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TIME SERIES ANALYSIS ON OCEAN WAVE HEIGHT USING EXPONENTIAL MOVING AVERAGE

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ABSTRACT:

The attributes of the nature are directly or indirectly affects each other; one of its causes was the ocean waves that are commonly generated by the wind. This wave sometimes affects the coastal areas and marine life. The sea waves are considerable with the time and space which can be represented in terms of mathematics. So, the analysis of ocean waves can give knowledge to predict the upcoming waves. The main objective of this paper is to study and analysis of ocean waves with help of exponential moving average.

KEYWORDS: Ocean wave; EMA; smoothing factor; Fibonacci series; wave height.

INTRODUCTION:

Waves are the forward movement of sea water due to the vibration of water molecule caused by the friction with wind over the sea surface. Waves are created by energy passing through the water, causes circular forward motion. When the wind blows over the sea surface, the continuous disturbance creates the wave. Actually, the hazardous waves are created due to bad weather, like storm. The strong wind and its heavy pressure during bad weather causes storm surge. A series of large and long wave creates in the deep sea far from the sea shore. Another cause of hazardous waves can be earthquakes, landslides or any other unwanted activities under the water. Ocean surface waves are the most important parameter in the marine life in shipping, costal protection etc.

This paper bends the light rays of prediction to focus it on the Oceanographic attribute i.e. wave height, using the strategy of Exponential Moving Average and the Fibonacci sequence. Depending on the wave height data for a short period of time collected from National Data Buoy Center (NDBC), a simple analytical model has been developed using Exponential Moving Average (EMA). With the strategies of EMA and time series data and with help of Fibonacci number, the model is plotted on a line graph considering the water height as Y-axis and time period as X-axis.

RELATED WORKS:

Several researches on the ocean waves are done over the past several years. Some of the research works in this field are as follows; In the year 2015, Johnson Glejin et.al carried out a time series analysis on the inter-annual variations in the wave characteristics [1]. In the same year, V. Sanil Kumar et.al carried out a time series analysis on the variations in wave spectral characteristics during 2009-2012 [2]. In the year 2014, R.D.Sathiya et.al, carried out a study on estimation of significant wave height of various ocean parameters [4]. In 2013, V.M. Aboobacker et.al, carried out a time series analysis on the modification and attenuation in wave energy in the near shore depths [3]. In 2012, P.Vethamony et.al studies the wave characteristics in the deep as well as near shore regions during different seasons using data mining techniques [8]. In 2011, V. Aboobacker et.al carried out a time series analysis on the dominance of pre-existing swells over wind seas [7]. In 2010, M. A. Nayak et.al evaluates a neural network based time series approach to predict wind speed in real time over shorter durations of up to 12 hr based on analysis of three hourly wind data [6]. In the same year, A.D.Rao carried out a time series analysis on variability of coastal ocean processes [5].

MOTIVATION:

Exponential Moving Average's vast effect on stock market analysis and the occurrence of Fibonacci

number in the pattern of nature is the main motivation of this work.

EXPONENTIAL MOVING AVERAGE:

Exponential Moving Average(EMA) is a also known as Exponential Weighted Moving Average is variation of moving average which is too similar to simple moving average ,where more priority is given to the last data Ruther than that of other moving averages. In other words EMA can be defined that it a type of infinite impulse response filter which applies exponentially decreasing weight factor [11].

Formula to calculate EMA

$EMA=EMA_p *\beta + (\text{current data} - EMA_p)$

Where EMA_p is the previous value of EMA and β is a constant moving factor or smoothing factor whose value is between 0 and 1.

$\beta= 2/ (1+N)$.

Where, N is the Number of Time periods.

FIBONACCI SERIES:

During 12th and 13th centuries, *Leonardo(born:c1170AD)* of Pisa was one of the greatest mathematician who was named as Fibonacci after his father name *Gugliemo Bonaccio*. He basically use to travelled to different countries and collect the knowledge of different system of computation .From *Liber geometriae(1220)* and *Liber quadratorum(1225)*, the two great mathematician, he was insisted to work on the theory of number. Fibonacci sequence was its outcome [10].

In this sequence, each term is the sum of the preceding two terms. The sequence was in this form

1, 1, 2, 3, 5, 8, 13, 21...

In modern days the sequence has been extended by one term and it was in the form

0, 1, 1, 2, 3, 5, 8, 13, 21...

Fibonacci sequence was very closer to the nature in their respective forms. It has been considered as natures number in some research work .It has been observed that the sequence has been maintained in various objects of nature like the leaf arrangement in plants, the pattern of florets of a flower, the bracts of a pinecone or the scales of a pineapple or the shell of the chambered Nautilus. So Fibonacci sequence is directly or indirectly related with the nature [9]. In this paper, time period to calculate predictive wave height column has been also followed the Fibonacci sequence.

RESULTS AND DISCUSSION:

During the wave height analysis process we got the time series data of wave column height from the National Data Buoy Center (NDBC) web site. We monitored the wave height data of a station numbered 23227 in Bay of Bengal at geographical co-ordinate of 6.23N, 88.74E, from November 11, 2016 to November 15, 2016. The station measured the wave height at every 15 minutes of time interval. While analyzing those data exponential moving average method is applied. As the data of wave height is been collected at a time interval of fifteen minutes, we assumed it as one time unit. We choose three time periods (N) which are Fibonacci numbers as mentioned earlier, for calculating the smoothing factor (β). For N=2, 5, 13 the smoothing factor was calculated.

Three EMA values are calculated for three smoothing factors for better analysis of wave heights. By analyzing the wave height values from November 11, 2016 to November 15, 2016 the following five graphs are plotted considering the water height as Y-axis and time period as X-axis. In those graph EMA_1 is plotted with N=2. EMA_2 is plotted with N=5 and EMA_3 is plotted with N=13. The theory of exponential moving states that when the flow of data remains below the EMA line, its tendency is to remain low and when the flow of data remain above the EMA line in the graph, the tendency is to remain up until it crosses the line. In this graph, we find that when the wave height line remains below the EMA line, its tendency is to remain low or its wave height values are low. When the height line tends to cross the line of EMA, it remains above the line of EMA. In our analysis process, we provide three EMA lines for three different time periods to measure the fall and rise of wave heights with more sharpness. When we analyze the wave heights with each EMA separately, we find that the height line is close with the EMA_1 line. The rise and fall of height line are very much close to it. With respect to EMA_2 line, it is noticed that when the height line crosses the EMA_2 line, their tendency of rise and fall are more than the EMA_1, i.e. when the height line crossed the EMA_2 line in rise, there is a big chance to rise of heights. In EMA_3 the chances are more than other two.

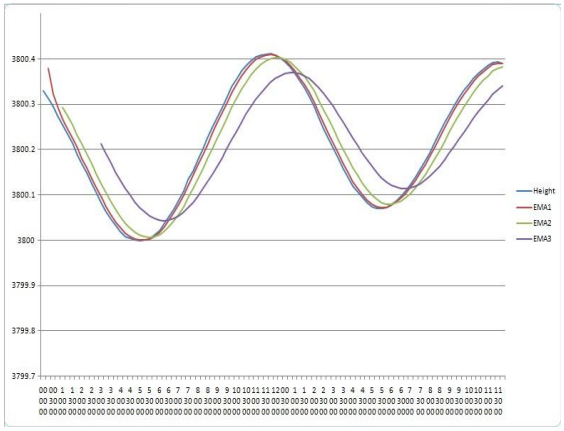

Fig1: Analysis graph of day1.

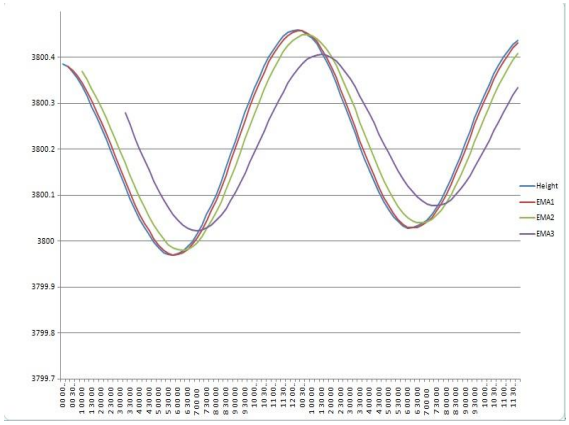

Fig2: Analysis graph of day2.

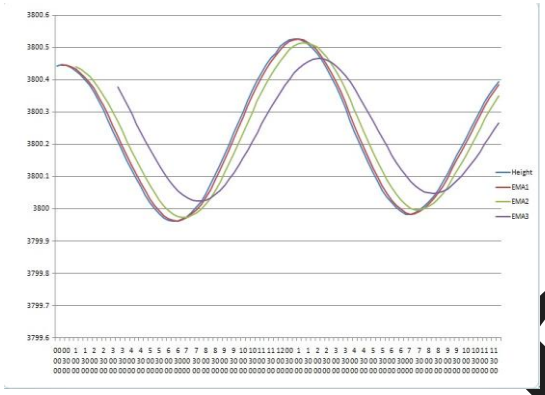

Fig3: Analysis graph of day3.

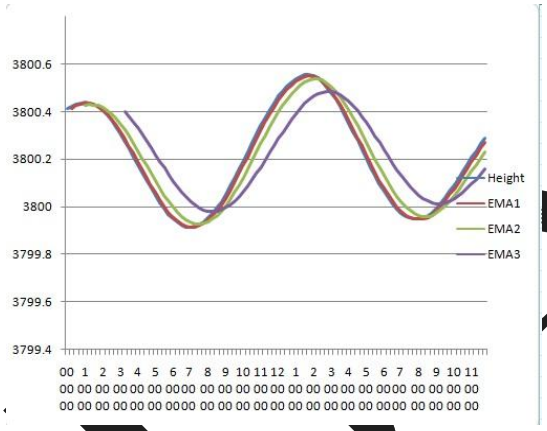

Fig4: Analysis graph of day4.

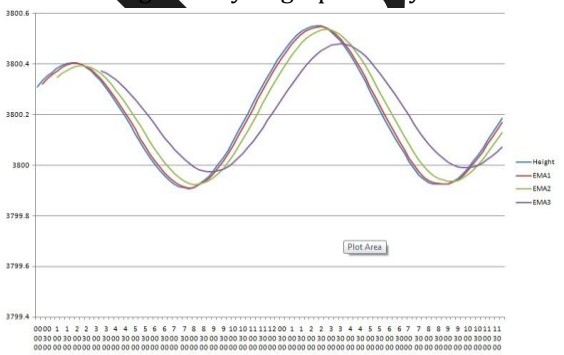

Fig5: Analysis graph of day5.

Above graphs are showing the analytical results on wave heights of five days. It is measured that the relation of EMA lines with the wave height line in these graphs, can predict the upcoming wave heights, either they remain high or low. In every hours graphical measurements we can predict that the height will remain high or low with respect to the EMA line. In figure1, the wave height line at first remains low with respect to all EMA lines. After 5:30:00 the wave height increases with respect to both EMA_1 and EMA_2. From this change, we can predict that the tendency of the height line is to remain high as it crosses both the line and when it crosses the EMA_3 line also the probability of rise in height is also increased. As well as, in downfall time of height line, when the height line crossed all the EMAs the probability of height fall is also increased. Likewise, by monitoring all 5 days graph, we find the same result with respect to first day.

CONCLUSION:

In the vast area of oceanographic research, analysis of ocean waves and prediction of upcoming waves is imperative. After keen observation of the wave height data from National Data Buoy Center in a graphical form, we come to a conclusion that Exponential Moving Average (EMA) can be taken into consideration for the study and analysis of ocean wave surface. It is also observed that the strategy of EMA can be used to predict the upcoming wave heights.

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