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CURVE REPRESENTATION OF DSE GENERAL INDEX WITH THE HELP OF WAVELET FUNCTIONS

By

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Abstract

In this study we collected the monthly raw data form DSE (Dhaka Stock Exchange) and we analyzed the data based on curve fitting. We represented this curve in wavelet form, especially in the form of Haar wavelet representation.

সংক্ষিপ্তসার

উক্ত অনুসন্ধানে আমরা DSE (ঢাকা স্টক্ এক্সচেঞ্জ) থেকে মাসিক অপরিমার্জিত রাশিতথ্য সংগ্রহ করেছি এবং রেখা মেলানোর (curve fitting) উপর ভিত্তি করে রাশিতথ্যকে বিশ্লেষণ করেছি। উক্ত বক্ররেখাকে ক্ষুদ্র তরঙ্গ (wavelet) আকারে, বিশেষতঃ হারের (Haar) ক্ষুদ্র তরঙ্গ আকারে প্রকাশ করা হয়েছে।

1. Introduction

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or functions. Wavelet transform of a function is the improved version of Fourier transform which is a powerful tool for analyzing the components of a stationary signal. The first connection of modern wavelets was made by Jean Baptiste Joseph Fourier in the nineteenth century. The next known link to wavelets came from Alfred Haar in the year 1909. After Haar's contribution to wavelets there was a big gap of time in research in this field until Paul Levy formulated some advance functions in the field of wavelets from 1930 to 1970. The next major advancement came from Jean Morlet around the year 1975. Morlet had made quite an impact in the field of wavelets; however, he wasn't satisfied with his efforts by any means. In 1981, Morlet teamed with man named Alex Grossman and they worked on an idea that Morlet discovered while experimenting on a basic calculator. The next two important contributors to the field of wavelets were Yves Meyer and Stephane Mallat, who applied the concept of wavelets in different applied problems. They introduced Multiresolution Analysis (MRA) for wavelets. The last wavelet researcher in our knowledge is Ingrid Daubechies who made a great contribution in the wavelet theory.

The Fourier transform is also a powerful tool for processing signals that are composed of some combination of sine and cosine signals Mallat (1999). Wells (1993) and Strang (1989) have shown that wavelets also allow filters to be constructed for stationary and non-stationary signals. However, wavelets have been applied in many other areas including non-linear regression and compression. An offshoot of wavelet compression allows the amount of determinism in a time series to be estimated Walnut (2001), Wojtaszczyk (1997). Charles (1991), Christensen (2004), Daubechies (1992), Addition, Paul S. (2002), Debnath (2002), Meyer (1993) extensively worked on wavelets.

In this paper, we have discussed about different wavelets, their properties and advantages. But with wavelet analysis, we can use approximating functions that are contained neatly in finite domains. Also, we collected the monthly raw data form DSE (Dhaka Stock Exchange) and we analyzed the data based on curve fitting and then represent the curves in wavelet form, especially in the Haar wavelet representation.

2. Materials and Methods

Wavelets: Wavelets are functions that are confined in finite domains and are used to represent data or a function. In an analogous way to Fourier analysis, which analyzes the frequency content in a function using sines and cosines, wavelet analysis analyzes the scale of a function's content with special basis functions called wavelets. For details we refer Debnath, L. (2002). Equivalent mathematical conditions for wavelet are:

$$(i)\ \int_{-\infty}^{\infty}|\psi(x)|^2 dx<\infty, \quad (ii)\ \int_{-\infty}^{\infty}|\psi(x)|dx=0, \quad (iii)\ \int_{-\infty}^{\infty}\frac{|\hat{\psi}(\omega)|^2}{|\omega|}d\omega<\infty$$

where $\hat{\psi}(\omega)$ is the Fourier Transform of $\psi(x)$, (iii) is called the admissibility condition.

Wavelet Transform: Wavelet transform analysis uses a little wave like functions known as wavelets. Wavelets are used to transform the signal under investigation into another representation, which presents the signal information in a more useful form. This transformation of signal is known as the wavelet transform. Mathematically speaking, the wavelet transform is a convolution of the wavelet function with the signals. Jean Morlet in 1982, first considered wavelets as a family of functions constructed from translations and dilations of a single function called the "mother wavelet", ψ(x). For details we refer to Debnath (2002) & Eugenio Hernandez & Guido Weiss (1996). They are defined by

$$\psi_{j,k}(x)=\frac{1}{\sqrt{|j|}}\psi\left(\frac{x-k}{j}\right) \qquad \text{j,k} \in \text{R},\ j\neq 0$$

Here j and k represent the scaling parameter which measures the degree of compression and the translation parameter which determines the time location of the wavelet respectively.The wavelet transform of f *can* be defined as

$$W_\psi f(j,k)=\frac{1}{\sqrt{|j|}}\int_{-\infty}^{\infty}\overline{\psi(\frac{x-k}{j})}f(x)\,dx$$

where $\overline{\psi(\frac{x-k}{j})}$ is the complex conjugate of $\psi(\frac{x-k}{j})$.There are many kinds of wavelet transforms such as continuous, discrete, fast, complex transforms as well as wavelet packet transforms.

Wavelet Series & Wavelet Coefficients: Now a day's wavelet representation of a function is very popular. Because Fourier transformation loss time information but wavelet representation does not loss time information. In the following way we can represent a function in wavelet series. The series $\sum_{j\in Z}\sum_{k\in Z}\langle f,\psi_{j,k}\rangle\psi_{j,k}(x)$ is called the wavelet series of f if the function $f\in L_2(R)$, and then $\langle f,\psi_{j,k}\rangle = d_{j,k} = \int_{-\infty}^{\infty} f(x)\ \psi_{j,k}(x)dx$ are called the wavelet coefficients of f.

Continuous Wavelet Transform: The continuous wavelet transform of $f\in L_2(R)$ can be defined as $T_\psi f(j,k)=|j|^{-\frac{1}{2}}\int_{-\infty}^{\infty} f(x)\bar{\psi}\left(\frac{x-k}{j}\right)dx=\langle f,\psi_{j,k}\rangle$, where $\bar{\psi}_{j,k}(x)$ is the complex conjugate of $\psi_{j,k}(x)$, $\psi_{j,k}(x)=|j|^{-\frac{1}{2}}\psi\left(\frac{x-k}{j}\right)$ is translated by k and dilated by j of ψ and $T_\psi f(j,k)$ is called the wavelet transform of $f(x)$ in $L_2(R)$.

Haar Function: A function defined on the real line R as

$$\psi(x)=\begin{cases}1 & for \quad x\in[0,1/2)\\ -1 & for \quad x\in[1/2,1)\\ 0 & otherwise\end{cases}$$

is known as the Haar function. The Haar function $\psi(x)$ is the simplest example of a wavelet. The Haar function $\psi(x)$ is a wavelet because it satisfies all the conditions of wavelet. Haar function is discontinuous at $x=0,\frac{1}{2},1$ and it is very well localized in the time domain. Haar function is known as Haar wavelet.

Haar Wavelet Representation of functions:

Haar Scaling Function: The Haar scaling function can be defined as

$$\varphi(x)=\chi_{[0,1)}(x)=\begin{cases}1 & if\ 0\le x<1\\ 0 & otherwise.\end{cases}$$

Haar Wavelet Function: Haar wavelet function $\psi(x)$ in terms of scaling function can be written as

$$\psi(x)=\chi_{[0,1/2)}(x)-\chi_{[1/2,1)}(x)=\begin{cases}1, & if \quad 0\le x\le 1/2\\ -1, & if \quad \frac{1}{2}\le x<1\\ 0, & otherwise.\end{cases}$$

Haar Wavelet Series and Wavelet Coefficients: Let f be defined on [0, 1], then it has an expansion in terms of Haar functions as follows. For any integer $j_0\ge 0$,

$$f(x)=\sum_{k=0}^{2^{j_0}-1}\langle f,\varphi_{j_0,k}\rangle\varphi_{j_0,k}(x)+\sum_{j=j_0}^{\infty}\sum_{k=0}^{2^j-1}\langle f,\psi_{j,k}\rangle\psi_{j,k}(x)=\sum_{k=0}^{2^{j_0}-1}c_{j_0,K}\ \varphi_{j_0,k}(x)+\sum_{j=j_0}^{\infty}\sum_{k=0}^{2^j-1}d_{j,k}\ \psi_{j,k}(x)$$

The series is known as the Haar wavelet series for the given function f. $d_{j,k}$ and $c_{j_0,k}$ are known as the Haar wavelet co-efficient and the Haar scaling co-efficient, respectively and are given by

$$d_{j,k}=\int_{-\infty}^{\infty} f(x)\ \psi_{j,k}(x)\ dx \text{ and } c_{j_0,k}=\int_{-\infty}^{\infty} f(x)\ \varphi_{j_0,k}\ dx$$

Share market general index: Index consists of group of shares. Index denotes the direction of the entire market. Like when people say market is going up or down then that means Index is going up or down. Index consists of high market capitalization and high liquidity shares. High Market capitalization shares - Companies having highest number of shares and highest price of each share. Market capitalization is calculated by multiplying current share price and number of shares in the market. High Liquidity shares - Shares in the market with high volumes.

Curve fitting as a straight line: Let $(x_i, y_i); i = 1,2,3,......,n$ be a given set of n pairs of values, x being independent variable and y the dependent variable. The general problem in curve fitting is to find, if possible, an analytic expression of the form $y = f(x)$, for the functional relationship suggested by the given data.

Let us consider the fitting of a straight line as

$$y = a + bx \tag{1}$$

To a set of n points $(x_i, y_i); i = 1,2,3,......,n$ equation (1) represents a family of straight lines for different values of the arbitrary constants a and b. The problem is to determine a and b so that the line (1) is of the line "best fit".

The term "best fit" is interpreted in accordance with Legender's principle of least squares which consists in minimizing the sum of the squares of the deviations of the actual values of y from their estimated values as given by the line best fit.

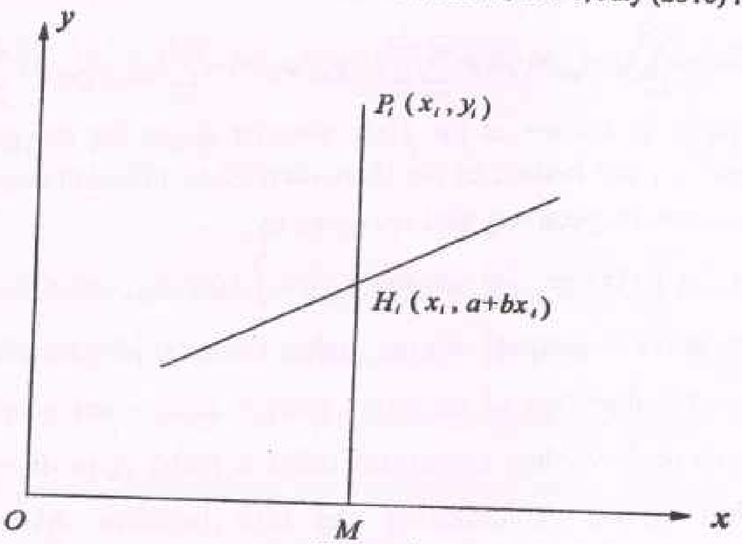

Figure 1

Let $P_i(x_i, y_i)$ be any general points in the scatter diagram. Draw $P_iM \perp$ x-axis meeting the line in H_i. Abscissa of H_i is x_i and since H_i lies on (1), its ordinate is $a+bx_i$. Hence the co-ordinates of H_i are $(x_i, a+bx_i)$. From fig. 1

$$P_iH_i = P_iM - H_iM = y_i - (a+bx_i)$$

which is called the error of estimation or the residual for y_i.

According to the principle of least squares, we have to determine a and b so that

$$E = \sum_{i=1}^{n} P_iH_i^2 = \sum_{i=1}^{n} (y_i - a - bx_i)^2$$

is minimum. From the maxima and minima, the partial derivatives of E, with respect to a and b should vanish separately, i.e.

$$\frac{\partial E}{\partial a} = 0 = -2\sum_{i=1}^{n}[y_i - a - bx_i]$$

$$\Rightarrow \sum_{i=1}^{n} y_i = na + b\sum_{i=1}^{n} x_i \qquad (2)$$

Again

$$\frac{\partial E}{\partial b} = 0 = 2\sum_{i=1}^{n}[y_i - a - bx_i](-x_i)$$

$$\Rightarrow \sum_{i=1}^{n} x_i y_i = a\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2 \qquad (3)$$

Equation (2) and (3) are known as the normal equations for estimating a and b.

From our collected data we can find the Table 1 and Table 2 for finding a and b

Table 1 Monthly DSE general index for 2005 to 2008

x	y	x^2	xy	x^3	x^4	x^2y
1	1893	1	1893	1	1	1893
2	1682	4	3364	8	16	6728
3	1660	9	4980	27	81	14940
4	1692	16	6768	64	256	27072
5	1328	25	6640	125	625	33200
6	1570	36	9420	216	1296	56520
7	1644	49	11508	343	2401	80556
8	2050	64	16400	512	4096	131200
9	2941	81	26469	729	6561	238221
10	2961	100	29610	1000	10000	296100
11	3090	121	33990	1331	14641	373890
12	2530	144	30360	1728	20736	364320
$\sum x=$ 78	$\sum y=$ 25041	$\sum x^2=$ 650	$\sum xy=$ 181402	$\sum x^3=$ 6084	$\sum x^4=$ 60710	$\sum x^2y=$ 1624640
x, y represents month and general index respectively.						

From (2) and Table 1 we get

$$25041 = 12a + 78b \tag{4}$$

From (3) and Table 2 we get

$$181402 = 78a + 650b \tag{5}$$

Solving (4) and (5) we get

$a = 1239.68$, $b = 130.32$, $y = 1239.68 + 130.32x$

which is our mathematical model as a straight line.

Mathematical model as an algebraic equation

If the curve represented by a 2nd degree equation, then we consider

$$y = a + bx + cx^2$$

$$E = \sum_{i=1}^{n}\left[y_i - a - bx_i - cx_i^2\right]^2$$

$$\frac{\partial E}{\partial a}=0=-2\sum_{i=1}^{n}\left[y_i-a-bx_i-cx_i^{\,2}\right]$$

$$\sum_{i=1}^{n}y_i=na+b\sum_{i=1}^{n}x_i+c\sum_{i=1}^{n}x_i^{\,2} \tag{6}$$

$$\frac{\partial E}{\partial b}=0=-\sum_{i=1}^{n}[y_i-a-bx_i-cx_i]x_i$$

$$\sum_{i=1}^{n}x_iy_i=a\sum_{i=1}^{n}x_i+b\sum_{i=1}^{n}x_i^2+c\sum_{i=1}^{n}x_i^3 \tag{7}$$

$$\frac{\partial E}{\partial c}=0=-2\sum_{i=1}^{n}\left[y_i-a-bx_i-cx_i^2\right]x_i^2$$

$$\sum_{i=1}^{n}x_i^2y_i=a\sum_{i=1}^{n}x_i^2+b\sum_{i=1}^{n}x_i^3+c\sum_{i=1}^{n}x_i^4 \tag{8}$$

From (6) and Table 1 we get, $25041=12a+78b+650c$

From (7) and Table 1 we get, $181402=78a+650b+6084c$

From (8) and Table 1 we get, $1624640=650a+6084b+60710c$

Solving above all those equations we get

$a=1830.39$, $b=-122.84$, $c=19.47$

$$y=1830.39-122.84x+19.47x^2 \tag{9}$$

This is the mathematical model of the above data.

Mathematical model as a power curve

If the curve represented by power curve, then we consider $y=ax^b$. Taking log on both sides we get, $\log y=\log a+b\log x$

Putting $\log y=y'$, $\log a=A$ and $\log x=x'$ we get the following mathematical model of DSE General Index for the year 2005 to 2008.

Table 2: Monthly DSE general index for 2005 to 2008

x	y	$\log x = x'$	$\log y = y'$	$x'y'$	x'^2
1	1893	0	3.277	0	0
2	1682	0.3031	3.225	0.9707	0.0906
3	1660	0.4771	3.220	1.536	0.2276
4	1692	0.6020	3.228	1.943	0.3624
5	1328	0.6990	3.123	2.183	0.4886
6	1570	0.7782	3.195	2.486	0.6055
7	1644	0.8450	3.215	2.716	0.7140
8	2050	0.9030	3.312	2.990	0.8154
9	2941	0.9541	3.468	3.308	0.9101
10	2961	1	3.471	3.471	1
11	3090	1.041	3.489	3.632	1.083
12	2530	1.081	3.403	3.675	1.1664
		$\sum x' = 8.68$	$\sum y' = 39.63$	$\sum x'y' = 28.913$	$\sum x'^2 = 7.46$
x,y represents month and general index respectively.					

The normal equations are

$$\sum y' = nA + b\sum x'$$

From Table (2), 39.63=12A+8.68b (10)

$$\sum x'y' = A\sum x' + b\sum x'^2$$

From Table (2), 28.913=6.68A+7.464b (11)

Solving (10) and (11) we get,

A=3.1509 i.e. a=1412.53 and b=0.208

$$y = 1412.53x^{(0.208)} \tag{12}$$

This is the mathematical model of the above data.

Haar Representation of Continuous Function:

Example 1:

From (9) the function can be written as

$$f(x) = \begin{cases} 19.47x^2 - 122.84x + 1830.39 & \text{if} \quad 0 \le x < 1 \\ 0 & \text{otherwise.} \end{cases}$$

We can represent $f(x)$ as (A). Let the starting scale be $j_0 = 0$, so the scaling coefficient $c_{0,0} = \int_0^1 (19.47x^2 - 122.84x + 1830.39)\varphi_{0,0}(x)\,dx = 1775.46$ and the wavelet coefficients $d_{0,0} = \int_0^1 (19.47x^2 - 122.84x + 1830.39)\psi_{0,0}(x)\,dx = 25.8425$, similarly $d_{1,0} = 10$, $d_{1,1} = 8.27$, $d_{2,0} = 3.683$, $d_{2,1} = 3.38$, $d_{2,2} = 3.1$, $d_{2,3} = 2.76$ and so on. Therefore

$$f(x) = 19.47x^2 - 122.84x + 1830.39 = 1775.46\ \varphi_{0,0}(x) + \left[25.84\ \psi_{0,0}(x)\right] +$$
$$\left[10.10\ \psi_{1,0}(x) + 8.27\psi_{1,1}(x)\right] + \left[3.68\ \psi_{2,0}(x) + 3.38\ \psi_{2,1}(x) + 3.1\ \psi_{2,2}(x) + 2.76\ \psi_{2,3}(x)\right] + \ldots\ldots$$
$$V_0 = 1775.46\ \varphi_{0,0}(x), W_0 = 25.84\ \psi_{0,0}(x), W_1 = 10.10\ \psi_{1,0}(x) + 8.27\psi_{1,1}(x))$$

$$W_2 = 3.68\ \psi_{2,0}(x) + 3.38\ \psi_{2,1}(x) + 3.1\ \psi_{2,2}(x) + 2.76\ \psi_{2,3}(x)$$
$$V_1 = V_0 \oplus W_0 = 1775.46\ \varphi_{0,0}(x) + 25.84\ \psi_{0,0}(x) \text{ and}$$

$$V_2 = V_1 \oplus W_1 = V_0 \oplus W_0 \oplus W_1 = 1775.46\ \varphi_{0,0}(x) + 25.84\ \psi_{0,0}(x) + 10.10\ \psi_{1,0}(x) + 8.27\psi_{1,1}(x)$$
$$V_3 = V_2 \oplus W_2 = V_1 \oplus W_1 \oplus W_2$$

$$= 1775.46\varphi_{0,0}(x) + 25.84\psi_{0,0}(x) + 10.10\psi_{1,0}(x) + 8.27\psi_{1,1}(x) +$$
$$\left[3.68\psi_{2,0}(x) + 3.38\psi_{2,1}(x) + 3.1\psi_{2,2}(x) + 2.76\psi_{2,3}(x)\right]$$

where V_j and W_j, $j \geq 0$ are the orthogonal subspaces of $L_2[0,1]$ and $\oplus$ is the direct sum.

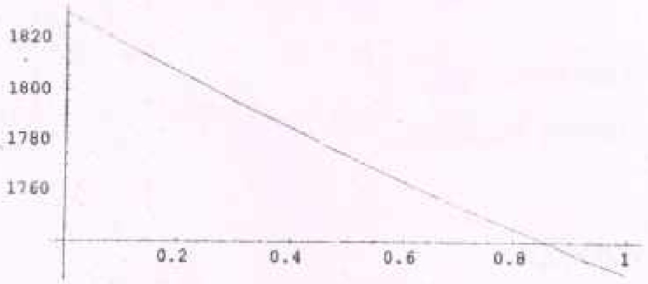

Figure 1.1 Graph of $f(x)$

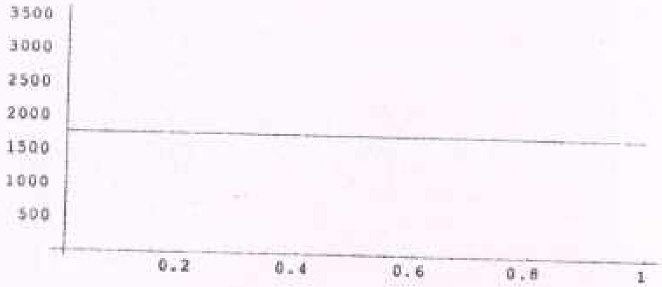

Figure 1.2 Graph of V_0

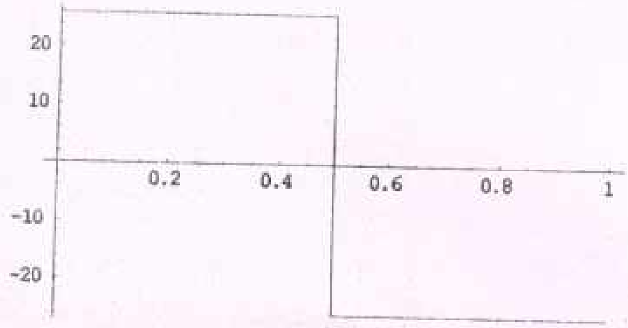

Figure 1.3 Graph of W_0

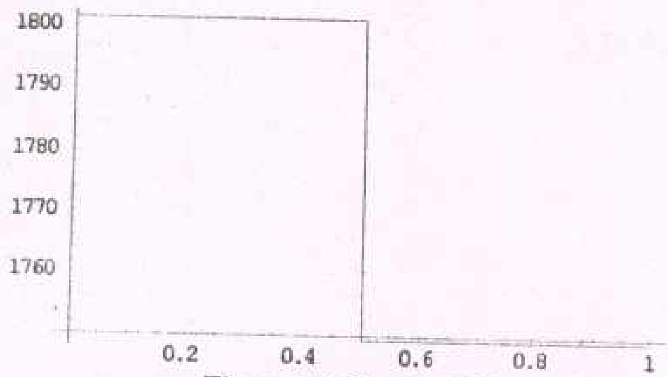

Figure 1.4 Graph of V_1

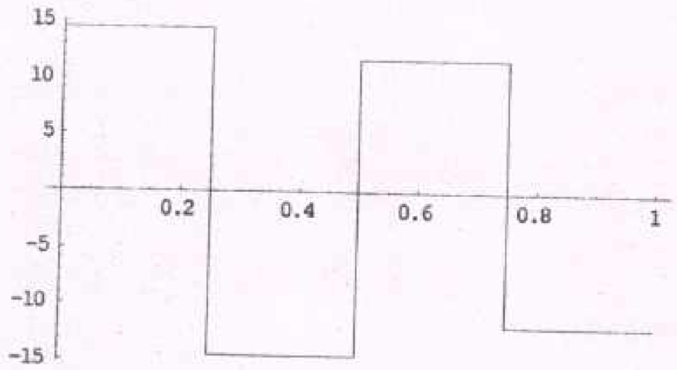

Figure 1.5 Graph of W_1

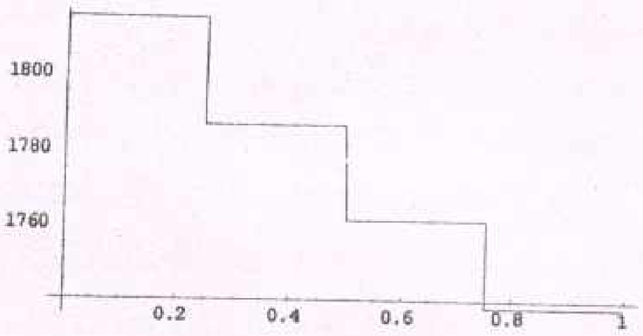

Figure 1.6 Graph of V_2

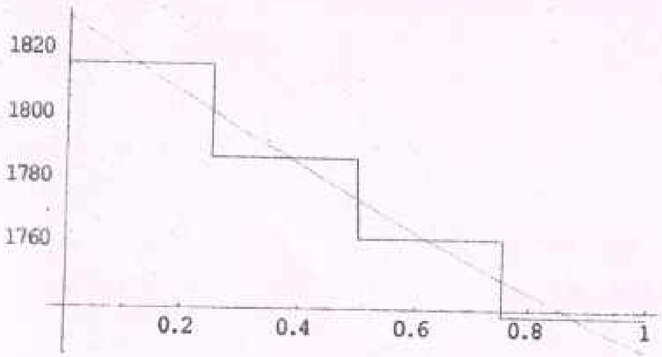

Figure 1.7 Graph of $f(x)$ and V_2 jointly

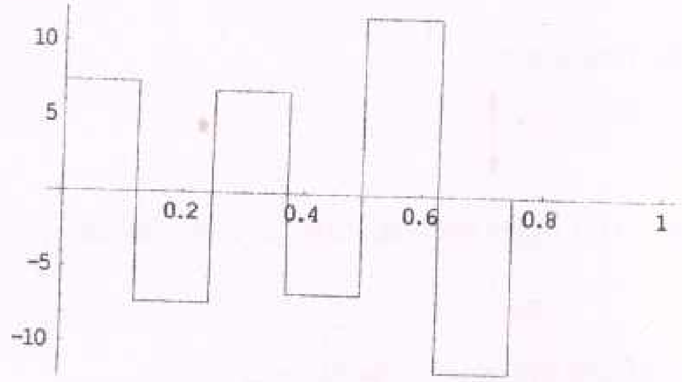

Figure 1.8 Graph of W_2

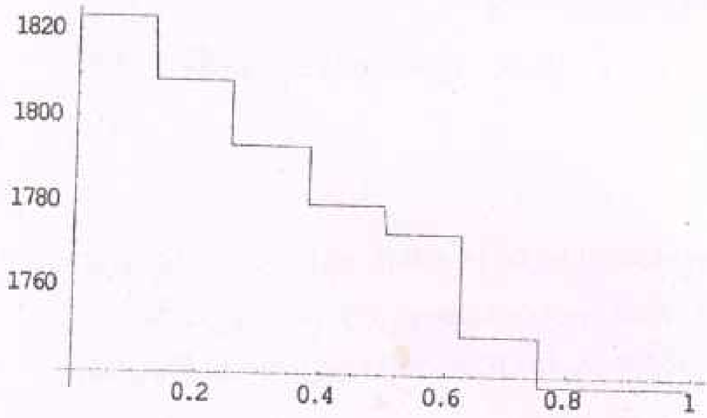

Figure 1.9 Graph of V_3

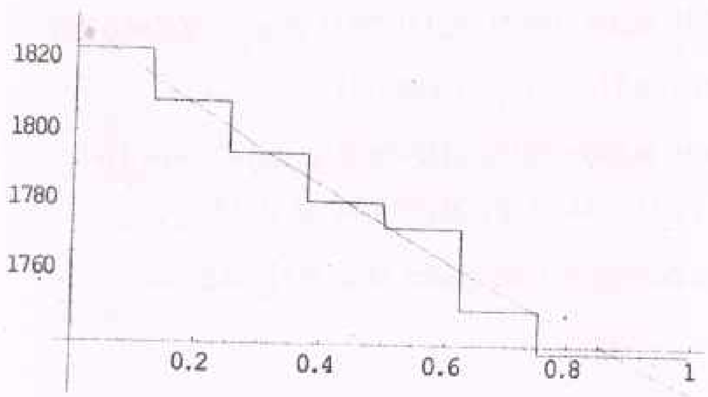

Figure 1.10 Graph of $f(x)$ and V_3 jointly

Example 2: From (12), the function is

$$f(x)=\begin{cases}1412.53\,x^{(0.208)} & if \quad 0\le x<1\\ 0 & otherwise\end{cases}$$

We can represent $f(x)$ as (A). Let the starting scale be j_0=0 , so the scaling coefficient

$c_{0,0}=\int_0^1 e^x\varphi_{0,0}(x)dx=1169.31$ and the wavelet coefficients

$d_{0,0}=-156.99,\ d_{1,0}=-96.107,\ d_{1,1}=-32.90,$

$d_{2,0}=-58.83,\ d_{2,1}=-20.238,\ d_{2,2}=-13.39,\ d_{2,3}=-10.23$ and so on.

Therefore

$$\begin{aligned}f(x)&=1412.53\ x^{(0.208)}\\ &=1169.31\ \varphi_{0,0}(x)+\left[-156.99\ \psi_{0,0}(x)\right]+\left[-96.11\ \psi_{1,0}(x)-32.90\ \psi_{1,1}(x)\right]+\\ &\quad\left[-58.83\ \psi_{2,0}(x)-20.24\ \psi_{2,1}(x)-13.39\ \psi_{2,2}(x)-10.23\ \psi_{2,3}(x)\right]+\end{aligned}$$

$V_0=1169.31\ \varphi_{0,0}(x), W_0=-156.99\ \psi_{0,0}(x), W_1=-96.11\ \psi_{1,0}(x)-32.90\psi_{1,1}(x))$

$W_2=-58.83\ \psi_{2,0}(x)-20.24\ \psi_{2,1}(x)-13.39\ \psi_{2,2}(x)-10.23\psi_{2,3}(x)$

$V_1=V_0\oplus W_0=1169.31\ \varphi_{0,0}(x)-156.99\ \psi_{0,0}(x)$ and

$V_2=V_1\oplus W_1=V_0\oplus W_0\oplus W_1=1169.31\ \varphi_{0,0}(x)-156.99\ \psi_{0,0}(x)-96.11\ \psi_{1,0}(x)-32.90\psi_{1,1}(x)=$

$1169.31\varphi_{0,0}(x)-156.99\psi_{0,0}(x)-96.11\psi_{1,0}(x)-32.90\psi_{1,1}(x)$

$$\begin{aligned}V_3&=V_2\oplus W_2=V_1\oplus W_1\oplus W_2=1169.31\ \varphi_{0,0}(x)-156.99\psi_{0,0}(x)-96.11\ \psi_{1,0}(x)-32.90\psi_{1,1}(x)+\\ &\left[-58.83\ \psi_{2,0}(x)-20.24\ \psi_{2,1}(x)-13.39\ \psi_{2,2}(x)-10.23\ \psi_{2,3}(x)\right]\end{aligned}$$

where V_j and W_j, $j\ge 0$ are the orthogonal subspaces of $L_2[0,1]$ and $\oplus$ is the direct sum.

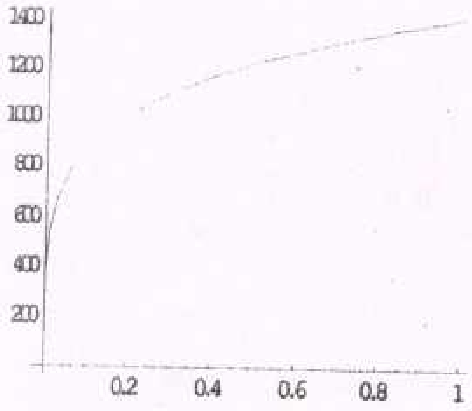

Figure 2.1 Graph of $f(x)$

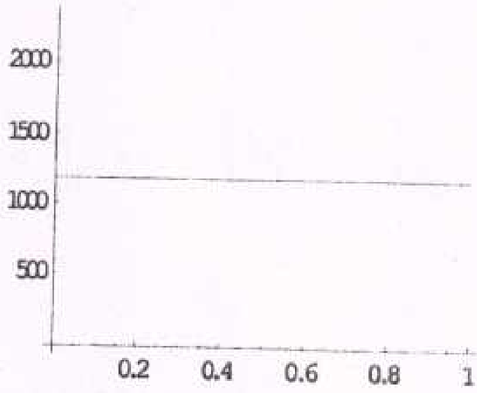

Figure 2.2 Graph of V_0

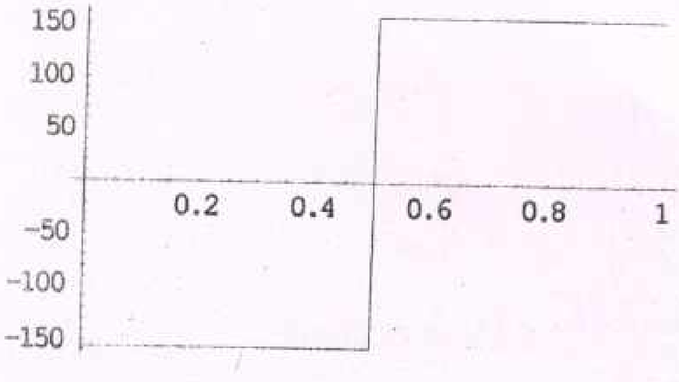

Figure 2.3 Graph of W_0

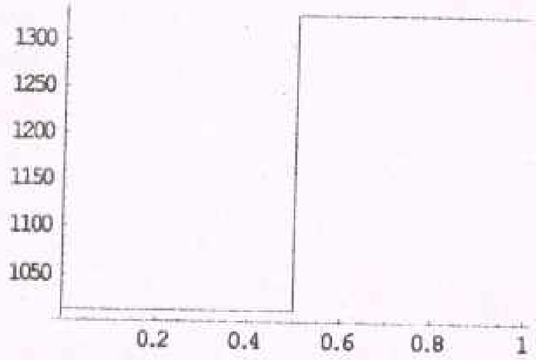

Figure 2.4 Graph of V_1

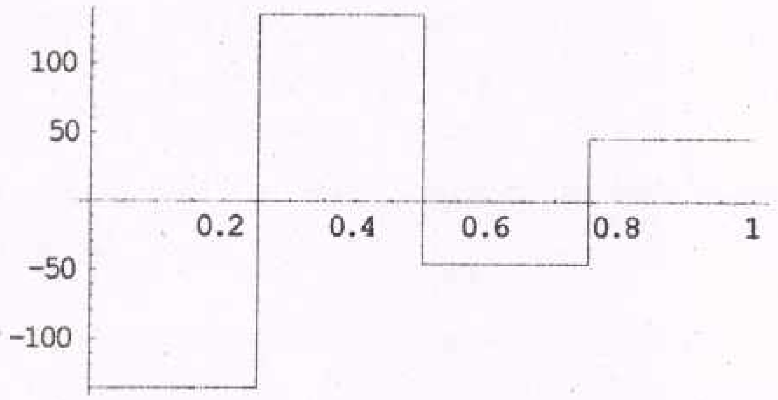

Figure 2.5 Graph of W_1

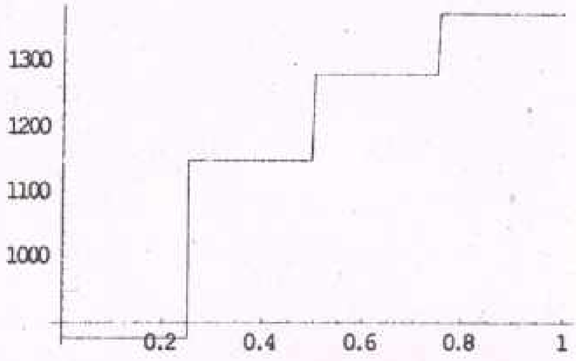

Figure 2.6 Graph of V_2

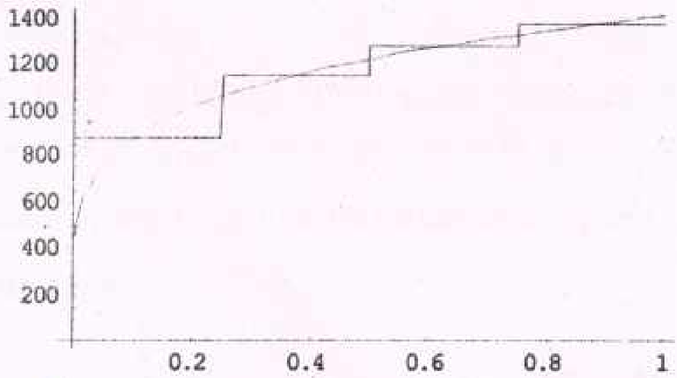

Figure 2.7 Graph of $f(x)$ *and* V_2 jointly

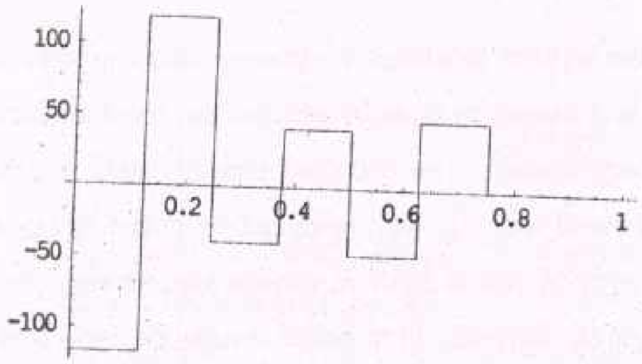

Figure 2.8 Graph of W_2

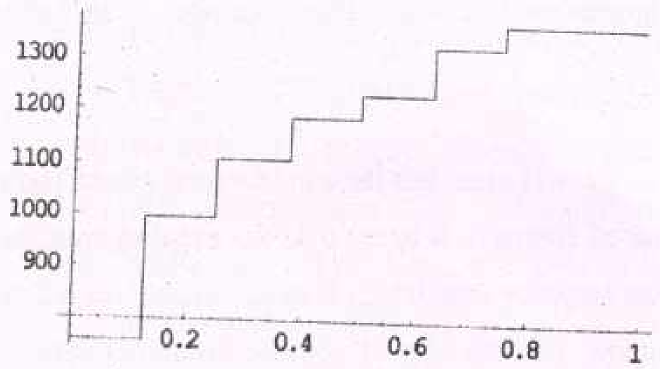

Figure 2.9 Graph of V_3

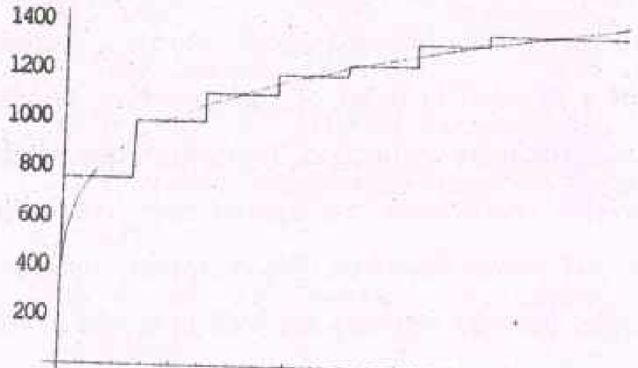

Figure 2.10 Graph of $f(x)$ *and* V_3 jointly

Using Mathematica we have drawn this above all the graphs.

3. Result and Discussion

From the figures of the wavelet functions, we observe that wavelets are well localized in both time and frequency domain whereas the standard curve is only localized in frequency domain. The collected monthly data of DSE (Dhaka Stock Exchange) general index is well analyzed by curve fitting as well as by wavelets. This study of data is made in various aspects and which can be seen from given figures. Wavelets give better results than the curve fitting processes. Hence we can say that data compression is the great achievement of wavelet transforms i.e. in wavelet transform, it is often possible to obtain a good approximation of the given function f by using only a few coefficients.

4. Conclusion

From our above discussion it is clear that the experimental results show that the wavelet transform based approach is better than the existing minutiae based method and it takes less response time which is more suitable for online verification with high accuracy. The analysis of collected monthly data of DSE (Dhaka Stock Exchange) general index give a clear presentation of economic ups and downs which is very important to the development of financial system of the country. We discussed about wavelets, wavelet transforms, representation of a function in terms of Haar wavelet. Wavelet transform is a new tool to approximate a function. By using Haar scaling coefficients and Haar wavelet coefficients we approximate continuous functions such as algebraic and power functions. We represent continuous curve in terms of Haar wavelet because wavelets are well localized in both time and frequency domain.

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