Journal of Industrial and Intelligent Information

CONTENTS

Volume 3, Number 2, June 2015

Time Series Forecasting of Crude Oil Consumption Using Neuro-Fuzzy Inference

Shaya Rubinstein, Aaron Goor, and Alexander Rotshtein
Dept. of Industrial Engineering & Management Jerusalem College of Technology, Jerusalem, Israel
Email: {shaya.rubinstein, Agoor84}@gmail.com, alexrot@inbox.ru

***Abstract*—Forecasting time series with lengthy and chaotic history can be challenging and complex. The demand of crude oil in the U.S. from 1974 – 2012 has much chaotic behavior. Many statistical methods are available for time series modeling for forecasting, however choosing the right method or methods is a difficult task. Forecasting and prediction models based on adaptive neuro-fuzzy inference systems (ANFIS) have shown to predict satisfactory error ranges in multiple fields of study. By experimenting with ANFIS we have succeeded to develop a method for modeling time series data parameters: the embedded delay and number of input variables. Our results show that ANFIS behavior across data models is intuitive and its projected forecast errors are indeed satisfactory. In addition, our best 12-month delay model in ANFIS provided a 12-month-ahead forecast with strikingly similar seasonal behavior to a forecast provided by the U.S. Dept. of Energy – Energy Information Administration for the same time period, and resulted in a lower overall projected forecast error. ANFIS as a parameter modeling tool for unaltered time series is therefore suggested to be quite helpful.**

***Index Terms*—ANFIS, crude oil, forecasting, fuzzy logic, neural networks**

I. Introduction

Forecasting time series that are chaotic in behavior over long periods of time can be challenging. While more widely-used methods such as linear and non-linear regression, trend analysis, and "deseasonalization" are common, the exact combination of which methods to employ for which time series is quite difficult to manage, in addition to determining which time series modeling parameters are optimal. In recent years, there has been significant research conducted in various fields to test the usefulness of *neural network sets* and *fuzzy logic* for constructing predictive models.

We have selected the demand of crude oil in the United States as our time series data object, and we are investigating the projected reliability and usefulness of forecasting models using neural networks and fuzzy logic sets, namely, ANFIS ("Adaptive Neuro-Fuzzy Inference Systems").

ANFIS as a method for forecasting will be discussed, with a main focus on the results of experiments conducted to test its advantages over classical statistical forecasting method(s), which are largely based on classic [Bayesian] probability. We will attempt to demonstrate that:

1) ANFIS can be used as a forecasting method which is both simpler to use and less expensive than other inference methods bearing optimistic results.
2) To accomplish this, we will attempt to determine an optimum number of input variables for building a time series data set for forecasting, while preserving the forecast error measured over time to a minimum.
3) When compared to other time series modeling methods (simple moving average, polynomial regression, and Gaussian regression), ANFIS may be the more attractive model to choose, as we intend to check all of the same parameters of forecast error in both methods, with the same data.

II. Background

A. Demand of Crude oil in the US has declined and has not recovered

The United States was until recently the world's largest importer of foreign crude oil, only to be surpassed by China (source: United States Energy Information Administration, Department of Energy). In 2008 crude oil prices (per barrel) climbed sharply and thus the demand for crude oil in the U.S. dropped accordingly. However since then the prices have balanced and global production has continued its previous growth trends while the demand for oil in the U.S. has not recovered to its previous trend. If this continues, the U.S. demand for oil will no longer be able to be considered as a stable consumer index and thus forecasting the behavior for demand of crude oil in the U.S. is significant.

Finding a method that could perhaps provide reliable, inexpensive and intuitive forecasting models for data of this type could be very useful. Today, the U.S. Energy Information Administration (US EIA) uses millions of dollars of congressional budget funds for "maintaining and operating" the NEMS (National Energy Modeling System) which is employed to model the data of many energy data inputs and provide short- and long-term forecasts for their monthly and annual reports. While the projections are made public, so are the basics of their modeling system as well as their congressional budget

Manuscript received March 8, 2014; revised July 8, 2014.

doi: 10.12720/jiii.3.2.84-90