

Exploration of Industry Case Teaching in Mathematics Curriculum Driven by the “Data-Computation-Intelligence” Ternary Thinking

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Abstract: With the rapid development of artificial intelligence technology, the demand for high-level interdisciplinary talents with mathematical literacy, computational ability, and intelligent thinking is becoming increasingly urgent. Graduate mathematics education, as the core link in cultivating high-end talents, is facing the dilemma of disconnection between theoretical teaching and industrial practice, and the insufficient integration of mathematical knowledge and practical application scenarios. Aiming at this problem, this paper proposes a construction path of industry-university integration resources for mathematics courses driven by the “Data-Computation-Intelligence” ternary thinking, taking advanced mathematical statistics as the breakthrough point. By integrating a typical industrial application case—failure risk analysis of autonomous vehicle visual recognition systems under extreme weather into the teaching process, the paper constructs a resource system integrating theoretical knowledge, industrial data, computational tools, and intelligent applications, and provides a feasible reference for the reform of graduate mathematics education and the construction of industry-university integration resources.

Keywords: Data-computation-intelligence; Ternary thinking; Mathematics courses; Industry-university integration

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1. Introduction

In the era of intelligence, data has become the core production factor, computation is the key means of data processing, and intelligence is the ultimate goal of data and computation integration. The “Data-Computation-Intelligence” ternary thinking integrates the logical characteristics of data acquisition and analysis, computational model construction, and intelligent decision-making, which is highly consistent with the core requirements of graduate mathematics education for cultivating students’ practical application ability and innovative thinking^[1,2]. Advanced mathematical statistics, as a core course for graduate students in mathematics, statistics and other disciplines, is an important carrier of cultivating students’ data analysis ability and computational thinking, but its traditional teaching mode is mainly focused on theoretical derivation and formula memory, ignoring the connection between mathematical knowledge and industrial practice,

and resulting in graduate students' "knowing the principle but not knowing how to apply it", and unable to effectively use mathematical statistical methods to solve practical problems in industry.

In recent years, domestic and foreign scholars have carried out extensive explorations on the reform of statistics teaching and industry-university collaborative education from multiple dimensions. Tang et al.^[3] put forward the reform path of postgraduate mathematics courses guided by computational thinking, pointing out the necessity of combining mathematical teaching with practical demands of industries. Liu and Xu^[4] constructed industry-university integrated teaching resources for mathematical statistics by relying on authentic industrial cases, which provides a feasible path to break the isolation between classroom knowledge and industrial reality. Huang^[5] explored a four-dimensional training framework for statistics majors based on industry-university cooperation, laying a theoretical foundation for the multi-module resource system designed in this research. Liu^[6] further supplemented the construction ideas of a practical teaching system for statistics courses under an industry-university integration background, emphasizing the importance of introducing real industrial data into classroom practice. In the field of industrial application of statistical modeling, many studies have realized the combination of mathematical statistics and autonomous driving engineering scenarios^[7-10].

Although existing studies have proposed diversified integrated teaching models to realize the deep integration of mathematical principles, algorithm logic and data practice, there are still prominent deficiencies: few studies systematically integrate the "Data-Computation-Intelligence" ternary logic into the overall design of curriculum resources, and most teaching cases remain separated from the core knowledge system of advanced mathematical statistics. In view of this research gap, this paper takes the construction of industry-university integration resources for graduate advanced mathematical statistics courses as the research object, takes the "Data-Computation-Intelligence" ternary thinking as the guidance, integrates typical industrial application cases of autonomous driving visual system risk assessment into the teaching process, constructs a comprehensive and practical resource system, and carries out teaching practice, so as to provide a new idea and method for the reform of graduate mathematics education.

2. Application practice of industry-university integration resources in Advanced Mathematical Statistics teaching

Taking the graduate advanced mathematical statistics course as the object, teaching practice reform is carried out by using the industry-university integration resource system driven by the "Data-Computation-Intelligence" ternary thinking. The teaching practice adheres to the teaching concept of "ternary thinking guidance, case-driven, practice-oriented", and integrates industrial application cases into the entire teaching process, realizing the organic combination of theoretical teaching and practical practice.

This case is mainly used to practice the application of logistic regression models in risk assessment, and cultivate students' data thinking, computational thinking and intelligent thinking. The specific practice process is as follows:

First, students use the autonomous driving vehicle operation dataset in the industrial data resource module, carry out data cleaning, sorting and visualization, analyze the distribution characteristics of visual sensor data under different extreme weather conditions, and explore the correlation between environmental factors (visibility, rainfall, snowfall) and the failure rate of visual recognition systems. For example, using Python's Pandas library to clean the data and using Matplotlib to draw the scatter diagram of visibility and failure rate, so as to find out the changing law of failure rate with visibility.

Second, based on the data analysis results, students establish a failure risk assessment model of visual recognition systems under extreme weather. Using a logistic regression model to establish the relationship between environmental factors and failure rate, and using the maximum likelihood estimation method to estimate the model parameters. At the same time, simulating the failure probability of visual recognition systems under different extreme weather conditions, and optimizing the model parameters to improve the accuracy of risk assessment.

Third, according to the results of the computational model, students put forward intelligent decision-making suggestions for the safe operation of autonomous vehicles under extreme weather, such as adjusting the vehicle speed according to the visibility, optimizing the visual sensor parameters, and adopting multi-sensor fusion strategies to reduce the failure risk. At the same time, students evaluate the effectiveness of the decision-making suggestions by comparing the failure rate before and after the implementation of the suggestions, referring to the safety risk evaluation index system of autonomous driving systems.

The practice results show that after the teaching reform, the excellent rate of practice reports has reached 80%. At the same time, through the questionnaire survey, 90% of the students said that the industry-university integration resources driven by ternary thinking have effectively improved their ability to apply mathematical knowledge to solve practical problems, enhanced their interest in learning advanced mathematical statistics, and laid a foundation for their future employment and scientific research.

3. Construction of industry case teaching resources driven by ternary thinking

3.1. Case background

This case is based on road test data from autonomous vehicles, selecting the operation data of autonomous vehicles under extreme weather (heavy rain, heavy fog, heavy snow, icing) scenarios, focusing on the failure risk of the visual recognition system (such as obstacle misrecognition, lane line loss, distance perception deviation). Select 1200 valid samples of extreme weather road test data from the ACDC dataset (<https://acdc.vision.ee.ethz.ch/>). The data has been desensitized and retains core feature information, which is consistent with the distribution of industrial real data. The feature-specific definitions, variable types, and value ranges of some features are shown in **Table 1**.

Table 1. Some feature descriptions

Feature Dimension	Feature Name	Feature Type	Value Range/Category
Weather Environment Features	Visibility (X_1)	Continuous	50–2000m
	Rainfall (X_2)	Continuous	0–100mm/h
	Road Slipperiness (X_3)	Categorical	0=Dry, 1=Wet, 2=Ponding, 3=Icing
Road Geometry Features	Road Type (X_4)	Categorical	0=Urban Expressway, 1=Arterial Road, 2=Collector Road, 3=Rural Road
	Road Curvature (X_5)	Continuous	0–5 (km^{-1})
	Vehicle Speed (X_6)	Continuous	0–120km/h
Vehicle and Sensor Features	Sensor Type (X_7)	Categorical	0=Monocular, 1=Binocular, 2=Millimeter Wave Radar + Visual Fusion
	Traffic Flow (X_8)	Continuous	0–50 (vehicles/minute)
Traffic and Scenario Features	Distance to Front Vehicle (X_9)	Continuous	5–200m

3.2. Model construction and solution

After handling missing values, outliers, feature encoding, and multicollinearity analysis, combined with the binary characteristics of autonomous driving visual recognition failure risk (failure=1, normal=0), a binary logistic regression model commonly used in the industry is selected to construct a risk assessment model with 17 features. The core formula of the model is as follows:

$$P(\text{failure} = 1 | \mathbf{X}) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{17} X_{17})}}$$

where $P(\text{Failure} = 1 | \mathbf{X})$ is the probability of visual recognition system failure given 17 features; β_0 is the model intercept term; $\beta_1, \beta_2, \dots, \beta_{17}$ are regression coefficients of each feature.

After solving by maximum likelihood estimation, 12 significant features are finally retained. The core parameter results are shown in **Table 2**.

Table 2. The core parameter results

Feature Name	Feature Symbol	Regression Coefficient	Standard Error SE	p-Value	Industrial-Level Impact Interpretation
Intercept	β_0	-1.236	0.312	< 0.001	When all features are at the baseline value, the failure probability is 22.5%
Visibility	β_1	-0.015	0.004	< 0.001	For every 100m decrease in visibility, the failure risk increases by 1.5%
Rainfall	β_2	0.032	0.011	< 0.01	A one-unit (1 mm/h) increase in rainfall is associated with an approximately 3.3% increase in the odds of system failure

This case focuses on the failure risk of autonomous driving visual recognition systems under extreme weather conditions. At the data level, based on real-world road test datasets, students perform missing value imputation, outlier removal, standardization, and encoding, thereby mastering the basic norms for processing complex industrial data. At the computation level, through the construction of a binary logistic regression model and maximum likelihood estimation, the marginal effects of key features—such as visibility, rainfall, and light intensity—on system failure probability are quantified, and the model parameters have clear engineering interpretability. At the intelligence level, the risk probability output by the model can provide a dynamic decision-making basis for autonomous driving systems.

4. Conclusion

Taking Advanced Mathematical Statistics as the carrier, we focus on the teaching resource framework for mathematical statistics under the Data-Computation-Intelligence ternary framework. By introducing real industrial cases into teaching reform, it constructs an industry-university integrated resource system guided by ternary thinking and forms a three-stage practical training paradigm of “data analysis, modeling and computation, intelligent decision-making”. Practices verify that the proposed construction and teaching mode can effectively resolve the disconnection between theoretical knowledge and industrial practice and improve postgraduates’ capabilities in mathematical application and interdisciplinary innovation.

Although the teaching practice has achieved certain results, there are still some problems that need to be further improved:

First, the update speed of industrial data resources needs to be accelerated. With the rapid development of industry, the types and characteristics of industrial data are constantly changing, and the current data

resources in the resource system need to be updated in a timely manner to keep up with the pace of industrial development. For example, the data of autonomous driving visual recognition systems needs to be updated with the iteration of sensor technology and the expansion of application scenarios.

Second, the depth of industry-university cooperation needs to be further strengthened. At present, the cooperation between universities and enterprises is mainly focused on the provision of data and cases, and the cooperation in curriculum design, teaching practice and talent training needs to be further deepened. For example, enterprises can send technical experts to participate in teaching activities, and universities can carry out targeted research according to the technical needs of enterprises, so as to realize the deep integration of industry and education.

Third, the evaluation system of teaching practice needs to be further improved. The current evaluation system mainly focuses on the evaluation of students' practice results, and the evaluation of the process of students' ternary thinking cultivation is not comprehensive enough. It is necessary to establish a more scientific and comprehensive evaluation system, which includes the evaluation of students' data thinking, computational thinking and intelligent thinking, so as to better guide the teaching practice.

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