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Retraction

Retracted: Pavement Performance Evaluation of Asphalt Expressway Based on Machine Learning Support Vector Machine

Wireless Communications and Mobile Computing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Q. Sun, G. Wang, Y. Sui, and I. Zakaria, "Pavement Performance Evaluation of Asphalt Expressway Based on Machine Learning Support Vector Machine," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 6011916, 13 pages, 2022.

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Research Article

Pavement Performance Evaluation of Asphalt Expressway Based on Machine Learning Support Vector Machine

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Pavement quality evaluation is important for pavement maintenance and is the basis for maintenance and investment decisions. With the use of asphalt pavements on highways, road maintenance problems are becoming increasingly serious. This paper introduces the prediction and evaluation of asphalt pavement and analyzes the quality evaluation methods of asphalt pavement in terms of damage degree, pavement smoothness, pavement gauge, and pavement strength. Based on this, a pavement quality evaluation based on machine learning, SVM, and other techniques is established, and a comprehensive evaluation model based on SVM, a set of asphalt pavement performance teaching materials, and a training label determination method are proposed to highlight the importance of highway asphalt pavement quality prediction and evaluation and provide reference for China's highway construction.

1. Introduction

With the expansion of domestic highway construction, the prediction and evaluation of asphalt pavement quality are particularly important. The quality of asphalt pavement is checked by actively predicting and evaluating the operational performance of asphalt pavement, controlling the risk of asphalt pavement use, establishing an effective evaluation system for asphalt pavement use quality, and improving the reliability of evaluation results. By the end of 2018, China accounted for 97% of the total highway mileage [1, 2]. Therefore, the application of artificial intelligence and mechanical learning in road engineering is inevitable. In China, the comprehensive evaluation of pavement performance is carried out according to the Road Technical Condition Evaluation Standard (JTGH20-2018) [3], which is based on each single evaluation index (excluding deflection values) with the corresponding weight, judged by calculating the product of pavement technical condition (PQI) values, and the weight of each subentry index is determined by combining expert experience to judge the importance of the index in a comprehensive manner and combined with the actual data, the primary factor of the road service function.

Asphalt pavement performance is the main reference index of road operation and maintenance, so it is necessary to ensure that the evaluation results are in line with the actual situation of the road and guarantee the authenticity, validity, and objectivity of the data. When extracting asphalt pavement data, it is necessary to make reasonable use of relevant formulations and simplify the data through computer equipment to achieve work optimization and cost control. In addition, the performance of asphalt pavements can be classified and recorded according to certain attributes. For important indicators, individual evaluation methods should be used, and a combination of various important indicators should be analyzed. Based on the analysis results, a full-section asphalt pavement evaluation system can be constructed to improve the evaluation efficiency.

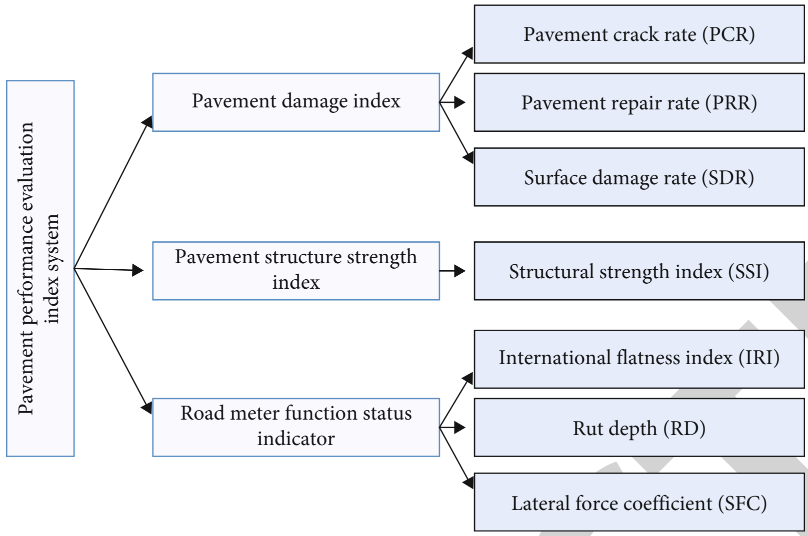

Figure 1: Evaluation index system of freeway asphalt pavement performance.

Table 1: PCI evaluation standard.

Evaluation standard	Excellent	Good	Middle	Poor	Bad
PCI	≥85	≥70, <85	≥55, <70	≥60, <55	<40

Table 2: Evaluation standard of road driving quality index (RQI).

Evaluation standard	Excellent	Good	Middle	Poor	Bad
RQI	>90	<90, ≥80	<80, ≥70	<70, ≥60	<60
IRI $(m \cdot km^{-1})$	≤2.4	>2.4, ≤3.5	>3.5, <4.3	>4.3, ≤5.0	>5.0

When evaluating the performance of highway asphalt pavements, the following influencing factors should be fully considered: the type of pavement structure, such as foundation structure, foundation depth, pavement temperature and humidity, asphalt pavement grade, and the traffic flow of the evaluated section [4]. Since excessive vehicle loads and pavement humidity during highway use can lead to a certain degree of damage to the pavement structure, fractures, asphalt, and shedding and affect the pavement roughness, which seriously affects driving comfort, evaluation indexes must be adjusted, and repair and maintenance work must be carried out in a timely manner to ensure that pavement performance is not affected and to improve the accuracy of evaluation results.

In the evaluation of highway asphalt pavement function, data such as pavement smoothness, antiskid coefficient, vibration characteristics, and vibration amplitude should be extracted according to the pavement operation quality, and they should be used as the basic indexes for pavement function evaluation. In the evaluation of pavement structure, the degree of pavement damage should be used as the main evaluation index, and the service life of pavement should be reasonably predicted by analyzing the bearing performance of pavement and determining the number of axial load actions that asphalt pavement can withstand [5].

2. Related Work

The performance of expressway is the comprehensive result of structure design, material performance, construction quality, driving load, natural factors, and maintenance. Pavement performance evaluation is the premise of mastering the technical status of pavement, evaluating the service quality of pavement, judging whether maintenance is needed, and making scientific maintenance planning. Therefore, evaluating the performance of asphalt pavement scientifically and accurately is of great significance to the efficient operation and scientific maintenance of expressway.

The traditional pavement performance evaluation method is a linear or nonlinear regression model established based on actual survey data and expert evaluation [6]. These models have the characteristics of clear indicators, easy to understand, and simple calculation, but they have the disadvantages of great subjective influence and difficulty in accurately representing the actual performance of pavement [7, 8]. In recent years, different scholars have adopted different methods to study pavement performance [9]. In [10], based on information entropy and multiobjective space theory, fuzzy entropy weight multiobjective evaluation method for asphalt pavement performance evaluation is proposed. In [11], combined with T-S fuzzy theory and BP neural

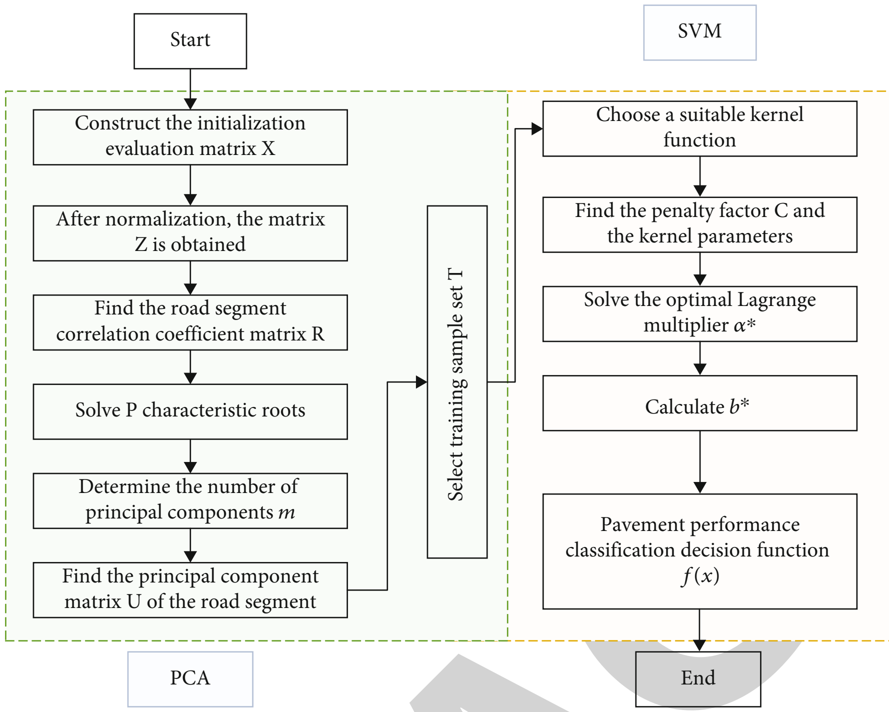

Figure 2: Basic steps of the PCA-SVM model.

Table 3: Road condition survey and testing items and equipment.

Test items	Main testing equipment	Detection purpose
PCI	Manual survey combined with road condition detection vehicle	Determining the condition, extent, and scope of road damage
Road driving quality index (RQI)	Vehicle-mounted laser flatness tester	Evaluate road surface smoothness
Rut depth index (RDI)	Laser rutting detector	Analysis of road rutting condition and extent
Pavement structural strength index (PSSI)	Laser automatic deflectometer	Evaluate the bearing capacity of the pavement
Slip resistance index (SRI)	Lateral force coefficient test	Evaluation of pavement skid resistance

Table 4: Pavement disease statistics of carriageway.

Disease type	Road surface damage		Pavement disease of the up-passing lane		Downlink road surface disease	
	Area (m^2)	Proportion (%)	Area (m^2)	Proportion (%)	Area (m^2)	Proportion (%)
Subsidence	1272.58	56.49	968.73	60.75	386.51	42.77
Lateral cracks	0.74	0.02	—	0.00	3.38	0.36
Pit	3.86	0.18	—	0.00	0.98	0.11
Block crack	650.13	28.64	641.24	39.18	512.61	51.88
Loose	245.64	11.54	—	0.00	—	0.00
Possesses	38.26	2.55	—	0.00	—	0.00
Repair	—	—	—	0.00	0.37	0.03
Longitudinal cracks	12.57	0.56	0.81	0.07	47.64	4.85
Total	2223.78	100.00	1610.78	100.00	951.49	100.00

network, the evaluation model of expressway pavement performance was established. In [12], an analytic hierarchy process based on expert evaluation was constructed to evaluate pavement performance. To overcome the subjective defects of previous pavement performance evaluation methods, a pavement performance evaluation model based on interval

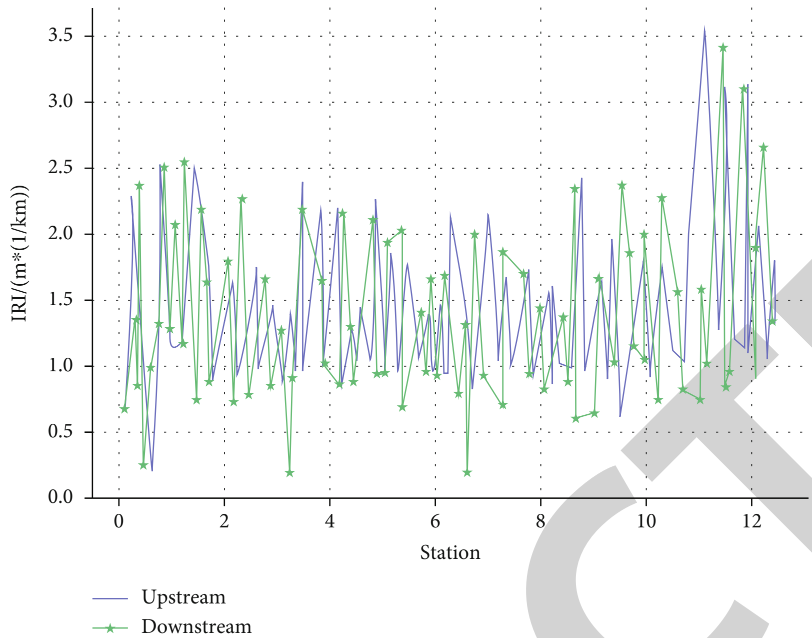

FIGURE 3: Distribution of IRI values in 100 meters of lane.

TABLE 5: Pavement smoothness index of different grade distribution of lane.

IRI $(m \cdot km^{-1})$	Roadway	Length (km)	Proportion (%)
	Up	110.8	85.89
<1.7	Down	112.2	86.98
	Across the board	222.9	86.40
	Up	9.9	7.62
1.7-1.9	Down	8.8	6.88
	Across the board	18.6	7.26
	Up	3.7	2.78
1.9-2.1	Down	2.5	1.87
	Across the board	6.1	2.34
	Up	2.6	1.95
2.1-2.3	Down	1.7	1.41
	Across the board	4.2	1.68
	Up	2.4	1.77
>2.3	Down	3.8	2.88
	Across the board	6.1	2.34

linkage membership degree was established after effectively considering the complex uncertainty of evaluation indexes [13].

The existing research on pavement performance evaluation mainly focuses on the model itself, but most of the models have shortcomings and defects [14]. For example, the grey theory mostly relies on the experience range of evaluation indicators. Neural network easily converges locally. Analytic hierarchy process has a large human influence factor [15]. However, there are few studies on the optimization of the evaluation indexes of specific pavement performance evaluation models, which reduces the scientificity and accuracy of the evaluation results to a certain extent [16]. Aiming at the characteristics of small volume, high dimension, and nonlinearity of asphalt pavement quality evaluation, this paper first uses the principal component method to reduce the evaluation index, forming an independent main component, then uses the analyzed main component to reduce the evaluation index, selects the main component samples to prepare the vector machine, and establishes the PCA-SVM model for expressway asphalt pavement performance evaluation. The actual performance data of Lenin circuit in 2016 are taken as an example for analysis.

In order to reasonably evaluate pavement performance, [17] proposed an improved grey theory grey clustering principle in order to avoid subjectivity and uncertainty. In [18, 19], extension theory is applied to pavement performance evaluation. In [20], a Markov mixed risk model based on layered Bayesian estimation is established, and the results show that the model can perform the short-term pavement performance evaluation well. In [21], the actual dominant damage of road surface in Gansu Province is investigated to evaluate the road surface performance. The evaluation results are more consistent with the actual road surface performance in Gansu Province. In [22], a match-element extension evaluation model of road performance based on game theory is established by selecting Beijing-Harbin high-speed index, which combines Delphi method and correlation function method to establish static game.

These model studies also have their own shortcomings; for example, neural network relatively easily converges locally, and analytic hierarchy process mainly determines the corresponding importance based on expert experience, so the objectivity is not strong, which reduces the accuracy of evaluation results [23]. With the rise of artificial intelligence, SVM (SVM) has been widely applied in various fields, and its effect in classification and evaluation is excellent [24,

Table 6: Different grades of SRI distribution of skid resistance index of lane pavement.

SRI	Roadway	Length (km)	Proportion (%)
	Up	1.8	1.33
<40	Down	0.0	0.00
	Across the board	1.8	0.67
	Up	0.2	0.24
40-42	Down	0.3	0.17
	Across the board00	0.6	0.18
	Up	0.0	0.00
42-44	Down	0.2	0.24
	Across the board	0.2	0.11
	Up	1.7	1.25
44-46	Down	1.2	1.02
	Across the board	2.8	1.11
	Up	2.3	1.87
46-48	Down	0.8	0.72
	Across the board	3.4	1.29
	Up	122.8	96.36
>48	Down	122.3	97.90
	Across the board	249.2	96.64

25]. Therefore, this study adopts three optimization models to optimize the parameters of SVM and obtains the best optimization model. Finally, the model is applied to the performance evaluation of 23 sections of an expressway in Guangdong Province [26].

3. Methods

3.1. Pavement Smoothness Evaluation System. The accuracy of pavement performance evaluation is directly related to the reasonableness of the indexes selected in the evaluation system. Therefore, it is very important to determine the reasonable pavement performance evaluation indexes before studying the pavement performance evaluation methods. Based on the existing specifications and previous studies, this paper analyzes the influencing factors of pavement performance from three aspects: pavement damage, pavement structural strength, and pavement surface function. The evaluation index system is shown in Figure 1.

From a large number of expressway asphalt pavement damage data, rut, crack, and repair are the most important damage types, accounting for a large proportion. In contrast, the pit, loose, hold package, subsidence, flooding, and other diseases account for less, because these diseases have a very huge impact on the safety of highway driving, daily once found, and will be repaired as soon as possible, so the repair of the number also indirectly reflects the damage of the road. The function of road table is an index to evaluate the service level of expressway surface, among which the driving quality and safety performance are the two most important aspects. Driving quality is related to three factors including people, vehicles, and roads. From the perspective of road surface, the main factor affecting road surface driving quality is road surface smoothness, which is commonly expressed by international smoothness index. Safety performance is usually expressed by skid resistance, and lateral force coefficient is the most commonly used skid resistance index.

Through the reasonable evaluation of pavement damage, the performance of asphalt pavement can be scientifically analyzed, and the basic data can be provided for the prediction of durability and service life of asphalt pavement. At the present stage, China mainly uses the pavement damage rate calculation formula DR to reasonably evaluate and analyze the pavement damage condition and integrates the pavement damage condition evaluation and analysis results through the PCI. The specific calculation formula is shown as follows:

$$\begin{gathered} \mathrm{DR} = \frac{D}{A} \times 100 = \frac{\sum\sum A_{ij} w_{ij}}{A} \times 100, \\ \mathrm{PCI} = 100 - a_0 \mathrm{DR}^{a_1}, \end{gathered} \tag{1}$$

where D is the sum of damaged areas of the road surface, W_i is the proportion of disasters on different roads surface, A_{ij} is the damaged area of the road surface, and A is the area of the road surface. Under normal circumstances, a_0 is 15.0, a_1 is 0.412, and the unified unit square meter is adopted for this standard. The PCI evaluation standard is shown in Table 1. According to the analysis of Table 1, the more serious the pavement damage is, the worse the functional evaluation result of the pavement is, indicating that the driving safety factor and driving comfort index of the pavement are lower. The PCI is a direct mapping of the pavement damage condition. By reasonably analyzing the pavement damage rate (DR) and the PCI, the pavement durability of the expressway can be predicted scientifically. At the same time, according to the combined prediction model of expressway asphalt pavement, the decay coefficient of pavement performance is calculated reasonably, so as to formulate pavement maintenance measures scientifically and rationally and extend the service life of expressway.

3.2. Evaluation and Analysis of Pavement Smoothness. In the evaluation process, IRI should be taken as the reference index to calculate RQI of road surface smoothness and complete the road surface smoothness analysis. The calculation formula of highway asphalt road quality index RQI is as follows:

$$\mathrm{RQI} = \frac{100}{1 + a_0 e^{a_1 \mathrm{IRI}}}, \tag{2}$$

where a_0 is the pavement roughness parameter, 0.026 is the value of expressway and first-level highway, a_1 is the prediction model parameter, and 0.65 is the value of expressway and first-level highway. The evaluation criteria are shown in Table 2.

3.3. Road Rutting Condition Evaluation and Analysis. In recent years, our country highway capacity increased gradually; through the asphalt pavement of more and more heavy transport vehicles, high strength load easily leads to the

Table 7: Grade distribution of pavement structural strength index (PSSI) evaluation.

Rating	Upstream PSSI rating distribution		Downstream PSSI rating distribution		The distribution of PSSI assessment grades across the board	
	Length (km)	Proportion (%)	Length (km)	Proportion (%)	Length (km)	Proportion (%)
Excellent	47	72.72	73	90.00	122	82.20
Good	14	22.74	8	8.76	24	15.08
Middle	2	3.04	2	1.26	4	2.06
Poor	1	1.53	0	0.00	2	0.69
Bad	0	0.00	0	0.00	0	0.00
Score	92.63		93.28		92.92	
Grade	Excellent		Excellent		Excellent	

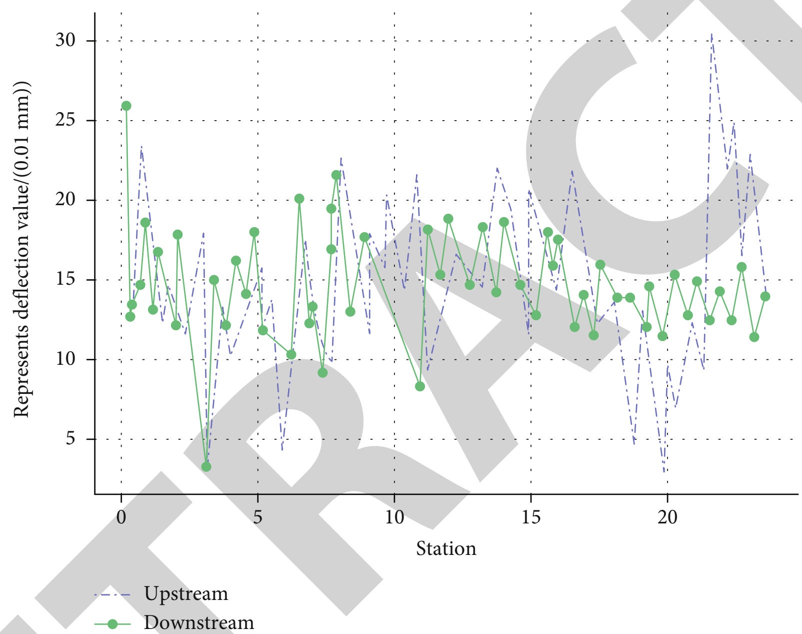

Figure 4: Lane represents the kilometer distribution of deflection value.

production of permanent deformation of asphalt pavement and the rut formation; the highway asphalt pavement road safety coefficient is reduced, so there must be accurate evaluation of asphalt pavement rutting situation. At the present stage, rut depth (RD) is mainly used as the main reference index for rut condition evaluation and analysis in China. On this basis, pavement rut depth index (RDI) is reasonably calculated.

3.4. Pavement Structural Strength Evaluation. Before evaluating the structural strength of expressway asphalt pavement, pavement strength must be tested. At present, the strength of asphalt pavement structure is tested mainly by rebound method and core drilling method. By analyzing the relevant data of asphalt pavement strength detection of major expressways, it can be seen that when the thickness of subgrade protective layer is more than 2 cm and the diameter of asphalt mixture is greater than 0.4 cm and less than 0.6 cm, the rebound value of asphalt pavement is relatively low. In order to save the testing cost, improve the testing accuracy, and ensure the testing efficiency, the static load of asphalt subgrade can be tested by the core drilling method to determine the compressive strength of pavement and the existing quality problems. Under normal circumstances, the pavement structure static load calculation formula $S = (0.004 - 0.01)b$ can be used to calculate the pavement bearing performance. In the actual detection process of asphalt pavement structural strength of expressway, the detection results should be optimized by fast pressure correction method, and the pavement load should be appropriately increased with 1 h interval, and the total increase of load should not be less than two times of the rated pavement load value.

Upon completion of the highway asphalt pavement structural strength detection work, there is also a need to use testing instrument; the pavement deflection value for reasonable measurement, by pavement deflection coefficient actual conducting a reasonable evaluation of plastic strain of asphalt surface size, if big deflection value measurement results, shows the asphalt pavement sections of plastic strain and the design requirements; there is a certain deviation lower wear resistance ability. The structural strength

Table 8: Performance index values of expressway from 2015 to 2020.

Year	PCI	RDI	Year	PCI	RDI
2015	99.9	96	2018	98.4	91.2
2016	99.7	95.1	2019	96.5	88.2
2017	99.3	93.3	2020	94.3	85.7

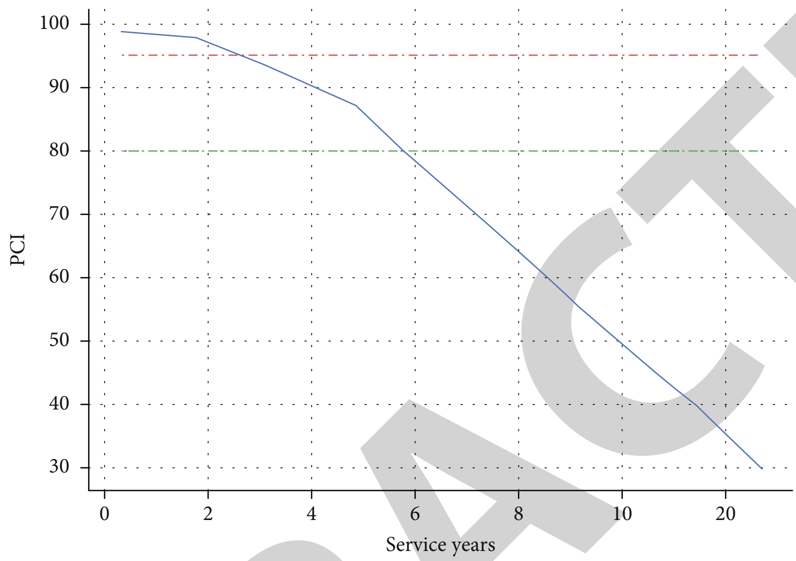

Figure 5: PCI evaluation curve of expressway.

evaluation indexes of asphalt pavement of expressway are as follows:

$$\begin{aligned} \mathrm{PSSI} &= \frac{100}{1 + a_0 e^{a_1, \mathrm{SSI}}}, \\ \mathrm{SSL} &= \frac{l_R}{l_0}, \\ & l_{R=600N^{-0.2}} A_1 A_2 A_3, \\ N &= \frac{(1+\gamma)^2 - 1x365}{\gamma} N_1 \tau, \end{aligned} \tag{3}$$

where SSL is the strength coefficient of pavement structure, and its value is the ratio of pavement design bend to actual bend l_R/l_0, N is the accumulative equivalent axis of one lane in the design life, A_1 is the highway grade coefficient, A_2 is the surface type coefficient, A_3 is the pavement structure type coefficient, γ is the average annual growth rate (%) of traffic volume in the design life, N_1 is the bidirectional average equivalent axis in the first year of operation, τ is the structural coefficient, a_0 is usually 15.71, a_1 is 5.19, and this evaluation standard adopts the uniform unit millimeter. The value of PSSI evaluation standard ranges from 0 to 100. The lower the value is, the weaker the expressway pavement strength is.

Generally, the state of pavement performance is expressed as "excellent, good, medium, inferior, and poor," which is a multiclassification problem. SVM has been widely used in many classifications and applications of good, but the impact of expressway asphalt pavement performance evaluation index is more, and when reflecting information has a certain correlation between the indexes and overlaps, if SVM is directly used, the performance evaluation of highway asphalt pavement evaluation index of the defects will be harmful to the evaluation results. Principal component analysis can solve this problem effectively by linear combination of indexes. The evaluation index achieves dimensionality reduction through principal component analysis, so as to form mutually independent principal components. By using principal component training SVM, the classification decision function of expressway asphalt pavement performance can be obtained, which can effectively improve the accuracy of evaluation. Therefore, this paper combined principal component analysis and SVM to establish the PCA-SVM model as in Figure 2.

(1) Construct the initialization evaluation matrix: $X = (x_{ij})_{n\times p}$

(2) Use Z-score method to standardize the elements in the X matrix

$$x_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \tag{4}$$

Table 9: PCI evaluation results of expressway K23 + 000-K31 + 000 section.

Mileage station	2019 PCI raw values	Converting road age (year)	PCI forecast for 2020	2020 PCI raw values	Relative error (%)
K23 + 000-K24 + 000	96.7	4.82	94.8	95.5	0.79
K24 + 000-K25 + 000	97.5	4.42	95.4	93.4	2.16
K25 + 000-K26 + 000	95.8	5.37	93.3	91.7	1.71
K26 + 000-K27 + 000	97.5	4.36	95.8	96.3	0.58
K27 + 000-K28 + 000	97.5	4.42	95.7	94.8	0.91
K28 + 000-K29 + 000	95.5	5.48	93.1	93.5	0.38
K29 + 000-K30 + 000	95.1	5.56	92.7	90.3	2.68
K30 + 000-K31 + 000	95.5	5.03	94.1	93.2	1.17

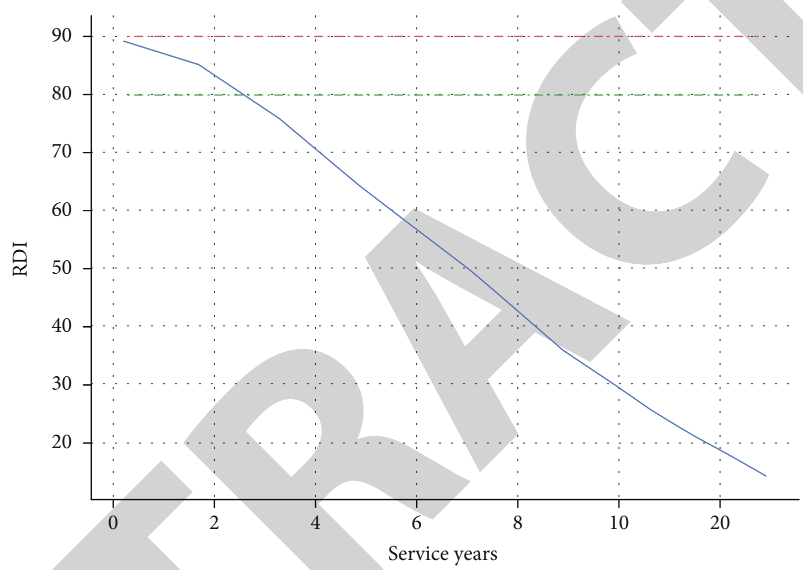

Figure 6: RDI decay curve of expressway.

(3) Calculate the standardized matrix

$$R = \left(r_{ij}\right)_{p\times p} = \frac{Z^T Z}{n-1} \tag{5}$$

(4) m value is determined according to $\sum_{i=1}^{m}\lambda_j/\sum_{i=1}^{p}\lambda_j \geq 0.85$, so that the utilization rate of expressway asphalt pavement performance evaluation index information can reach more than 85%. For each λ_j, $j = 1, \cdots, m$, solve the equations $Rb = \lambda_j b$, and get unit eigenvector $b_j^0 = b_j/\|b_j\|$

(5) Transform the normalized matrix Z into the section principal component matrix

(6) Training sample set from the section principal component matrix U

(7) Choose the appropriate kernel function

(8) The cross-validation method is used to obtain the optimal penalty factor C and kernel parameters, and the quadratic optimization problem is constructed

(9) Construct the classification decision function of the highway pavement performance

By substituting the principal components of expressway sections that need to be evaluated into the classification decision function, the grades of the performance of each section of expressway asphalt pavement that need to be evaluated can be determined.

4. Case Study

A road condition survey was conducted on a highway section K315 + 990-K445 + 750 in a province. The main test items and equipment are shown in Table 3.

4.1. Detection and Evaluation of Asphalt Pavement

4.1.1. Carriageway Pavement Disease Statistics. According to the statistical method of asphalt pavement disease area in

Table 10: RDI evaluation results of expressway K23 + 000-K31 + 000 section.

Mileage station	2019 RDI raw values	Converting road age (year)	RDI forecast for 2020	2020 RDI raw values	Relative error (%)
K23 + 000 -K24 + 000	89.5	4.68	86.7	86.9	0.28
K24 + 000 -K25 + 000	88.2	5.11	85.5	86.1	0.91
K25 + 000 -K26 + 000	87.7	5.34	84.9	85.7	1.18
K26 + 000 -K27 + 000	90.4	4.16	87.8	88.5	0.56
K27 + 000 -K28 + 000	89.4	4.58	86.9	87.8	1.27
K28 + 000 -K29 + 000	88.6	4.89	86.1	87.2	1.49
K29 + 000 -K30 + 000	87.3	5.45	84.4	86.2	1.71
K30 + 000 -K31 + 000	89.7	4.48	87.1	88.1	1.32

JTGH20-2007 "Highway Technical Condition Assessment Standard," the road pavement disease of this section is counted, and the results are shown in Table 4. The road surface diseases of this section are mainly manifested as subsidence, looseness, block crack, and inclusion, supplemented by transverse cracks, longitudinal cracks, cracks, and pits.

4.1.2. Pavement Smoothness Analysis of Carriageway. According to JTGH20-2007 Highway Technical Condition Assessment Standard, the international roughness index (IRI) of road surface was calculated with 100 meters as an assessment unit to analyze and assess road running quality as in Figure 3. The IRI values of upbound and downbound lanes are mainly 0.61-1.85 mm/km, and RQI comprehensive evaluation scores are 94.2 and 94.6, respectively, both exceeding the standard values, and the comprehensive evaluation grade is excellent. The total mileage of the 2.3 m/km section is 6 km, accounting for 2.33%, of which the upstream section is 2.3 km, accounting for 1.78%, and the downstream section is 3.7 km, accounting for 2.87%. >2.3 m/km corresponds to 90 minutes.

In order to further understand the roughness of road surface, the distribution of IRI < 1.7, 1.7 − 1.9, 1.9 − 2.1, 2.1 − 2.3, and >2.3 m/km was counted with 100 meters as an evaluation unit, and the results are shown in Table 5.

As can be seen from Table 5, the total mileage of the section IRI > 2.3 m/km is 6 km, accounting for 2.33%, among which the upstream section is 2.3 km, accounting for 1.78%, and the downstream section is 3.7 km, accounting for 2.87%. IRI > 2.3 m/km corresponds to an RQI score of 90. In order to ensure driving comfort, treatment should be carried out on these sections.

4.1.3. Evaluation of Skid Resistance of Pavement. According to JTGH20-2007 Standard for Highway Technical Condition Assessment, SRI of road skid resistance was calculated by taking 100 meters as an assessment unit. The results are shown in Table 6. The SRI values of the ascending and descending lanes mainly ranged from 48 to 55, and the comprehensive SRI scores were 92.2 and 92.4, respectively, indicating that the comprehensive evaluation grade was excellent.

4.1.4. Pavement Structural Strength Analysis and Evaluation. The laser bending detection instrument was used to conduct sampling inspection on part of the carriageway with a sampling length of 149.635 km. The detection results are shown in Table 7 and Figure 4.

It can be seen from Table 7 and Figure 4 that the comprehensive score of PSSI of the upstream and downstream is 92.52 and 93.29, respectively, and the comprehensive score of PSSI of the whole line is 92.91, which indicates that the comprehensive evaluation grade is excellent. The overall performance of pavement structural strength of this section is good.

The pavement performance test data of the expressway (see Table 8) were used to evaluate the PCI and rut depth index(RDI).

4.2. Evaluation of PCI. The highway PCI decay equation model and evaluation curve were established based on the road condition data from 2015 to 2020 (see Equation (6) and Figure 5), and the precision of PCI evaluation model was verified by using the road condition data from K23 + 000 to K31 + 000. The results are shown in Table 3.

$$\mathrm{PCI} = 99.8\left\{1 - \exp\left[\left(\frac{19.88}{y}\right)^{0.884}\right]\right\}, \quad R^2 = 0.998, \tag{6}$$

where y is the number of years of road use since 2015.

From Figure 5, the PCI attenuation rate on expressways shows a trend of slowing down at first and then accelerating.

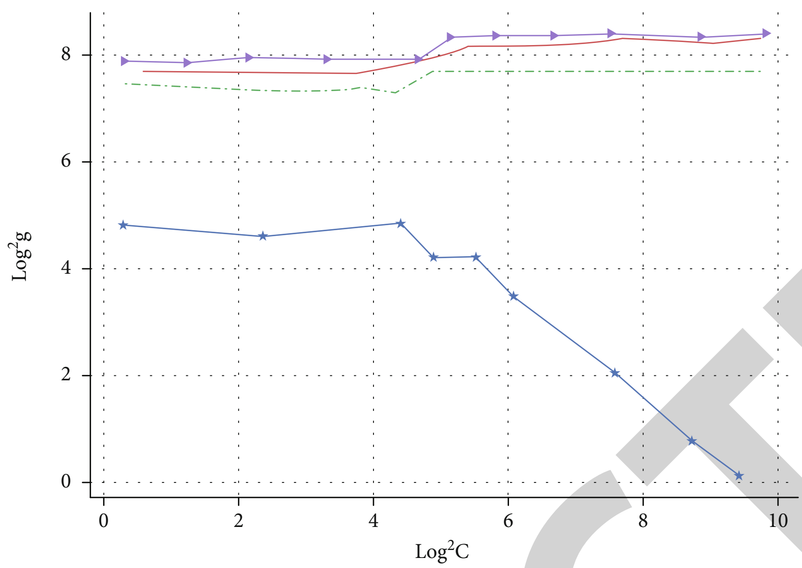

FIGURE 7: Contour diagram of primary selection for optimal parameters.

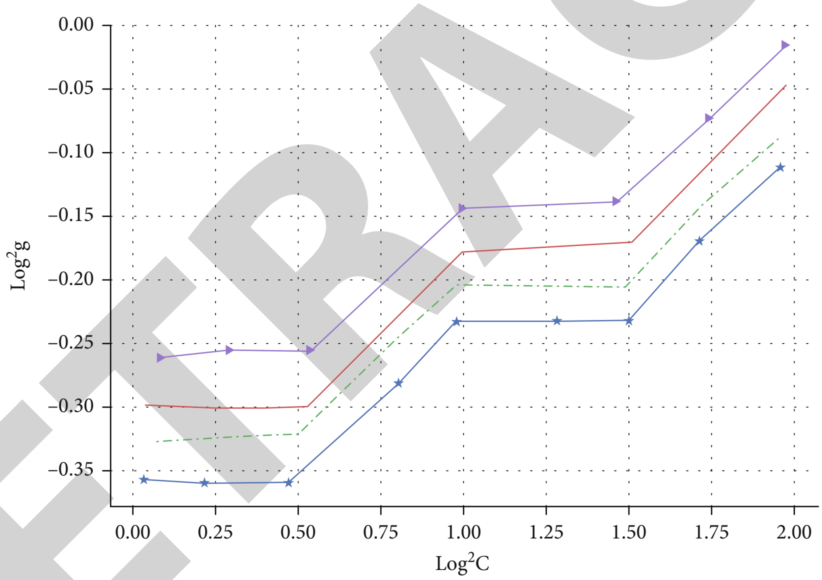

FIGURE 8: Final selection contour diagram of optimal parameters.

After 5 to 6 years of use, PCI will drop to about 95. If no preventive maintenance measures are taken to damage the road surface and it is allowed to decay normally under natural conditions, PCI will drop to middle and below in 11 to 12 years. According to the decay equation of PCI standard, the preventive maintenance measures such as crack filling, microsurface, or slurry sealing layer implemented in the period [5.58, 11.47] can improve the pavement condition in time and reduce the subsequent maintenance funds.

It can be seen from Table 9 that the standard attenuation equation of PCI performance has high evaluation accuracy and relative errors are all less than 5%, which can better fit the attenuation law of PCI on expressways and analyze pavement maintenance requirements.

4.3. Evaluation of RDI. The highway RDI decay equation model and evaluation curve were established based on the road condition data from 2015 to 2020 (see Equation (7) and Figure 6), and the accuracy of the RDI evaluation model was verified by using the road condition data from K23 + 000 to K31 + 000, and the results are shown in Table 10.

$$\mathrm{RDI} = 96.0\left\{1 - \exp\left[\left(\frac{18.97}{y}\right)^{0.697}\right]\right\}, \quad R^2 = 0.999. \tag{7}$$

The comprehensive score of PSSI of the upstream and

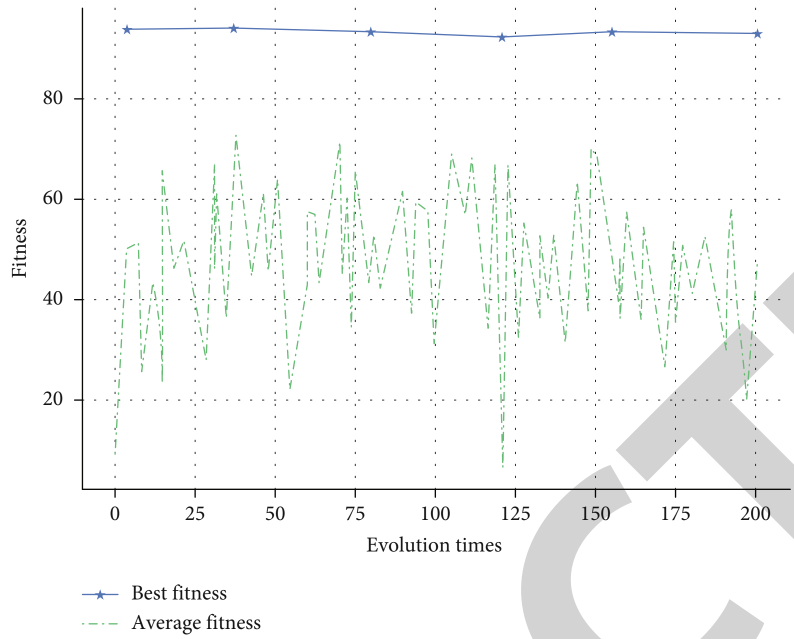

Figure 9: Fitness curve of particle swarm optimization.

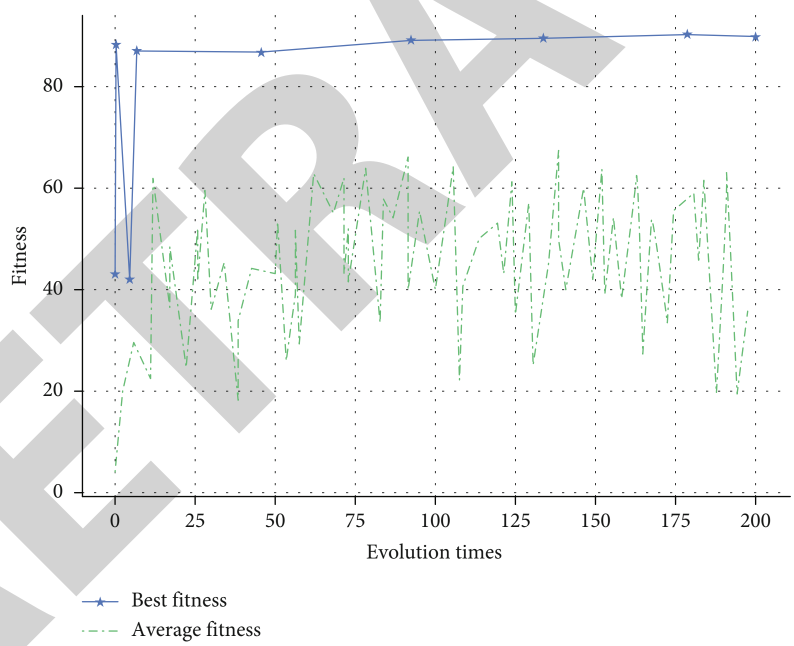

Figure 10: Fitness curve of genetic algorithm.

Table 11: Parameter optimization results of the three models.

Model	C	g	Accuracy rate (%)
Cross validation model	0.252	0.0624	99.62
Particle swarm optimization	4.856	0.5031	96.65
Genetic algorithm	0.965	0.4072	94.78

downstream is 92.52 and 93.29, respectively, and the comprehensive score of PSSI of the whole line is 92.91, which indicates that the comprehensive evaluation grade is excellent.

From Figure 6, the RDI decay rate of expressway asphalt pavement is relatively fast, and the RDI value is about 90 when it is used for 4-5 years. In this case, the pavement should be taken for medium repair. According to the standard decay equation of RDI, preventive maintenance measures such as microsurface and thin-layer cover should be implemented in the period of [4.39, 8.22]. From Table 10, the RDI standard attenuation equation of pavement performance is applied to evaluate expressway, and there is little difference between the evaluated value and the actual value, with the maximum error of 1.72%, both less than 5%.

4.3.1. Cross-Validation. K-CV model cross-validation was adopted to select the optimal penalty parameter C and function parameter g, as shown in Figure 7. First, the range of C_1 is $2^{-10}\sim 2^{10}$, and the value of g_1 is $2^{-10}\sim 2^{10}$. The optimal punishment parameter is $C_1 = 0.001$ and $g_1 = 0.001$, and the accuracy is 97.00%. Through the primary election, as shown in Figure 8, the value range of C_1 was narrowed to -2.0~2.0, and the value range of g_1 was narrowed to -4.0~0.00. Meanwhile, the change interval in contour line was reduced. Finally, the optimal parameter C_1 is 0.25, g_1 is 0.0625, and the maximum accuracy is 99.60%.

4.3.2. Particle Swarm Optimization. When the number of iterations is 200 and the population number is 20, the fitness curve of particle swarm optimization algorithm is shown in Figure 9. When the optimal parameters C_2 and g_2 are 4.858 and 0.503, respectively, the accuracy rate reaches up to 96.67%.

4.3.3. Genetic Algorithm. Similarly, when the number of iterations is 200 and the population number is 20, the fitness curve of the genetic algorithm is shown in Figure 10. The optimal parameters C_3 and g_3 are 0.964 and 0.407, respectively, and the accuracy rate is 94.77%.

Three models were used to optimize the parameters of the training set. The accuracy of each model and the obtained parameters are shown in Table 11.

From Table 11, the cross-validation model has the highest accuracy, followed by particle swarm optimization and genetic algorithm. Therefore, the author chooses the best parameters obtained by cross-validation to evaluate the pavement performance.

5. Conclusion

In recent years, due to the serious damage at the initial stage of the highway, the highway maintenance time is shortened, the maintenance cost is increased, and the traffic capacity is reduced. The quality evaluation of expressway asphalt pavement is the basis of freshness keeping decision system. Accurate assessment of road conditions will enable road maintenance personnel to have a comprehensive understanding of road conditions. Aiming at the reasonable comprehensive evaluation of asphalt pavement quality, a comprehensive evaluation model based on SVM, a set of asphalt pavement performance textbooks, and a method for determining training labels are proposed. The standard attenuation equation of pavement performance is used to evaluate the expressway. The difference between the evaluation value and the actual value is small, and the maximum error is 1.72%, both less than 5%. The performance evaluation model is established according to the evaluation results. In addition, this intelligent algorithm is used to evaluate its performance and is used as particle swarm optimization algorithm and genetic algorithm to ensure the maximum accuracy of the estimation results.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

References

[1] S. Wu, W. Zhang, S. Shen, X. Li, B. Muhunthan, and L. N. Mohammad, "Field-aged asphalt binder performance evaluation for Evotherm warm mix asphalt: comparisons with hot mix asphalt," *Construction and Building Materials*, vol. 156, pp. 574–583, 2017.

[2] J. Gong, Y. Liu, Q. Wang et al., "Performance evaluation of warm mix asphalt additive modified epoxy asphalt rubbers," *Construction and Building Materials*, vol. 204, pp. 288–295, 2019.

[3] G. Cai, Y. Fang, J. Wen, S. Mumtaz, Y. Song, and V. Frascolla, "Multi-carrier M-ary DCSK system with code index modulation: an efficient solution for chaotic communications," *IEEE Journal of Selected Topics in Signal Processing*, vol. 13, no. 6, pp. 1375–1386, 2019.

[4] K. Chandra, A. S. Marcano, S. Mumtaz, R. V. Prasad, and H. L. Christiansen, "Unveiling capacity gains in ultradense networks: using mm-wave NOMA," *IEEE Vehicular Technology Magazine*, vol. 13, no. 2, pp. 75–83, 2018.

[5] F. B. Saghezchi, A. Radwan, J. Rodriguez, and T. Dagiuklas, "Coalition formation game toward green mobile terminals in heterogeneous wireless networks," *IEEE Wireless Communications*, vol. 20, no. 5, pp. 85–91, 2013.

[6] S. Palanisamy, B. Thangaraju, O. I. Khalaf, Y. Alotaibi, S. Alghamdi, and F. Alassery, "A novel approach of design and analysis of a hexagonal fractal antenna array (HFAA) for next-generation wireless communication," *Energies*, vol. 14, no. 19, p. 6204, 2021.

[7] S. N. Alsubari, S. N. Deshmukh, A. A. Alqarni et al., "Data analytics for the identification of fake reviews using supervised learning," *CMC-Computers, Materials & Continua*, vol. 70, no. 2, pp. 3189–3204, 2022.

[8] X. Shi, A. Mukhopadhyay, D. Zollinger, and K. Huang, "Performance evaluation of jointed plain concrete pavement made with Portland cement concrete containing reclaimed asphalt pavement," *Road Materials and Pavement Design*, vol. 22, no. 1, pp. 59–81, 2021.

[9] L. Qingfeng, L. Chenxuan, and W. Yanan, "Integrating external dictionary knowledge in conference scenarios the field of personalized machine translation method," *Journal of Chinese Informatics*, vol. 33, no. 10, pp. 31–37, 2019.

[10] K. Kalita and P. Rajbongshi, "Variability characterisation of input parameters in pavement performance evaluation," *Road Materials and Pavement Design*, vol. 16, no. 1, pp. 172–185, 2015.

[11] S. A. Bansode, V. R. More, S. P. Zambare, and M. Fahd, "Effect of constant temperature (20 0C, 25 0C, 30 0C, 35 0C, 40 0C) on the development of the Calliphorid fly of forensic importance, Chrysomya megacephala (Fabricus, 1794)," *Journal of Entomology and Zoology Studies*, vol. 4, no. 3, pp. 193–197, 2016.

[12] F. A. Al-Mekhlafi, R. A. Alajmi, Z. Almusawi et al., "A study of insect succession of forensic importance: dipteran flies (diptera) in two different habitats of small rodents in Riyadh City, Saudi Arabia," *Journal of King Saud University-Science*, vol. 32, no. 7, pp. 3111–3118, 2020.

[13] M. Guo, H. Liu, Y. Jiao et al., "Effect of WMA-RAP technology on pavement performance of asphalt mixture: a state-of-the-art review," *Journal of Cleaner Production*, vol. 266, article 121704, 2020.

[14] A. Algalil, M. A. Fahd, and S. P. Zambare, "New species of flesh fly (Diptera: Sarcophagidae) Sarcophaga (Liosarcophaga) geetai in India," *Journal of Entomology and Zoology Studies*, vol. 4, no. 3, pp. 314–318, 2016.

[15] H. R. Jahanian, G. H. Shafabakhsh, and H. Divandari, "Performance evaluation of Hot Mix Asphalt (HMA) containing bitumen modified with Gilsonite," *Construction and Building Materials*, vol. 131, pp. 156–164, 2017.

[16] A. M. Al-Azab, A. A. Zaituon, K. M. Al-Ghamdi, and F. M. A. Al-Galil, "Surveillance of dengue fever vector Aedes aegypti in different areas in Jeddah city Saudi Arabia," *Advances in Animal and Veterinary Sciences*, vol. 10, no. 2, pp. 348–353, 2021.

[17] S. Luo and X. Yang, "Performance evaluation of high-elastic asphalt mixture containing deicing agent Mafilon," *Construction and Building Materials*, vol. 94, pp. 494–501, 2015.

[18] S. Yang, M. Guo, X. Liu, P. Wang, and H. Liu, "Highway performance evaluation index in semiarid climate region based on fuzzy mathematics," *Advances in Materials Science and Engineering*, vol. 2019, Article ID 6708102, 7 pages, 2019.

[19] Y. Xue and Z. Qian, "Development and performance evaluation of epoxy asphalt concrete modified with mineral fiber," *Construction and Building Materials*, vol. 102, pp. 378–383, 2016.

[20] D. Wu, Y. Lei, M. He, C. Zhang, and L. Ji, "Deep reinforcement learning-based path control and optimization for unmanned ships," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 7135043, 8 pages, 2022.

[21] N. Suaryana, "Performance evaluation of stone matrix asphalt using Indonesian natural rock asphalt as stabilizer," *International Journal of Pavement Research and Technology*, vol. 9, no. 5, pp. 387–392, 2016.

[22] R. Ali, M. H. Siddiqi, and S. Lee, "Rough set-based approaches for discretization: a compact review," *Artificial Intelligence Review*, vol. 44, no. 2, pp. 235–263, 2015.

[23] G. Valdes-Vidal, A. Calabi-Floody, and E. Sanchez-Alonso, "Performance evaluation of warm mix asphalt involving natural zeolite and reclaimed asphalt pavement (RAP) for sustainable pavement construction," *Construction and Building Materials*, vol. 174, pp. 576–585, 2018.

[24] B. Jahangiri, H. Majidifard, J. Meister, and W. G. Buttlar, "Performance evaluation of asphalt mixtures with reclaimed asphalt pavement and recycled asphalt shingles in Missouri," *Transportation Research Record*, vol. 2673, no. 2, pp. 392–403, 2019.

[25] G. Ying, D. Geng, X. Huang, and G. Li, "Degradation evaluation index of asphalt pavement based on mechanical performance of asphalt mixture," *Construction and Building Materials*, vol. 140, pp. 75–81, 2017.

[26] A. Faghih-Imani and L. Amador-Jimenez, "Toward sustainable pavement management: incorporating environmental impacts of pavement treatments into a performance-based optimization," *Transportation Research Record*, vol. 2366, no. 1, pp. 13–21, 2018.