MODELLING AND ANALYSIS OF AUTOMATIC AIR CONDITIONING SYSTEM USING SUPPORT VECTOR MACHINE

by

Santhosh SRINIVASAN[a*], Sakthivel PERUMAL[a], Rajaguru KADASARI[b], Lakshmanan PANDIYAN[b], and Suresh Kumar BALAKRISHNAN[b]

[a] Department of Mechanical Engineering, Sri Krishna College of Technology, Coimbatore, India
[b] Department of Mechanical Engineering, K. Ramakrishnan College of Technology, Trichy, India

Original scientific paper
https://doi.org/10.2298/TSCI190622437S

Automatic air conditioning system is encouraged in most of the automotive especially passenger cars. This system can enable higher standard of comfort to the passengers, so the automotive industries are trying to implement the automatic air conditioning system in most of their vehicle. One the other hand manufacturing simulation is additional processing experienced in most of the manufacturing industry, to analysis the complete performance of the product or vehicle before it manufacturing. In recent decade more than 100 simulators are developed to analysis the various operation of the manufacturing and vehicle. But simulation analysis of air conditioning system and automatic air conditioning system is challenging to the engineer. They may require to spend more time to analysis the performance of the automatic air conditioning system. Thus in later period soft computing based system for the effective performance prediction of automatic air conditioning system is proposed. But the prediction accuracy of the past technique is not in the satisfactory level. Hence in this paper, a novel soft computing technique is proposed for the effective prediction of the performance of the automatic air conditioning system. In the proposed system support vector machine is used for the prediction of the performance of automatic air conditioning system. The performance of the proposed technique is compared with the ANN.

Key words: *automatic air conditioning, support vector machine, ANN, manufacturing simulation*

Introduction

In recent decade the automatic air conditioning (AC) system is encouraged in most of the automotive especially passenger car [1]. The automatic AC system can helps to maintain a comfort environment condition to the passenger in the car compartment. In order to achieve this comfort condition, the AC outlet direction, velocity, volume and temperature of the air should adjusted based on the environment and mode of drive of the car [2]. In most of the automatic AC system the compressor is belt driven, the belt is mostly connected to the vehicle engine. So the capacity of cooling is proportional to speed of the car or engine. In advanced cars the ac system should lower the temperature quietly and quickly to maintain comfort of the passenger. Due to these wide constrains the automatic AC system is more complicated than the conventional static AC system [3].

* Corresponding author, e-mail: drssmech@gmail.com

In the advancement of the automotive system, the researcher intend to predict the performance of the automatic AC system before its implementation [4]. In the initial stage the experimentation was conducted to evaluate the performance of the automatic AC system. In some research the authors used R-12 and R-134a refrigerants are to evaluate the performance such as compressor speed and determined the optimum condition for operating the automatic AC. In some other research the authors used R-134a refrigerant to analysis the performance such as mode of heat pump and operating condition. In some research the speed of air at both inlet and outlet is analyzed [5].

In recent year the simulation is encouraged in most of the manufacturing activity [6], thus in the performance analysis of automatic AC system simulation is used. In most of the previous research, the authors used the simulation technique to optimize the different refrigerant for the best performance automatic AC system [7]. In some work the automatic AC system is mathematically modelled to analysis the performance such as refrigerant and component selection for the system. The most of the simulation based research work demonstrated the similarity of the experimental and simulation result [8]. In the most of the simulation work they predicted the performance with the tolerance of 10%. It might not be such a big issue comparing to the economic factor of the real performance prediction [9].

But now days the researchers have developed better performing soft computing artificial intelligence technique for the multipurpose in engineering and application. In this series, 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 soft computing classifier technique for the effective prediction of the performance of the automatic AC system.

Experimentation and data collection

The experimental works were performed on compact system that can be used commercially in various applications like room cooling, mobile refrigeration storages, automotive cooling system, *etc*. In the present work, Denso air conditioning was carried out with the aid of R134a refrigerant and other important components of air conditioning system. Values of several parameters were measured precisely with higher accuracy using specific devices that are mentioned in tab. 1. The pressure was monitored using bourdon tube pressure gauge, K-type thermocouples were used for temperature measurement of air flowing in and out of the system and temperature of refrigerant flowing through various components. A flow meter was utilized to monitor the amount of refrigerant flowing in the system. Condition of refrigerant was monitored by positioning a sight glass tube over the flow meter.

Modelling of support vector machine for automatic AC system

The intension of the proposed model is to predict the performance of the automatic system such as cooling effect, C_{effect}, compressor input power, P_{comp}, and COP. The prediction is made based on the inputs compressor speed, S_{comp}, evaporator temperature, T_{evap}, velocity of condenser, V_{cond}, and condenser temperature, T_{cond}. Thus the proposed model has four inputs and three output or class. The support vector machine (SVM) is a machine learning algorithm used to solve the complex classification problem. The SVM can effectively categories the input data based on the class value.

The SVM classifier has two major phases, they are training and testing. In the training phase the data collected from the experimentation is trained to model the SVM to perform

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%
The RTD sensors	Temperature	–25 °C-100 °C	±0.3 °C
Velocity transducer	Air velocity	0-20 m/s	±0.5%

as an automatic AC system. Then in the testing phase the performance of the automatic AC system is predicted *via* the modelled the SVM system. The schematic of the proposed SVM system for the prediction of performance of automatic AC system is given in fig. 1.

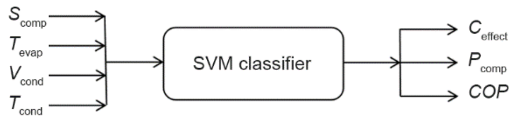

Figure 1. The SVM system for automatic AC performance prediction

Performance analysis

In the proposed system the SVM is proposed for the modelling of automatic AC system, and its performance is compared with the conventional ANN. The proposed system is implemented in MATLAB using the experimental data obtained from [10].

The comparison is made based on the metrics such as mean square error (MSE) and prediction accuracy. The overall performance of the proposed system is better than the conventional system. The MSE of the proposed and existing system is given in tab. 2.

Table 2. The MSE of proposed and existing system

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

Table 2 gives the MSE and MSE in percentage of ANN and SVM for the prediction of performance of the automatic AC system. The results clearly proves that the ANN has error percentage of 1.65% and in case of proposed SVM technique the error is reduced less than the unit percentage. Similarly the prediction accuracy of the proposed SVM is compared with the ANN and its performance chart is given in fig. 2.

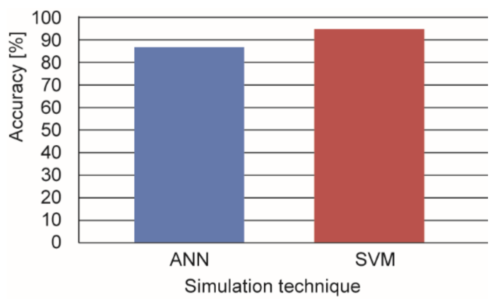

Figure 2. Accuracy comparison

Figure 2 shows the comparison chart of ANN and SVM 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 accuracy of the SVM is higher than the 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 SVM for the modelling of automatic AC system is more suitable for the effective prediction of automatic AC system performance.

Conclusion

The paper proposed a novel technique for the modelling of automatic AC system and the model is used to predict the system performance. The proposed system utilized the SVM classifier, it is modelled with four inputs and three outputs. The inputs are compressor speed, evaporator temperature and condenser temperature and velocity. Then the model predicts the cooling effect, evaporator input power and COP. The proposed system is tested using a test data obtained from the literature. Then the performance of the system is analysed with the ANN technique. The performance analysis proves the effectiveness of the proposed technique. Ultimately it is evident that the proposed technique will become a suitable alternate for the performance prediction of automatic AC system.

References

[1] Helveston, J. P., *et al.*, Institutional Complementarities: The Origins of Experimentation in China's Plug-in Electric Vehicle Industry, *Research Policy, 48* (2019), 1, pp. 206-222
[2] Saravankumar, P. T., *et al.*, Ecological Effect of Corn Oil Biofuel with SiO_2 nanoadditivies, *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 41* (2019), 23, pp. 2845-2852
[3] Sathish, T., Experimental Investigation on Degradation of Heat Transfer Properties of a Black Chromium-Coated Aluminium Surface Solar Collector Tube, *International Journal of Ambient Energy, Taylor and Francis Publishers,* (2018), On-line first, https://do.org/10.1080/01430750.2018.1492456
[4] Vivekanandan, M., *et al*., Pressure Vessel Design using PV-ELITE Software with Manual Calculations and Validation by FEM, *Journal of Engineering Technology, 8* (2019), 1, pp. 425-433
[5] Pradeep Mohan Kumar, K., *et al.*, Computational Analysis and Optimization of Spiral Plate Heat Exchanger, *Journal of Applied Fluid Mechanics*, *11* (2018), Special issue, pp. 121-128
[6] Sathish, T., Karthick, S., HAIWF-Based Fault Detection and Classification for Industrial Machine Condition Monitoring, *Progress in Industrial Ecology, 12* (2018), 1/2, pp. 46-58
[7] Avudaiappan, T, *et al.*, Potential Flow Simulation through Lagrangian Interpolation Meshless Method Coding, *Journal of Applied Fluid Mechanics*, *11* (2018), Special issue, pp. 129 -134
[8] Karthick, S., Semi Supervised Hierarchy Forest Clustering and KNN Based Metric Learning Technique for Machine Learning System, *Journal of Advanced Research in Dynamical and Control Systems, 9* (2017), Special issue 18, pp. 2679-2690
[9] Godwin Antony, A., *et al.*, Experimental Investigation of I. C. Engine Using Various Diesel Blends, *Asian Journal of Research in Social Sciences and Humanities*, *6* (2016), 12, pp. 221-235
[10] Kamar, M. H., *et al*., Artificial Neural Networks for Automotive Air-Conditioning Systems Performance Prediction, *Applied Thermal Engineering, 50* (2013), 1, pp. 63-70

Paper submitted: April 12, 2019
Paper revised: May 12, 2019
Paper accepted: June 3, 2019