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A hybrid fuzzy and neural approach for DRAM price forecasting

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ABSTRACT

The trend in the price of dynamic random access memory (DRAM) is a very important prosperity index in the semiconductor industry. To further enhance the performance of DRAM price forecasting, a hybrid fuzzy and neural approach is proposed in this study. In the proposed approach, multiple experts construct their own fuzzy multiple linear regression models from various viewpoints to forecast the price of a DRAM product. Each fuzzy multiple linear regression model can be converted into two equivalent nonlinear programming problems to be solved. To aggregate these fuzzy price forecasts, a two-step aggregation mechanism is applied. At the first step, fuzzy intersection is applied to aggregate the fuzzy price forecasts into a polygon-shaped fuzzy number, in order to improve the precision. After that, a back propagation network is constructed to defuzzify the polygon-shaped fuzzy number and to generate a representative/crisp value, so as to enhance the accuracy. A real example is used to evaluate the effectiveness of the proposed methodology. According to experimental results, the proposed methodology improved both the precision and accuracy of DRAM price forecasting by 66% and 43%, respectively.

1. Introduction

Dynamic random access memory (DRAM) is a type of volatile memory products. It uses capacitors to store information, and can be encapsulated into memory working modules. Currently DRAM has been extensively used in computer-related applications, communication systems, and other electronic devices. The price of DRAM not only influences the prices of the end products to a certain degree, but also is critical to the factory in establishing stock control policy and in planning capacity. Chen [1] also considered price as one of the sources to the competitiveness of a DRAM product. Besides, the trend in the price of DRAM is a very important prosperity index in the semiconductor industry. To reduce the risks of a DRAM factory in stock planning and capacity expansion, accurately forecasting the price of DRAM becomes very important.

There are two viewpoints in forecasting the price of a DRAM product. The first viewpoint, input-output relationship viewpoint, is to find out factors (e.g. demand, supply, economic conditions, etc.) that are influential to the price, and then to apply different approaches (e.g. multiple linear regression (MLR), artificial neural network (ANN), etc.) to model the relationship between the price and these factors, so as to forecast the price. The second viewpoint, time-series viewpoint, is to treat the fluctuation in the price as a type of time series. Theoretically there are many approaches, e.g. moving average (MA), weighted moving average (WMA), exponential smoothing (ES), MLR, ANN, and the others that can be applied to forecast the price. Generally, an ANN is suitable for modeling a nonlinear pattern of the price, while traditional approaches such as MA, WMA and ES have good performances when the trend in the price is stable.

Recently, some innovative attempts have been made. Chen and Wang [2] applied fuzzy interpolation to forecast the price of a DRAM product. The accumulation in the fuzziness is a problem in their study. Recently, Ong et al. [3] incorporated genetic algorithm (GA) and auto-regressive integrated moving average (ARIMA) for the same purpose, which improved the forecasting accuracy significantly. ARIMA was firstly introduced by Box and Jenkins [4] to analyze stationary univariate time series data, and has been used in various fields since then. Tseng et al. [5] proposed the fuzzy ARIMA (FARIMA) approach to forecast the exchange rate. However, the precision of the price forecast is an important issue, but which has seldom been investigated in the past. Namely, an interval containing the actual value has to be generated, especially when the possibly maximal and minimal profits of the factory needs to be estimated. Even with these attempts, it is still very difficult to forecast the price of a DRAM product accurately. Cupertino [6] highlighted the fact that it is only possible to quantitatively anticipate the turning points in this industry by measuring independent economic factors that influence purchases of DRAM products. Further, it is considered easier to estimate the demand/market of a DRAM product than its price.

Many studies have shown that fusing soft computing technologies such as ANN, fuzzy logic, GA, and the others may significantly

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improve the performance of an analysis [7–9]. The reasons are explained as follows. First, these technologies are for the most part complementary and synergistic. ANNs are usually used for learning and curve fitting. Fuzzy logic is suitable for dealing with imprecision and uncertainty, while GA can be applied in searching and optimization. Recently, Chen and Lin [10] combined fuzzy logic and a BPN and proposed a two-step approach for semiconductor yield forecasting, in which multiple experts constructed their own fuzzy yield learning models from various viewpoints to forecast the yield of a product. To aggregate these fuzzy yield forecasts, a two-step aggregation mechanism was applied. After the first step, it was guaranteed that the aggregation result had a narrower range and contained the actual value. Subsequently, the defuzzification of the aggregation result was turned into an optimization problem. In this way, both the precision and accuracy of semiconductor yield forecasting were simultaneously improved. Such concepts are considered applicable to forecasting the price of a DRAM product in this study. However, the models will be completely different. Besides, whether the two-step approach is also effective in a different field also needs to be examined.

To further enhance the performance of DRAM price forecasting, a hybrid fuzzy and neural approach, inspired by Chen and Lin's methodology, is constructed in this study. In the proposed approach, multiple experts (or decision makers) construct their own fuzzy multiple linear regression models from various viewpoints to forecast the price of a DRAM product. The rationale for adopting a fuzzy approach is explained as follows. Fuzzy (multiple) linear regression has been universally applied in forecasting various phenomena. There is considerable fluctuation in the price of a DRAM product that is not easily anticipated in advance. In fact, the price of a DRAM product is subject to two major stochastic factors – the supply and the demand in the industry. Fitting the demand or the supply within a future period with a distribution function is not easy, implying that a stochastic approach might not be applicable.

Price forecasts made by multiple fuzzy linear regression models are fuzzy in nature. The fuzzy price forecasts made by different fuzzy linear regression models need to be aggregated, in order to optimize some criterion. Each fuzzy multiple linear regression model can be converted into two equivalent nonlinear programming problems to be solved. Besides, these expert opinions can also be considered as unequally important. Subsequently, a two-step aggregation mechanism is applied. At the first step, fuzzy intersection is applied to aggregate the fuzzy price forecasts into a polygon-shaped fuzzy number, in order to improve the precision of DRAM price forecasting. After that, considering the special shape of the polygon-shaped fuzzy number, a BPN is constructed to defuzzify the polygon-shaped fuzzy number and to generate a representative/crisp value, so as to enhance the accuracy.

The rest of this paper is organized as follows. Section 2 introduces the proposed methodology which is composed of three steps. The real price data of a DRAM product have been collected and is used to demonstrate the application of the proposed methodology. To evaluate the effectiveness of the proposed methodology, some existing approaches are also applied to the collected data for comparison in Section 3. Based on analysis results, some points are made. Finally, the concluding remarks and some directions for future research are given in Section 4.

2. Methodology

The proposed methodology has several steps (see Fig. 1) that will be described in the following sections:

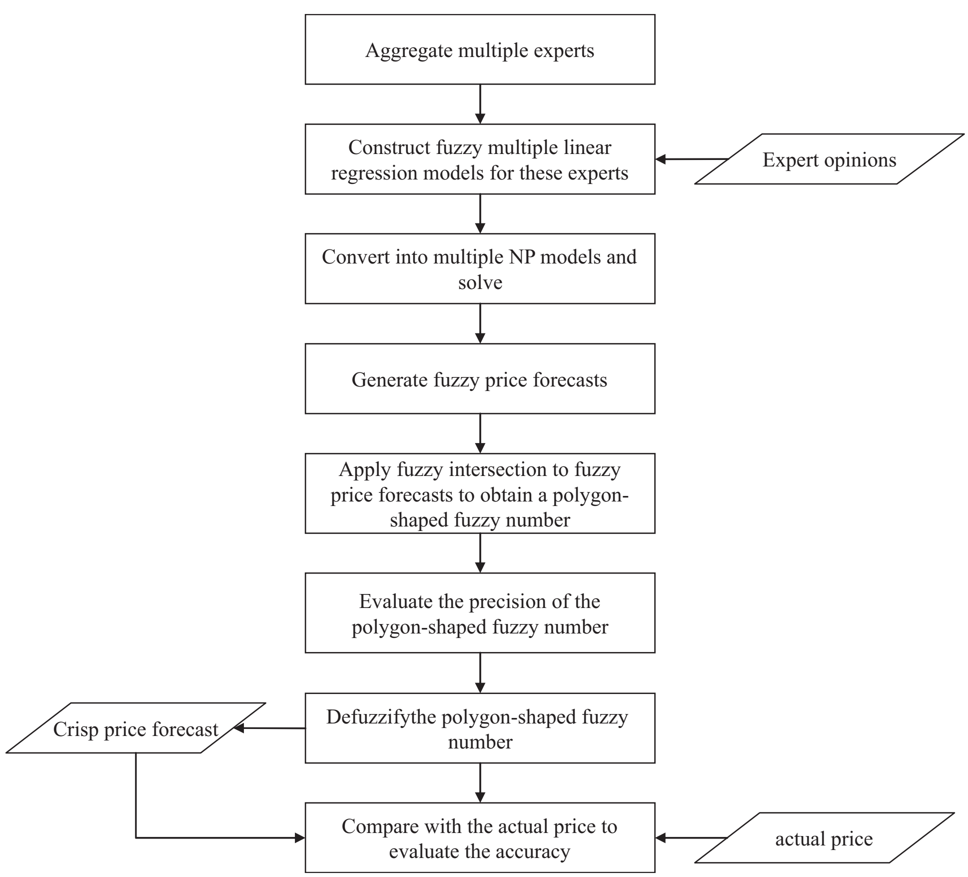

Fig. 1. The steps in the proposed methodology.