Forecasting Oil Prices using Wavelets

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Abstract :

Forecasting prices of various commodities is ubiquitous in the commodities markets. We illustrate how Wavelets can be employed in predicting oil prices. First we perform a multi-level decomposition of the time series signal of oil prices using a particular wavelet. Then we perform spline and trigonometric fitting on the wavelet coefficients and extend them. Finally we reconstruct the signal using these extended coefficients. The results are compared with respect to the data from future markets on oil.

Introduction :

There are two types of trades that are practiced in the oil market, namely the one that is based on immediate delivery and the one which is based on delivery at some point in the future. The Spot markets deal with the former kinds of trades and the Futures and Forward markets deal with the latter kind of trades. Now, in the Spot markets, the transaction is quite straightforward. You just buy the desired quantity of oil at the existing price at the date and time of your transaction. Often, the market conditions like market risk, trade imbalances and things like credit and insurance risks and seasonal factors are blamed for causing a lot of uncertainty in the oil markets. Futures market are devised to provide hedging mechanisms to deal with these uncertainties in the market. In the futures market, the buying and selling prices of oil at a future dates are established in accordance with certain trade and delivery terms. In a way, the Futures oil contract would be an expectation of the market condition at a future date.

Whether or not the futures market is efficiently priced is a very controversial matter. By performing a wavelet based analysis of the oil prices and subsequent comparison of our analysis with the actual rates of contract, we attempt to shed some light on the effectiveness of Futures market prices.

Wavelets in Economics and Finance :

Although wavelets are known to have significant impact and widespread application in a variety of scientific fields (such as hydrodynamics, geophysics, data processing, image compression, detection of discontinuities, neural networks, etc.), the wavelet methodology appears to be an uncharted territory in the realm of social sciences. Only recently, a few studies rely on the wavelet methodology as a viable tool for studying dynamic properties of different financial and economic phenomena

Wavelet analysis is seen as a preferred alternative alternative for analysis of signals which exhibit scaling properties, discontinuities, sharp spikes etc. Basically, wavelet analysis is known to succeed better in situations where other analysis methods may not be as good.

In this project, we are attempting to test the effectiveness of the oil futures contracts based on our wavelet analysis of the actual data for the oil prices. We will attempt to make some sample forecasts of the oil prices using certain curve-fitting techniques and hence, we will see if we can come up with a better estimate of the oil prices rather than the futures contracts do. The procedure we apply is based on fundamental properties of wavelets and is based on application of the Discrete Wavelet Transform (DWT) on a time series data of average monthly crude oil prices. Using a wavelet analysis, we should be able to divide the signal into a low frequency and a high frequency part. By applying the DWT on our data of crude oil prices, we decompose the data into many scales (as desired) of coarse and fine representations of the data. The coarse representations exhibit the general trend of the data as a whole, over a period of time. Whereas the finer scales are an indicator of the seasonal variations, natural factors, singular events and noise.

Forecasting using Wavelets :

For forecasting the future oil prices, we perform an adaptive extension of the decomposed signals using an appropriate curve-fitting method.
For example, we can fit the coarse data using, say a spline fitting routine, because this data does not very so much. Whereas, for the finer data, there are a lot fo fluctuations both up and down and this cannot be efficiently modeled using the spine fitting. However, using the trigonometric fitting functions is a good option in this case.
Consequently we find out-of-scale values of the relevant signals. We can then perform a wavelet reconstruction using our extended signals to obtain values for the forecasted oil price data.

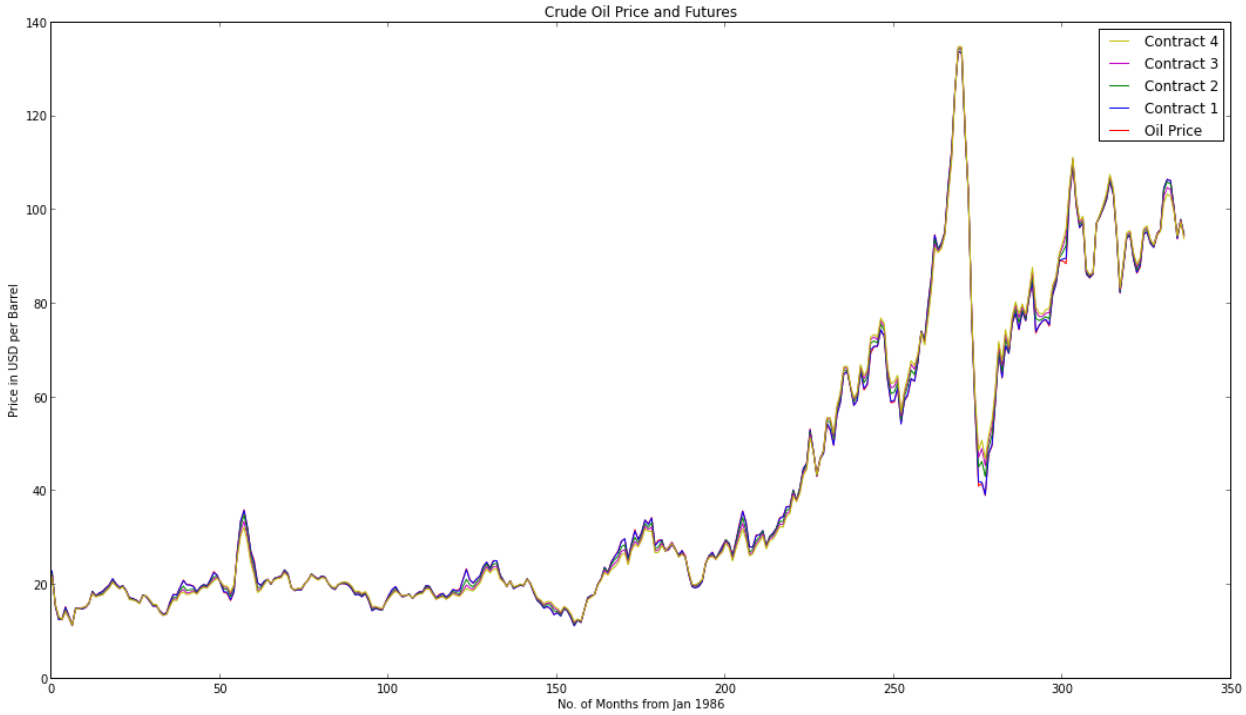
In our project, we have done a wavelet decomposition of 337 samples using a Daubechies 8 wavelet. The decomposition is a five level one. We get six signals out of it, i.e. the coarse signal at level 5 and the 5 fine signals at each decomposition level.

We have modeled and subsequently interpolated the coarse signal using two methods - Univariate Spline Fitting and Radial Basis Function based fitting. Both these forecasts are visible in graphs in the report.

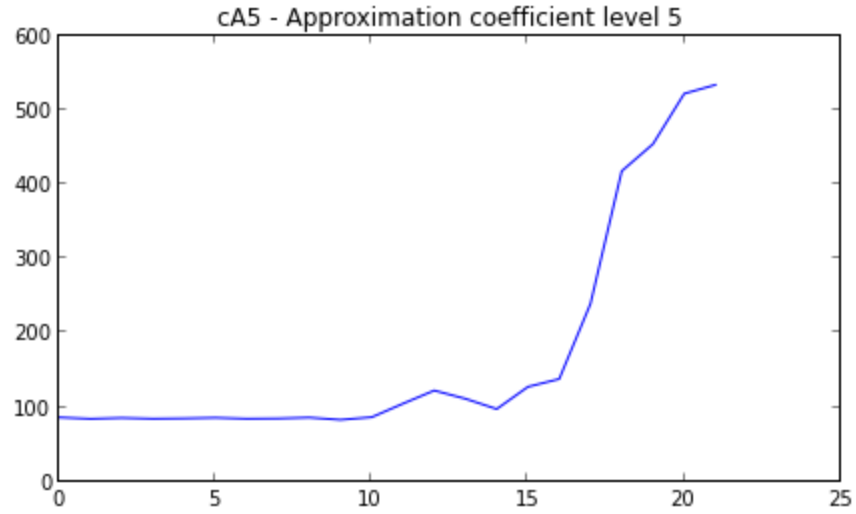
We have modeled the fine signals at each level by running a sine fitting code on them. This code models given signal with a sine function. While this is a crude approximation, we get satisfactory results from it. The sine fitting code returns estimated values of Amplitude, Frequency and Phase of the input signal.

Results :

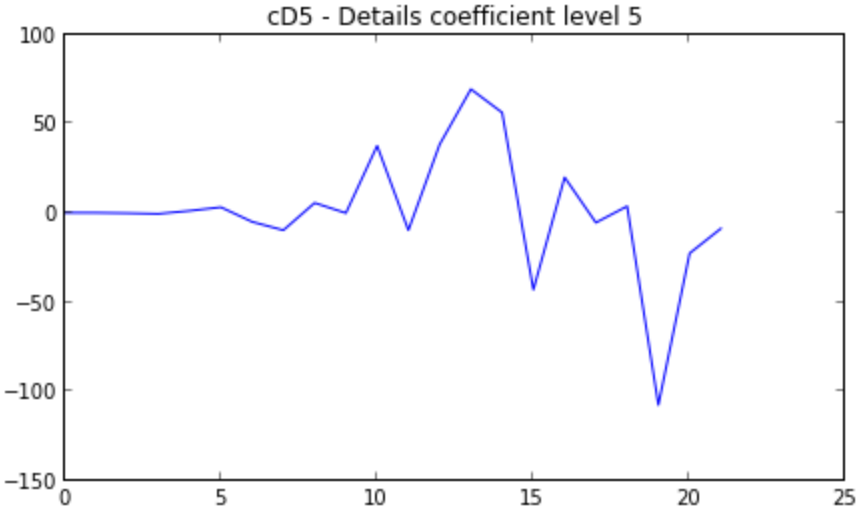
Plotting the original data of monthly oil prices for 336 months since 1986.

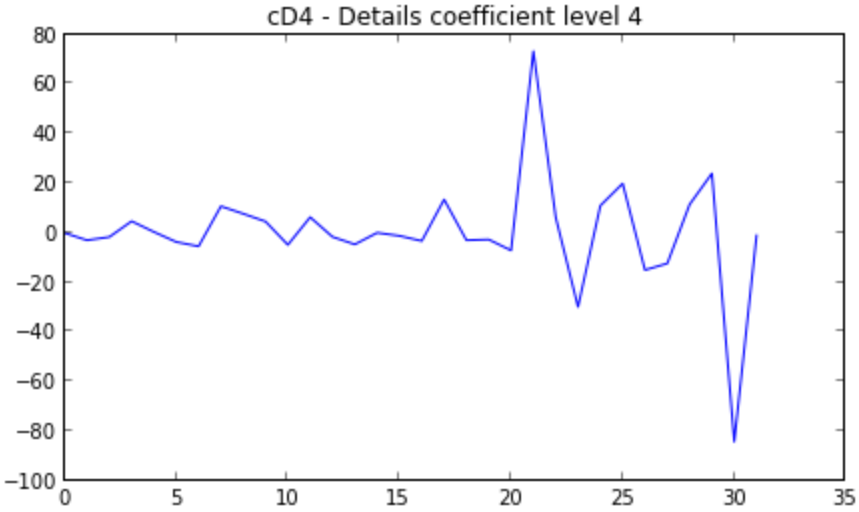


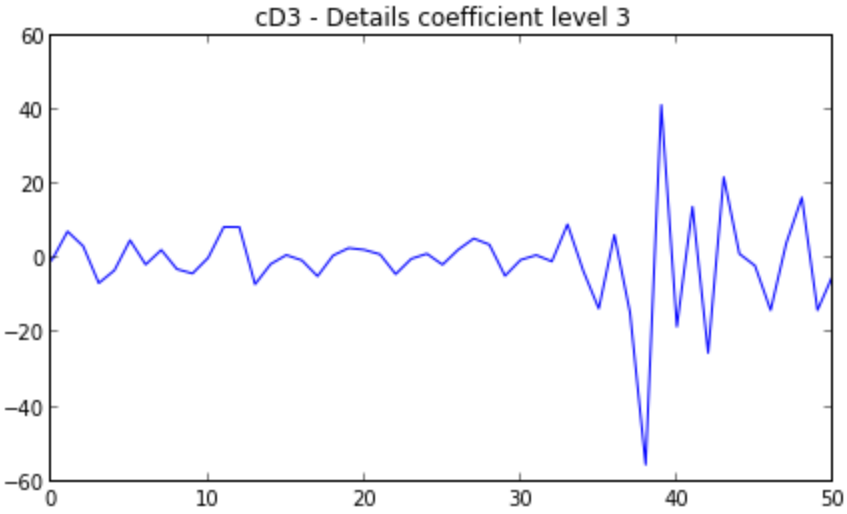
The 5th level Approximation coefficients obtained after 5 level wavelet decomposition of the Oil prices time series data using Daub8 wavelet.

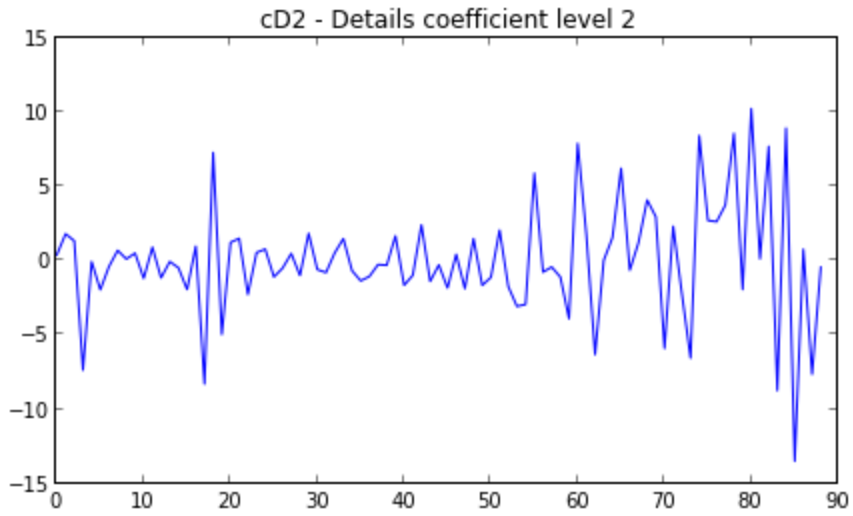


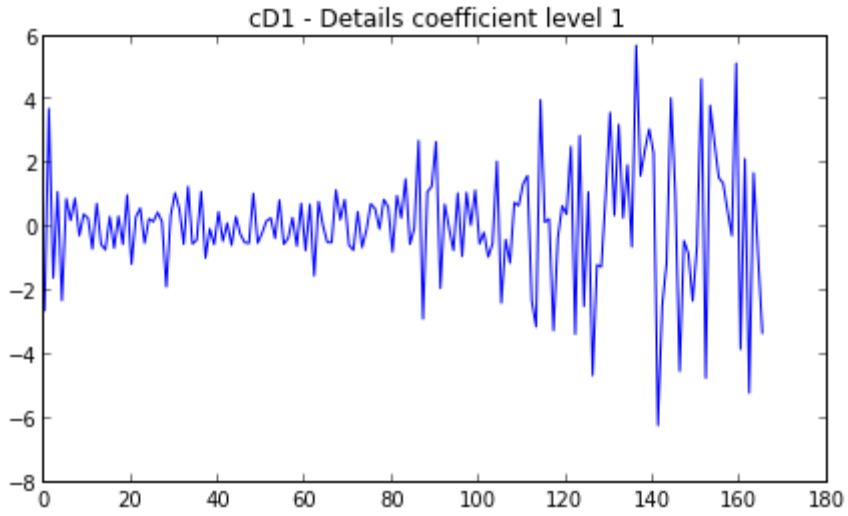
The following are the plots Detail coefficients obtained after 5 level wavelet decomposition of the Oil prices time series data using Daub8 wavelet.



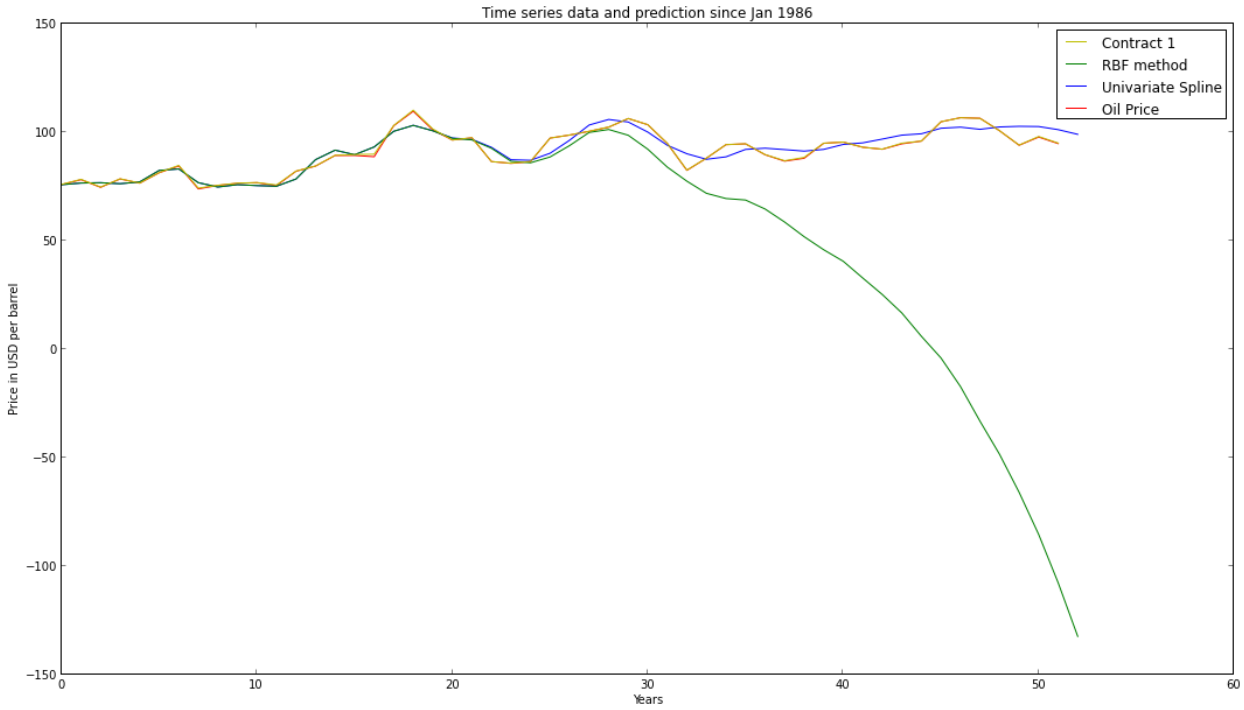








The detail coefficients were extended after fitting a sine curve. We tried two different methods to fit and extend the Approximation coefficients - i) Univariate Spline ii) Radial Basis Function(RBF) The following plot shows the reconstructed signal using the extended coefficients. As can be observed, reconstructed signal using Univariate Spline fit decently follows the actual signal for 36 months in future.



Conclusion:

We can see from the above graphs that we are able to reasonably predict the oil prices by performing the wavelet analysis as described above.

However, our predictions are not as good as those in the futures oil contract. Clearly, while wavelet based analysis is a good option, our implementation may not have taken care of all relevant factors which are necessary for such a prediction and those are beyond the scope of this course project.

References:

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