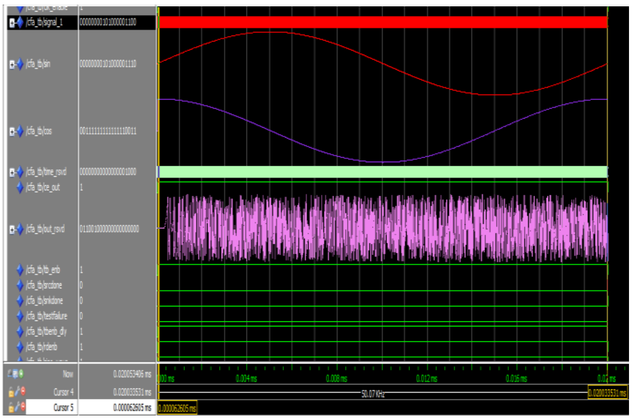

Figure 3. Output waveform of CFA on modelsim simulator

VIII. CONCLUTION

In this paper the dynamic programming algorithm is applied to appreciable goodness of fit. A simple approach is proposed to implement CFA on FPGA with low computational complexity. The curve-fitting method is generalized to approximate sine curves and fast algorithm is also provided. Our algorithm has been tested on a number of segment and satisfactory results have been obtained.

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