International Journal of Mathematics and Physical Sciences Research ISSN 2348-5736 (Online)
Vol. 10, Issue 1, pp: (32-37), Month: April 2022 - September 2022, Available at: www.researchpublish.com

Spectral analysis of health and vegetables index using discrete wavelet transforms

Prof. Anil Kumar

Principal, Gandhi Smarak College, Surjannagar-Jainagar, Moradabad, U.P. (INDIA)

Affiliated to MJP Rohilkhand University, Bareilly

DOI: https://doi.org/10.5281/zenodo.6651373

Published Date: 16-June-2022

Abstract: **Sociophysics reveals that non-physical things of society can be understood and explained by the laws of physics. Health of people is one of the main parameters that decide the development of a country. Vegetables are the main and clean source of nutrition to nurture the human body and mind. Vegetables provide multivitamins and minerals that are essential for the health of human beings and have manifold health benefits. Wavelet transforms is a powerful and computational efficient tool which has wide applications in field of data analysis and signal processing. We have taken health and vegetable data of India from Jan. 2013 to Aug. 2021 as raw data. Wavelet transforms of this data is performed by software dyadwaves using Haar wavelet, decomposition level-5. In first level of decomposition, the data is decomposed into approximation and wavelet coefficients. The approximation represents average behaviour and detail represents differential behaviour of the data. Approximation is the slowest part of data which describes trend of the data. In each further level of decomposition, the approximation is further decomposed into next level approximation and detail. It has been found that wavelet analytical results are strongly consistent with statistical analytical results.**

Keywords: **Approximation, detail, health, vegetables, wavelet.**

1. INTRODUCTION

Health is described as a state of complete harmony of the body and mind. On the other hand, health is comprised of physical as well as mental well-beings. It is a state of body in which there is no physical disability and mental distraction exist [1-2]. Vegetables are the main source of nutrition for nurturing the body and mind. Vegetables are one of the highest plant-based protein sources and fulfil the requirement of amino acid to build strength and muscle mass [3]. Vegetables provide a cleaner food than animal-based proteins. Vegetables also provide multivitamins like A, C, K and folate with minerals including sulphur, potassium, calcium, iron, etc. Vegetables in form of salad serves as rich source of dietary fibres which helps to increase the digestion and healthy bowel movements. Green leafy vegetables are one of the best sources of omega-3 fatty acids (Alpha Linoleic Acid) and are essential for the brain and its neurological activities and also helps to reduce inflammation in various body parts. The chlorophyll of green leafy vegetables has very similar structure to the human body cells, hence helpful to enhance oxygen transportation and red blood cells production [4]. Green vegetables' juice helps to nourish and cleans the blood, purify the lever and the lymphatic system of the body. Vegetables are very useful to remove or neutralize poisonous substances produced by radiations and other pollutants in the body. Vegetables are most effective to provide protection against cognitive decline. Vitamin K enhances brain activity and improve psychomotor behaviour, relaxes and overall cognition. The folic acid is useful to maintain haemoglobin level of the body and helps to decrease the depression and anxiety. Vitamin B9 improves concentration as well as memory power of a person. Green vegetables help to make the blood more alkaline for improving the calcium absorption process of our bones. Presence of rich amount of folate in vegetables helps in ovulation and prevention of heredity effects. Green vegetables are the good source of antioxidant, vitamin A and collagen boosting vita that cause to fight against aging effect, reduces the wrinkles and fine lines on the skin and helps to keep skin looking as healthy and glowing. Therefore, health benefits of vegetables are not just limited but are actually manifold [5].

Fourier transform provides frequency information of a stationary signal having finite energy, but it is not suitable to analyse non-stationary or transient signal. For obtaining time localization characteristics of a signal, window fourier transform (WFT) is introduced in 1946 and also called short time fourier transform (STFT). In window fourier transform, a window function is multiplied to the signal and its fourier transform is performed to obtain the spectral information of any signal. Heisenberg uncertainty principle states that the time and frequency resolution of a signal can not be performed accurately and simultaneously. To overcome the discrepancies of window fourier transform, the wavelet transform is introduced which captures the time frequency information of a signal. It is a new, powerful and computational efficient tool for numeric and spectral analysis of a signal, so that has wide applications in signal processing, data analysis, image processing, speech and face recognition, and computer graphics [6].

1.1 Basics of wavelet transforms

The wavelet refers to a small wave which can be dilated and translated. The wavelet functions are oscillatory in nature and exist for a short time interval. Any continuous wavelet function for two real numbers a and b can be expressed as follows: -

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) = T_b D_a \psi$$

where a is called dilation parameter and b is translation parameter. By putting $a = 2^{-j}$ and $\frac{b}{a} = k$, a discrete wavelet can be obtained and expressed as follows: -

$$\psi_{j,k}(t) = 2^{j/2}\psi(2^j t - k)$$

Here ψ(t) is real-valued function and $\psi_{0,0}(t)$ is called mother wavelet [7]. The continuous wavelet transforms of any function $f(t)$ is defined as follows: -

$$W_{a,b} = \int f(t)\frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) dt$$

While, the discrete wavelet transforms is defined as follows: -

$$W_{j,k} = \int f(t) 2^{j/2}\psi(2^j t - k)\, dt$$

Multiresolution analysis (MRA) is a discrete wavelet transforms having resolutions adapted with the signal. In MRA any vector space is decomposed into subspaces satisfying the following properties [8-11]: -

1) $V_{j+1} \subset V_j \quad : j \in \mathbb{Z}$

2) $\cap_{j\in\mathbb{Z}} V_j = \{0\}, \ \cup_{j\in\mathbb{Z}} = L^2(\mathbb{R})$

3) $f\ (t) \in V_j \Rightarrow f(2t) \in V_{j+1},\ \forall\ j\ \in \mathbb{Z}$

4) If a function $(t)\ \in\ V_0$, then $\{\phi(t-k): k \in \mathbb{Z}\}$ is orthonormal basis of V_0.

The function $\phi(t)$ is called scaling function of given MRA and implies dilation equations as follows: -

$$\phi(t) = \sum_{k\in Z} h_k \sqrt{2}\,\phi(2t-k)$$

Where h_k is called low pass filter and defined as follows: -

$$h_k = \left(\frac{1}{\sqrt{2}}\right)\int_{-\infty}^{\infty} \phi\ (\mathrm{t})\phi\ (2t-k)\, dt$$

The space V_0 can be decomposed into following manner:

$$V_0 = V_1 \oplus W_1$$

where W_1 be the orthogonal compliment of V_1 in V_0 . If $\psi \in W_1$ be any wavelet function then $\psi(t)$ is expressed as: -

$$\psi(t) = \sum_{k\in Z} g_k \sqrt{2}\,\phi(2t-k)$$

where $g_k = (-1)^{k+1} h_{1-k}$ is called high pass filter. In general, we can write,

$$V_j = V_{j+1} \oplus W_{j+1}$$

So that, $$V_{j+1} = V_{j+2} \oplus W_{j+2}$$

Therefore,

$$V_j = W_{j+1} \oplus W_{j+2} \oplus V_{j+2}$$

$$.. \quad .... \quad ..$$

$$V_j = W_{j+1} \oplus W_{j+2} \oplus W_{j+3} \oplus \ldots\ldots\ldots W_{j+p} \oplus V_{j+p}$$

By MRA, the orthogonal decomposition of pth level of space V_j is expressed as follows [12]: -

$$V_j = V_{j+p} \oplus \sum_{p=1}^{\infty} W_{j+p}$$

where p is any desired number which represents the order of level of decomposition.

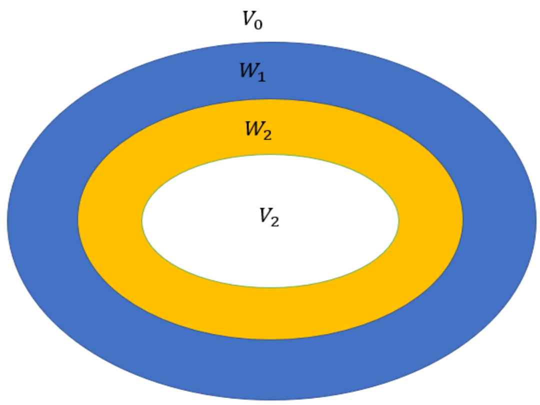

Figure 1: Orthogonal decomposition of vector space

In vector space V_j, a finite function $f(t)$ in terms of wavelet series can be is defined as follows: -

$$f(t) = \sum_{k\in\mathbb{Z}} a_{j+p,k}\ \phi_{j+p,k}(t) + \sum_{p=1}^{\infty} \sum_{k\in\mathbb{Z}} d_{j+p,k}\ \psi_{j+p,k}(t)$$

Here, the sum $\sum_{k\in\mathbb{Z}} a_{j+p,k}\ \phi_{j+p,k}(t)$ is the orthogonal projection of function on the space V_{j+p} and $\sum_{p=1}^{\infty} \sum_{k\in\mathbb{Z}} d_{j+p,k}\ \psi_{j+p,k}(t)$ is orthogonal projection on the space W_{j+p} [13].

2. RESEARCH METHODOLOGY

Any discrete signal or data $f[n]$ can be described in space of square summable sequences $\ell^2(\mathbb{Z})$ as follows [14-15]: -

$$f[n] = \frac{1}{\sqrt{M}} \sum_k a[j+p,k]\phi_{j+p,k}[n] + \frac{1}{\sqrt{M}} \sum_{p=1}^{\infty} \sum_k d[j+p,k]\psi_{j+p,k}[n]$$

Here the discrete functions $f[n]$, $\phi_{j+p,k}[n]$ and $\psi_{j+p,k}[n]$ are defined in interval $[0, M-1]$, totally M points. Here the sets $\{\phi_{j+p,k}[n]\}_{k\epsilon\mathbb{Z}}$ and $\{\psi_{j+p,k}[n]\}_{k\epsilon\mathbb{Z}, p\epsilon\mathbb{Z}^+}$ are orthogonal to each other. The scaling and wavelet coefficients can be obtained by taking the inner product as follows: -

$$a[j+p,k] = \frac{1}{\sqrt{M}} \sum_n f[n]\ \phi_{j+p,k}[n]$$

$$d[j+p,k] = \frac{1}{\sqrt{M}} \sum_n f[n]\ \psi_{j+p,k}[n]$$

where $a[j+p,k]$ and $d[j+p,k]$ are called approximation and detail coefficients respectively. With help of low pass and high pass filters any data or signal is decomposed into approximation and detail coefficients respectively (Figure 2).

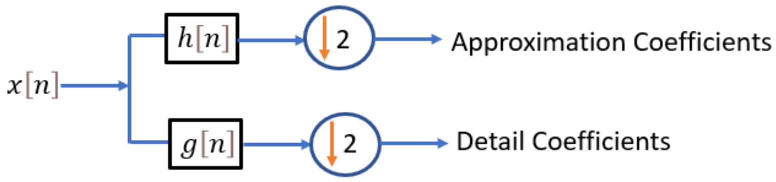

Figure 2: Data decomposition into approximation and detail coefficients

Proceeding with the same manner, approximation is again decomposed into approximation and detail coefficients of the next level (Figure 3).

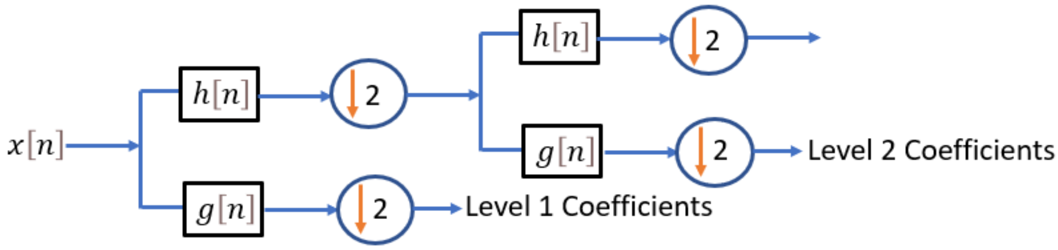

Figure 3: Data decomposition up to level 2

For the first level of decomposition, the data (function f) is expressed as follows: -

$$f(1) = A_1 + D_1$$

For the second level of decomposition,

$$f(2) = A_2 + D_2 + D_1$$

Similarly,

$$f(3) = A_3 + D_3 + D_2 + D_1$$

$$f(4) = A_4 + D_4 + D_3 + D_2 + D_1$$

$$f(5) = A_5 + D_5 + D_4 + D_3 + D_2 + D_1$$

3. RESULTS AND DISCUSSION

The health and vegetables index of India from January 2013 to August 2021 are taken as raw data or original signal, imported from website data.gov.in. The wavelet transforms of this data is performed up to decomposition level-5 using Haar wavelet by software dyadwaves (Figure 4 and 5) for detailed investigation.

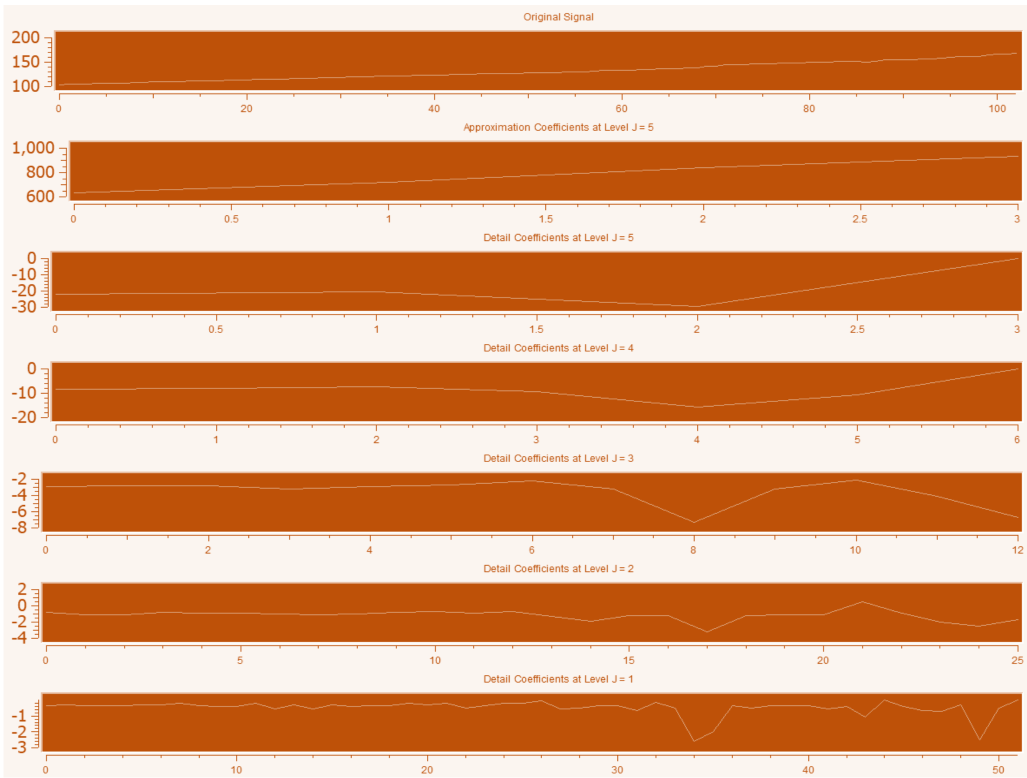

Figure 4: Health index of India from Jan. 2013 to Aug. 2021 and its wavelet decomposition

Figure 5: Vegetable index of India from Jan. 2013 to Aug. 2021 and its wavelet decomposition

By discrete wavelet transforms, any original signal is decomposed into approximation and detail coefficients. Approximation represents average behaviour or trend of the signal, which represents the slowest part of a signal. In wavelet analysis term, it corresponds to the greatest scale value. As the scale increases, resolution decreases, producing a better estimate of unknown data. The detail represents the differential behaviour of the signal. The approximation of health data reveals the continuous growth of health in India from 2013 to 2021, while the approximation of vegetables data reveals overall growth with decreasing trend in the recent years. The differential behaviour of health and vegetable for the same tenure reveals the fluctuations in time to time.

Table 1: Statistical parameters of health and vegetables index

S. No.	Parameter	Health	Vegetable
1	Skewness	0.32060	0.78632
2	Kurtosis	-1.04168	1.328746
3	Standard Deviation	17.83161	24.99682
4	Correlation	0.541187	

Skewness is a measure of symmetry or more accurately the lack of symmetry of any data, while Kurtosis is a measure of flatness of data relative to a normal distribution [16]. Positive value of skewness indicates that the given data is skewed to the right, means its right tail is longer than left tail. Negative value of kurtosis indicates that the outlier character of given data is less extreme that expected from a normal distribution. Positive value of kurtosis indicates that the outlier character of given data is more extreme than expected from a normal distribution. Zero value of kurtosis indicates that the outlier character of given data is similar to what is expected from a normal distribution. Standard deviation indicates that how much the data points are spread out over a wider range of values. High value of standard deviation indicates highly spreading data from mean value. Correlation represents the degree of linear relationship between two data, functions, or signals. The positive value of correlation means they are linearly related with positive slope and medium value means that they are moderately related.

4. CONCLUSION

Non-linear social reality can be analysed by the laws and concepts of sociophysics. In present analyses, we found that the approximation of health index of India from Jan. 2013 to Nov. 2021 shows continuous increasing trend, while vegetable index shows overall growth with decreasing trend in recent years. The details of health and vegetable for the same tenure reveals the fluctuations in time to time. Data of health and vegetables both show weak intermittency. The health and vegetable index are positively and linearly related. The wavelet analytical results provide strong consistency with the statistical analytical results. By virtue of these results, we can say that sociophysics of health and vegetables provides a simple and accurate framework to investigate the development of India.

REFERENCES

[1] Benz, J.; Blakey, C.; Oppenheimer, C.C.; Scherer, H. and Robinson, W.T. (2013). The healthy people initiative: Understanding the user's perspective. Journal of Public Health Management and Practice. 19 (2): 103–09.

[2] Jadad, A.R. (2013). On living a long, healthy and happy life, full of love and with no regrets until our last breath. Verhaltenstherapie. 23 (4): 287–89.

[3] Li, Thomas S.C. (2008). Vegetables and Fruits: Nutritional and Therapeutic Values. CRC Press. pp. 1–2.

[4] Hui, Y.H.; Ghazala, Sue; Graham, Dee M.; Murrell, K.D. and Nip, Wai-Kit (2003). Handbook of Vegetable Preservation and Processing. CRC Press. pp. 286–90.

[5] Rickman, Joy C.; Bruhn, Christine M. and Barrett, Diane M. (2007). Nutritional comparison of fresh, frozen, and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. Journal of the Science of Food and Agriculture. 87 (7): 1185–96.

[6] Hernandez, E. and Weiss, G. (1996). A First Course on Wavelets. CRC Press, New York.

[7] Antoine, J. P. (2004). Wavelet analysis: A new tool in Physics. Wavelets in Physics. Van Den Berg, J. C., ed., pp. 9-21.

[8] Mallat, S.G. (1989). Multiresolution approximations and wavelet orthonormal bases of $L^2(R)$, Transactions of the American Mathematical Society. 315: 69-87.

[9] Daubechies, I. (1990). The wavelet transforms, time frequency localization and signal analysis. IEEE Trans Information Theory. 36: 961-1005.

[10] Faizer, M. and Jawerth, B. (1990). A discrete transform and decomposition of distribution spaces. Journal of Functional Analysis. 93: 34-170.

[11] Mallat, S.G. (1989). Multiresolution approximations and wavelet orthonormal bases of, Transactions of the American Mathematical Society. 315: 69 – 87.

[12] Kumar, A.; Kumar, S and Pathak, J.K. (2015). Spectral analysis of river Ramganga hydraulics using discrete wavelet transform. Proceedings of International Conference of Advance Research and Innovation. pp. 370-373.

[13] Santhosh, M.; Charles, B.S. and Prasad, M.N.G. (2012). Adaptive filter design for wavelet decomposition and reconstruction in image processing applications. ARPN Journal of Engineering and Applied Sciences. 7(3): 314-318.

[14] Kumar, A. (2020). Wavelet and statistical analysis of dissolved oxygen and biological oxygen demand of ramganga river water. Asian Journal of Research and Reviews in Physics. 3(3): 45-50.

[15] Diwakar, R; Singh, B; Bajpai, A. and Kumar, A. (2022). Image pattern recognition by edge detection using discrete wavelet transforms. Journal of Decision Analytics and Intelligent Computing. 2(1): 26-35.

[16] Rockinger, M. and Jondeau, E. (2002). Entropy densities with an application to autoregressive conditional skewness and kurtosis. Journal of Econometrics. 106(1): 119-142.