K-NEAREST NEIGHBOUR TECHNIQUE FOR THE EFFECTIVE PREDICTION OF REFRIGERATION PARAMETER COMPATIBLE FOR AUTOMOBILE

by

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Manufacturing simulation is an encouraging research area in resent decade. Creation or development of better simulation tool or technique is one of the major intension in manufacturing simulation. In resent research most of the manufacturing processes are simulated successfully. But some processes are not yet simulated effectively, especially automatic air conditioning (AC) system or refrigeration system. The automatic AC system for the passenger vehicle are not yet effectively simulated. Hence in this paper a machine learning technique is adopted for the effective prediction of parameter of automatic AC system. The proposed system uses k-nearest neighbour technique for the prediction of parameter will less error and high accuracy. The proposed system is implemented using MATLAB and its performance is compared with the support vector machine and ANN in terms of mean square error and accuracy. The proposed technique outperforms the conventional technique and suggest that the k-nearest neighbour become the most suitable technique for the modelling and performance analysis of automatic AC system.

Key words: *automatic AC system, k-nearest neighbor, refrigeration modelling, machine learning algorithm*

Introduction

Refrigeration system or AC systems are widely used in many field especially medicine, food, *etc.* In order to maintain a substance at a stable temperature the refrigeration is used. It can reduce the temperature of environmental air by passing it through a cooler or coolant. In the modern world to make and to the advancement of technology and its usage [1]. The refrigeration is used in the day to day activities of the human being in the universe. The

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normal air conditioner is used in building to maintain the temperature level. In the later period the AC system is equipped with most of the automobile. In particular the latest cars or most of the passenger vehicle are equipped with advanced AC system to make their journey more comfort [2].

The AC system consists of three main parts, such as condenser, compressor, and evaporator. The compressor produce air the condenser and fan observe the hot air from the room and the air is cool down by evaporator [3]. The condenser is one side and the evaporator is another or outside. In the convention AC system the temperature level, speed of fan is tuned manually. Automatic AC system are the latest version of AC system, it can automatically adjusted to maintain the speed of air and temperature level [4].

In the latest automobile or passenger vehicle the automatic air conditioning system is installed to make more comfort to the passenger. The automatic AC system the direction of ac outlet, velocity of air, and temperature is automatically adjusted based on the mode of drive of the car and the environmental temperature [5]. In this type of AC system the compressor belt is directly connected to the vehicle engine to make a co-ordination between vehicle and AC system. Due to this, the dive mode or the speed of vehicle can influence the control of AC system. These type of AC system is more complicated than conventional system, but is mostly used to its features [6].

The automotive industry, should maintain a research and development department to consistently improve the performance of their vehicle. In this sense, the expert in the R&D team of automotive industry also concentrated on the design of an effective AC system [7]. One of the major activities of R&D is manufacturing simulation, in which they design, model and simulate the vehicle and analysis its performance before manufacturing. In past two decade, the researcher developed numerous tools for the simulation of various functioning of vehicle. But simulation of some resent technology including AC system is more complicated due to the lack of proper simulation system [8].

Hence in recent years, some researchers concentrated their research on the development of suitable technique for the simulation of AC system. Most of these techniques used the mathematical modelling of the AC system to choose the proper component. In some research the authors used optimization technique for the selection of suitable refrigerant [9]. Recently as an advanced technique, the authors simulated a AC system and modelled it then the performance of actual and predicted is analyzed. In the advanced simulation technique they can predict more accurate result with maximum tolerance of 10%.

In current era, artificial intelligence are penetrated in every field for the betterment of the particular field. In this sense the artificial intelligence or soft computing technique are used of the modelling and analysis of automatic AC system for automobile application. Kamar *et al.* [10] have presented an ANN for the effective prediction of performance of the automatic AC system. They have reduced the mean square error up to 1.65% and achieved good accuracy. Still the level of accuracy is not up to the mask. Hence in this work we planned to proposed a novel machine learning technique for the effective prediction of the performance of the automatic AC system.

Modelling of k-nearest neighbour for AC parameter prediction

The k-nearest neighbour (KNN) is a simple and easy to implement machine learning algorithm used for the classification of unknow data. It is a supervised classifier or the machine learning technique can be used as a regression or classifier. The major function of KNN is that it can store all the know data and predict the unknow data based on the similarity with

the know data. This technique uses similarity measure to predict the closer value using Euclidean distance. Euclidean distance is a simple function or formula to measure the similarity between two point or data. The architecture for the KNN is given in fig. 1.

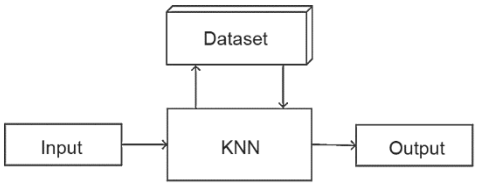

Figure 1. The KNN architecture for the AC system

Data collection

In this work we used the data obtained by the experimentation conducted in [10]. In the experimentation the authors constructed the automatic AC system using original components of a Denso AC system. The system was used at compact size to suitable for car and used the R-134a refrigerant. In the experimental set-up they used temperature sensor to measure input and outlet temperature of air-flow. A velocity transducer was used to measure the velocity of air flowing through the condenser coil and evaporator. Then a frequency inverter was used to regulate the compressor speed. Then k-type thermos-couples were used at various location of refrigeration to measure the refrigerant temperature. The line diagram of automatic AC system for passenger vehicle is given in fig. 2.

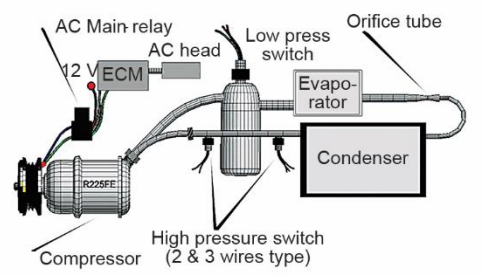

Figure 2. Automatic AC system of passenger vehicle

The Bourdon tube pressure gauge was used to measure the variable pressure at the discharge and compressor section. In their experimentation they set zero loss at the piping, so the actual pressure at the condenser and evaporator had not change. Then a flow meter was used to measure the refrigerant's mass-flow rate. The flow meter was mounted at the condenser exit valve. The cooled state of the refrigerant was ensured by using sight glass tube, which was place before the flow meter. The description of instruments used in the experimentation is given in tab. 1.

Table 1. Component and instrument description

Instrument	Measured variable	Range	Uncertainty
Bourdon gauge	Pressure	0-300 kPa	±1 kPa
Digital ammeter	Current	0-20 A	±1%
Digital tachometer	Compressor speed	0-20,000 rpm	±2%
Digital voltmeter	Voltage	0-250 V	±1%
Flow meter	Mass flow rate	0-25 kg/s	±1%
Humidity sensor	Humidity	0-100% RH	±1%
RTD sensors	Temperature	–25 °C-100 °C	±0.3 °C
Velocity transducer	Air velocity	0-20 m/s	±0.5%

The KNN has two major phases they are training and testing, in training 70% of the collected data is used and the rest 30% is used for testing. The training phase KNN maintain a

dataset of actual or know data. Then with used for finding the similarity between the unknown data.

Training

In the training phase of KNN the know data with class is store in separate database. In the proposed study the known data is nothing but the data collected from the experimentation. In which the actual input as well as the output is known. The training phase will create a training model or KNN model, then its model is used at the testing phase to evaluate the similarity.

Testing

The testing phase is the evaluation phase in which, the KNN is evaluated for giving unknow data and the output is obtained. In the testing phase of the KNN the system will find the *k* similar data from the training model and gives the maximum number of same class as output. Here the Euclidean distance is used to find the k similar data and is given:

$$Dist = \sqrt{\sum_{i=1}^{k}(x_i - y_i)^2} \tag{1}$$

Example: Let X is the training model and it contains *n* samples, then *Y* is the testing input, set $k = 3$. Then the system finds the 3 similar data from the *x* to the *y* is found, then analysis the class of obtained 3 similar data. Then the class occurred maximum time is assumed as the class of *y*.

Performance analysis

The proposed KNN technique for the effective prediction of automatic AC system parameter is implemented using MATLAB in windows platform. The proposed system is compared in terms of mean square error (MSE) with ANN and support vector machine (SVM). The MSE of various classifier technique is given in tab. 2.

Table 2. The MSE of various algorithms

Simulation technique	MSE	MSE
ANN	9.05×10^{-5}	1.65%
SVM	3.14×10^{-5}	0.97%
KNN	2.56×10^{-5}	0.89%

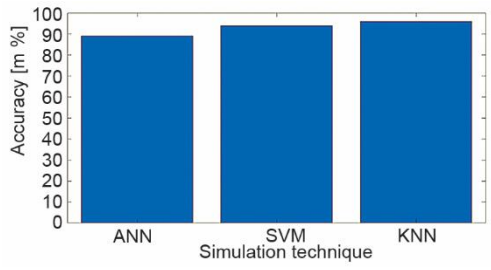

Figure 3. Accuracy comparison of various technique

Table 2 gives the MSE and MSE in percentage of ANN, SVM, and KNN for the prediction of performance of the automatic AC system. The results clearly proves that the ANN has error percentage of 1.65% and SVM has 0.97% but the proposed KNN has lesser error than other technique. Similarly the prediction accuracy of the proposed KNN is compared with the ANN and SVM and its performance chart is given in fig. 3.

Figure 3 shows the comparison chart of ANN, SVM, and KNN based on accuracy. One of the major intension of this work is to enhance the prediction accuracy by using proper classification technique for the automatic AC system. The chart clearly shows that the accu-

racy of the KNN is higher than the SVM, and ANN technique, hence it overcome the issue in the literature by achieving the more than 90% accuracy. Thus based on this performance analysis we suggest that the KNN for the modelling of automatic AC system is more suitable for the effective prediction of automatic AC system performance.

Conclusion

The KNN for the modelling of automatic AC system is given in the proposed paper. The KNN is used for the development of machine learning based simulation technique for the manufacturing simulation of automatic AC system for passenger vehicle. The proposed technique has two major phase in the initial phase the experimentation is conducted to collect the real or actual data for the creation of training model. Then the Euclidean distance is employed to obtain the *k* similar data to the test data. Then based on the obtained CLASS the output class value will be predicted. Then proposed system is implemented using MATLAB and the performance are analyzed in terms of MSE and MSE percentage. The results of conventional ANN, SVM are compared with the proposed KNN. The performance analysis clearly proves the effectiveness of the proposed system for the modelling and analysis of automatic AC system.

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