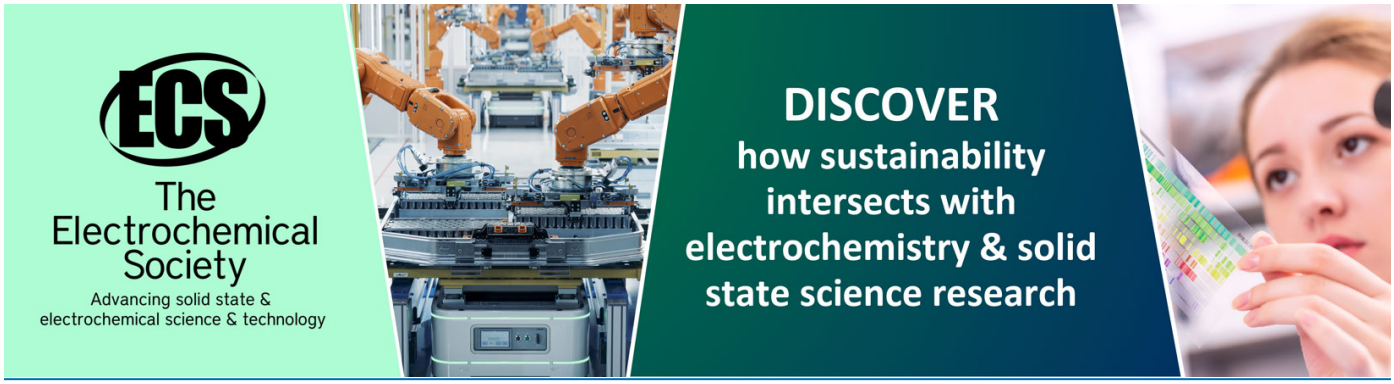
Application of Artificial Intelligence Technology in Mechanical and Electronic Pump System



Application of Artificial Intelligence Technology in Mechanical and Electronic Pump System

Yanmei Jiao*

Xi'an University School of Mechanical and Material Engineering 710065

*Corresponding author e-mail: 285654584@qq.com

Abstract. With the rapid development of modern science and technology today, a variety of emerging technologies representing advanced productivity can not only greatly improve the effect of equipment automation, but also promote the overall quality and level of manufacturing equipment, and even to the greatest extent to avoid the occurrence of safety accidents caused by human factors. Recently, in the mechatronic pump industry has emerged with the development of artificial intelligence technology color, the complexity of its internal structure and the precision of electronic control system has even reached a jaw-dropping degree. Artificial intelligence technology involves a wide range of knowledge, and has a very high degree of complexity and technology, the use of mechanical and electronic industry will certainly promote the whole industry to a higher stage of development. It can be expected that if ai technology can be applied continuously and stably in the mech industry, then the integrated drive system is expected to achieve the goal of high turnover and low cost, and will achieve value compensation in terms of economy and efficiency by improving operation characteristics and saving energy.

Keywords: Artificial Intelligence Technology, Mechatronics Pump, Instrument Automation, Electronic Control

1. Introduction

Modern mechanical and electronic pump system is an engineering system with many design disciplines, which can also be classified into the category of mechanical integration [1]. The development history of mechatronics pump can be roughly divided into the following three stages: the first stage is also the primary stage, in this stage, mechanical electronics is still in the embryonic stage of development, there are more development constraints, many development opportunities are not mature, the efficiency of the machine chemical industry production is low; The second phase is also called the development phase, at this stage, machinery and electronics engineering began to move

towards marketization of mechanical production direction, formed the assembly line production mode, to improve the labor efficiency greatly, and the precision of the products, also has further guaranteed and the worker's labor has been greatly reduce [2-3]. However, market demand is not static. With the development and growth of the market, higher requirements are put forward for products [4]. The operation mode of the assembly line can only process the standard parts, and its disadvantages are exposed. The third stage is the mature stage, which shows that with the continuous penetration of artificial intelligence technology into all walks of life, it has been more and more widely applied in the field of mechatronic, making the field of mechatronic engineering finally enter the mature stage of development [5-6]. With the penetration of artificial intelligence technology, mechanical and electronic products have become smaller and smaller in size, but more and more powerful in function, thus meeting various high requirements of the market [7].

In the development process of the machinery industry, research achievements on mechanical systems engineering and artificial intelligence technology are also emerging, and the relationship between mechatronic engineering and artificial intelligence technology is getting closer and closer. The former provides product support for the application of the latter, while the latter provides strong technical support for the former [8-9]. At present, the research on mechanical and electronic pump system at home and abroad is focused on the linear system. Foreign researchers believe that the characteristics of mems are their multivariable and nonlinear outputs. If the traditional system analysis method is used to identify the mems, it will be found that there are still insurmountable obstacles in mathematical theory [10]. In China, on the basis of complex calculation and batch processing, some researchers began to study how to use the genetic algorithm of artificial intelligence combined with relevant theories to solve problems encountered in reality [11]. However, current researches only focus on system prediction, system identification and optimal control, and the research on mechatronics pump simulation modeling and artificial intelligence technology combined with neural network algorithm is still in a blank stage [12-13].

The research in this paper regards artificial intelligence technology as an unconventional expression, gives it the function of establishing system models, and regards it as the inverse dynamic model of controlled objects [14]. In the research method, the neural network method and the mechanical and electronic pump system component modeling method are used to solve the electronic pump system identification problem. According to the experimental results, the average error between the test data and the ideal value obtained by combining the above two methods is only 6.45%. This indicates that it is feasible for ai technology to distinguish the mechatronics pump system, and ai technology has the potential to solve the control error of the mechatronics pump system and optimize the performance [15].

2. Method

2.1 Construction of Mechatronics Pump System Component Model

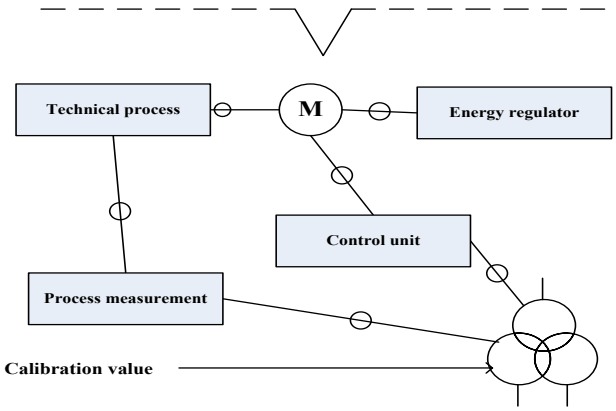


Figure 1. Mechatronics pump system component model framework diagram

Speaking of the mechatronics pump drive device, in most cases can be understood to be controlled by the frequency modulation motor. In this respect, the function of the frequency-modulator is to allow the user to control and adjust the alternating current of constant amplitude and frequency to a variable configuration as required. Electronic pump speed regulation can also achieve the purpose of energy saving. As the volume of the electronic pump module continues to shrink, more and more components have been allowed to merge into a physical whole, and the model composition of the electronic pump module has been presented. The model composition of the system component is shown in figure 1 below. It can be seen from the figure that which of the physical components of the whole mechatronics pump are integrated together and the implementation components of its assembly are fully viewed.

2.2 Requirements for Artificial Intelligence Integrated Drive System

In recent years, the realization of partial intelligence of partial artificial intelligence has promoted the attention of artificial intelligence devices. Based on these deployment goals and requirements, electronic pumps play an essential role in the overall process. Partial artificial intelligence means that the electronic pump needs to undertake the functional adaptation of connectivity and adaptation to changes in process requirements as well as its own monitoring. Based on the fact that ai electronic pump drives often work in complex processes and in different applications, we outline a wide range of requirements:

High reliability and availability;

-- Simple matching with application through field parameterization;

-- With integrated drive protection function and defect diagnosis function;

-- Achieving required and economical fluid transfer through speed adjustment;

-- Electromagnetic coordination;

-- Having an interface to communicate with the superior system;

-- Mechanical compatibility with IEC standard motors;

-- With pump characteristic control function;

-- Simple mechanical and electrical connection;

-- Simple operation, local control or remote control;

-- Simple mechanical and electrical connection;

-- With local artificial intelligence characteristics.

2.3 Neural Network Algorithm Based on Artificial Intelligence Technology

The neural network structure of feedforward network is adopted in this paper. In order to adopt sufficient system information, the inlet water temperature of condenser, compressor frequency, condenser water flow, evaporator water flow and inlet water temperature of evaporator are taken as the network input. Two neural networks are used to output the outlet water temperature of the condenser and the outlet water temperature of the evaporator respectively. The characteristic parameters of other heat pump systems can be calculated based on these two and known parameters, and the weight adjustment rate of the neural network is selected as:

$$\Delta w = (J^T J + \mu I)^{-1} J^T e \quad (1)$$

In the formula of the weight adjustment rate, J is the matrix of the derivative of the error with respect to the weight, e is the error vector, is a scalar when is very small, the above formula becomes the gauss-newton method. In this method, is adaptive. In order to facilitate the convergence of the network, the network input is normalized, and the normalized formula is:

$$(x-a)/(b-a) = (a-x)/(a-b) \quad (2)$$

Where, x is the actual input vector before normalization, a is the minimum input in the actual input vector, and b is the maximum input in the actual input vector.

3. Experiment

In the experiment of the mechatronics pump, we set the inlet temperature of the evaporator to keep around 40℃, while the inlet temperature of the condenser was set at 50℃, 45℃, 40℃, 35℃ and 30℃. After the system was stable, the data began to be read. If manual recording is adopted to read data, the acquisition frequency is once every 10 minutes, while the computer acquisition frequency is once every minute to collect 20 sets of data. Then the frequency converter is used to adjust the input frequency of the primary compressor. The set compression frequency is altogether 5, respectively 30Hz, 35Hz, 40Hz, 50Hz and 55Hz.

After the tests of 5 groups of different frequencies are completed, the inlet water temperature of the condenser is adjusted to reach another temperature set point, while the inlet water temperature of the evaporator is kept at about 40℃. Then the test is conducted according to the above 5 groups of frequencies and the data are recorded. After all the above tests, change another condenser water flow rate.

During the whole test, a total of 5 condensers were transformed, which were 0.053kg/s, 0.082kg/s, 0.151kg/s, 0.136kg/s and 0.162kg/s. That is, fix two of the three variables, change all the variable values in the change field of the other variable once, and make a round of experiments until all the operating points of various combinations of the three variables are achieved. In this study, a total of 130 groups of experimental data under working conditions were recorded, and the data collected under these 130 groups of working conditions constituted the data sample set for establishing and testing the system model.

4. Discuss

4.1 Identification Analysis of Electronic Pump Heat Pump Based on Neural Network Algorithm

In this study, the training network adopted experimental data of 130 working conditions, while the test network tested the water temperature test error at the outlet of the condenser and the water temperature test error at the outlet of the evaporator with five groups of evenly distributed data. The data results obtained from the identification of electronic pump heat pump were shown in figure 2 below.

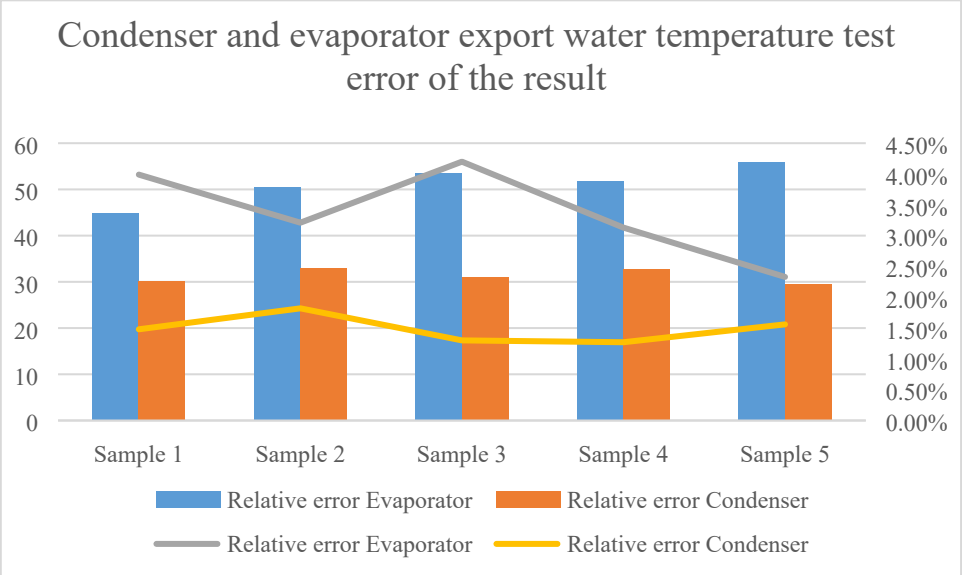


Figure 2. Test error results of water temperature at the outlet of condenser and evaporator

When the neural network algorithm based on artificial intelligence technology is applied to the research of mechatronics pumps, it is necessary to use the random method to program the primary generation population, and to generate the primary generation individuals by the hybrid method. During the crossover process, the maximum depth of the individual algorithm tree is 17, the crossover probability is 0.86, the maximum depth of the initial generation individual algorithm tree is 7, and the number of individuals in the group is 450. Four individuals are used to illustrate the overall process of identification. The individual adaptability measurement results are shown in table 1 below.

Table 1. Individual adaptability measurement results

		a(℃)	b(Hz)	c(kg/s)	d(kg/s)	E(℃)	T(℃)
Sample	1	50	55	0.1442	0.2653	36.342	59.01
	2	50	55	0.1643	0.296	37.183	61.23
	3	50	55	0.0874	0.2649	37.827	66.07
Return value	Individual 1	31.7	8.058	48.536	-49.215	/	
	Individual 2	31.7	6.382	47.541	-49.274		
	Individual 3	31.7	4.709	45.031	-49.196		
	Individual 4	42.48	6.731	44.905	-57.939		

In the table, a, b, c, d and E respectively represent the inlet water temperature of the evaporator, the compressor frequency, the evaporator water flow, the condenser water flow and the inlet water temperature of the condenser, and T represents the measured value of the outlet water temperature of the condenser. It can be seen from the table that individual 3 has the best adaptability, while individual 4 has the worst adaptability.

4.2 Application Analysis of Artificial Intelligence Technology in Mechanical Pumps

In this paper, the neural network algorithm as the underlying algorithm, combined with artificial intelligence technology, through the experiment to collect a variety of operating conditions of samples, to determine the mechanical and electronic pump system model. From the process of obtaining the model, the neural network algorithm has the ability of learning and adaptation. Therefore, in the field of mechanical and electronic engineering, artificial intelligence can promote the development of the entire industrial production and manufacturing.

The application of artificial intelligence technology in electrical engineering automation is in the central link, which can reduce the coordination problem between equipment and production in traditional industrial production, ensure the simplification of production and manufacturing process, and greatly reduce the manufacturing cost, so as to avoid safety risks caused by manual operation. Since artificial intelligence has its own calculation program, it can make everyone have the knowledge and experience of experts, and conduct automatic analysis and processing of the problems encountered in mechanical and electronic pump control to ensure the accuracy of calculation.

For the neural network model, if the accuracy after modeling cannot reach the required accuracy, it can use the good self-learning of artificial intelligence technology to improve the accuracy of the model; From the expression form of the model, it can be seen that the model determined by the neural network algorithm can be expressed in a simple and explicit way, which indicates that the mechano-electronic pump based on artificial intelligence technology can find out the factors and variables closely related to the output, and is more consistent with the physical law.

5. Conclusion

Mechatronics pump system has entered the mature stage of later development with the support of artificial intelligence technology, and the further development of artificial intelligence technology is feeding the field of mechatronics engineering to develop in depth, so that the performance of mechatronics pump system will be improved to a greater extent. In the near future, by intensifying the research on artificial intelligence technology, we can not only gradually improve the existing application field, but also open up more extensive application space more actively, so as to better serve the field of mechatronics.

References

[1] Simon Stern. Introduction: Artificial intelligence, technology, and the law[J]. University of Toronto Law Journal, 2018, 68(101):1-11.

[2] Kelly Wolfgang. Artificial Intelligence and Machine Learning: Pushing New Boundaries in Hearing Technology [J]. Hearing Journal, 2019, 72(3):26-34.

[3] D. Bertram, C. Macaskill, M. J. Davis. Valve-related modes of pump failure in collecting lymphatics: numerical and experimental investigation[J]. Biomech Model Mechanobiol, 2017, 16(2):1-17.

[4] Hongwei Wu, Pei Zhao, Xin Li. Tuning for Visible Fluorescence and Near-Infrared Phosphorescence on a Unimolecular Mechanically-Sensitive Platform via Adjustable CH-π Interaction [J]. Acs Applied Materials & Interfaces, 2017, 9(4):3865-3872.

[5] J. Liu, R. Hu, Z.-Q. Fan. Magneto-electronic properties and mechano-magnetic coupling effects in transition metal-doped armchair boron nitride nanoribbons[J]. Acta Physica Sinica, 2017, 90(36):26-32.

[6] Praveen Kumar Gupta, Vidhya Shree, Lingayya Hiremath. The Use of Modern Technology in Smart Waste Management and Recycling: Artificial Intelligence and Machine Learning[J]. Studies in Computational Intelligence, 2019, 84(43):8-11.

[7] Jan Zibner. Legal Personhood: Animals, Artificial Intelligence and the Unborn. Kurki, V. A. J.; Pietrzykowski, T. (eds.)[J]. Masaryk University Journal of Law & Technology, 2018, 12(1):81-87.

[8] Jian Wu. The Next Era: Flourish of National Health Care & Medicine with the World Leading Artificial Intelligence[J]. Chinese Medical Sciences Journal, 2019, 34(2):69-70.

[9] Jia-Ying Joey Lee, James Alastair Miller, Sreetama Basu. Building predictive in vitro pulmonary toxicity assays using high-throughput imaging and artificial intelligence[J]. Archives of Toxicology, 2018, 92(6):2055-2075.

[10] Olga C. Santos. Artificial Intelligence in Psychomotor Learning: Modeling Human Motion from Inertial Sensor Data[J]. International Journal of Artificial Intelligence Tools, 2019, 28(4):194-206.

[11] Paul Shapshak. Artificial Intelligence and brain[J]. Bioinformation, 2018, 14(1):038-041.

[12] Jacques Biot. How will clinical practice be impacted by artificial intelligence[J]. European Journal of Dermatology, 2019, 29(1):8-10.

[13] Chen Weidong, Chu Leyang, Yang Li. 4D Printing and Its Education Application Outlook:Also on the Combination with “Artificial Intelligence+Education”[J]. Journal of Distance Education, 2018, 4(19):7-15.

[14] Nakashima H, Kawahira H, Kawachi H, et al. Artificial intelligence diagnosis of Helicobacter pylori infection using blue laser imaging-bright and linked color imaging: a single-center prospective study[J]. 2018, 31(4):462-468.

[15] Vicente Moret-Bonillo. Emerging technologies in artificial intelligence: quantum rule-based systems[J]. Progress in Artificial Intelligence, 2018, 55(173):1-12.