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Deep Learning Using Computer Vision in Self-driving Cars for Traffic Sign Detection

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Abstract: ***Two key aspects of this paper are lane detection and vehicle and obstacle detection using cameras. In lane detection, research has focused on several different methods and techniques. Aziz et al. (2017) proposed a lane detection model based on colour region, line selection, edge selection, and Hough transformation. The method uses computer vision and sensor fusion, combined with path planning technology, to help autonomous vehicles stay in a specific lane or switch to another lane on the road. First, the method captures road images and then performs a colour selection, mask, and edge detection process to identify and track lanes accurately. However, this algorithm, based on changes in image brightness, can perform poorly at night when the light is dim because the image contrast is low, leading to difficulties in lane detection. In summary, the application of these research results in autonomous driving technology provides a variety of innovative methods and technologies for lane detection and vehicle and obstacle detection, which helps to improve the safety and performance of autonomous driving systems.***

Keywords: Artificial intelligence; Autonomous driving; Image processing; Computer vision technology.

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1. Introduction

The application of artificial intelligence technology in the field of autonomous driving is developing rapidly, and its potential is not only to improve driving safety but also to reduce the incidence of traffic accidents effectively. According to statistics, in the United States alone, the number of deaths caused by car accidents every year exceeds 40,000, and it reaches millions worldwide. Most of these accidents can be avoided by drivers being more aware of their surroundings [1]. As a result, several tech giants, including Tesla [2], Google's Waymo, Uber and Apple [3], as well as traditional automakers such as Audi, BMW [4], Ford and Volvo, have invested billions of dollars in developing autonomous driving technology.

Autonomous driving technology can improve driving safety and effectively deal with accidents caused by factors such as driver fatigue, ignoring traffic signs, or pedestrians suddenly crossing the road. By 2025, self-driving cars are expected to account for 20% of total U.S. sales. While people may have misgivings about letting computers drive their own vehicles, in fact, autonomous driving technology could significantly improve road safety.

Core components of autonomous driving technology include long-range radar systems, ultrasonic sensors, cameras equipped with image recognition software, and real-time traffic data and satellite image support [5][6]. These technologies can effectively help cars recognize other vehicles, pedestrians, and traffic signs and use real-time traffic data to determine the best route to travel, thereby optimizing the driving experience and safety.

In the development stage of autonomous driving technology, there are several levels, including no automation, driver assistance, partial automation, conditional automation, high automation and full automation [7]. From the non-automated phase that completely relies on human driving to the fully automated phase that fully relies on autonomous driving technology, these technologies gradually reduce the need for human drivers to intervene in the driving process, greatly improving the safety and efficiency of driving.

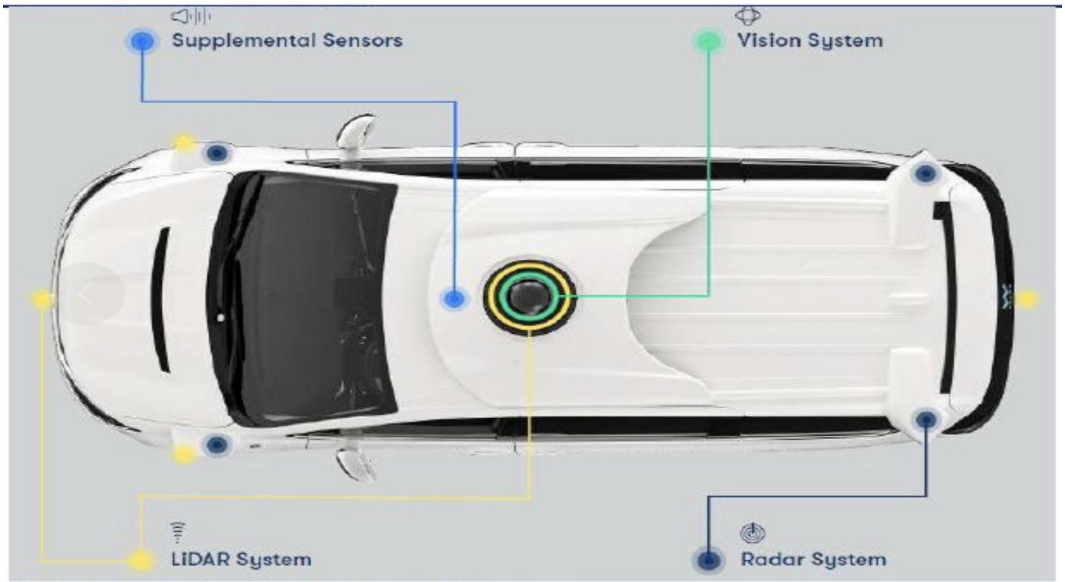

Figure 1: Autonomous driving perceptual environment architecture

This paper uses computer vision technology combined with deep learning to realize the efficient recognition and detection of traffic signs in autonomous vehicles. Deep learning technologies such as convolutional neural networks (CNN) [8] and recurrent neural networks (RNN) [9] play an important role in feature extraction, object detection and data preprocessing (Rahul et al., 2019; Gaurav et al., 2020; Mishra et al., 2018; Chatrati et al., 2020) [10]. The automatic driving system can respond quickly and make corresponding driving decisions by capturing traffic sign images on the road through cameras, combined with image recognition software for real-time analysis and interpretation. This technology improves the adaptability of autonomous vehicles in complex road environments and significantly enhances the safety and reliability of driving, taking an important step towards fully automated driving.

2. Computer Vision Technology

In recent years, computer vision is a direction of modern technology development. The main task of this direction is to classify the objects in the photo or camera [11]. Case-based machine learning methods are used to solve common problems. This paper introduces computer vision application in traffic sign recognition using machine learning algorithm. A road sign is a flat, man-made object with a fixed shape. The road sign recognition algorithm is applied to two practical problems. The first task is to control the self-driving car.

A key component of a driverless vehicle's control system is object recognition. The objects of identification are mainly pedestrians, other vehicles, traffic lights, and road signs. The second traffic sign recognition task is the automatic mapping based on data from [12] DVRs installed in the car. Next, we will detail how to build a CNN [13] network that can recognize traffic signs.

2.1 Introduction to Computer Vision

Computer vision uses various imaging systems instead of visual organs as input-sensitive means, and the computer replaces the brain to complete processing and interpretation. The ultimate goal of computer vision research is to enable computers to observe and understand the world through vision like people and have the ability to adapt to the environment independently. The ultimate goal of the effort before the ultimate goal is to build a visual system that can perform certain tasks with some degree of intelligence based on visual sensitivity and feedback [14]. For example, an important application area of computer vision is the visual navigation of autonomous vehicles, and no system can recognize and understand any environment and complete autonomous navigation like a conditional human. Therefore, the research goal of people's efforts is to realize the visual driving assistance system with road tracking ability on the highway, which can avoid collision with the vehicle in front.

The point to be pointed out here is that the computer acts as a substitute for the human brain in the computer vision system. Still, it does not mean that the computer must complete the processing of visual information in the way that human vision does. Computer vision can and should process visual information according to the characteristics of computer systems [15][16]. However, the human visual system is the most powerful and perfect visual system known so far, and the research on the human visual processing mechanism will provide inspiration and guidance for computer vision research. Therefore, it is also a very important and interesting research field to study the mechanism of human vision and establish the computational theory of human vision by means of computer information processing.

2.2 The Image Processing Method of Computer Vision Technology

In computer vision systems, the processing technology of visual information mainly depends on the image processing method, which includes image enhancement, data encoding and transmission, smoothing, edge sharpening, segmentation, feature extraction, image recognition, and understanding [17]. After this processing, the quality of the output image has been improved to a considerable extent, which not only improves the image's visual effect but also facilitates the computer to analyze, process, and recognize the image.

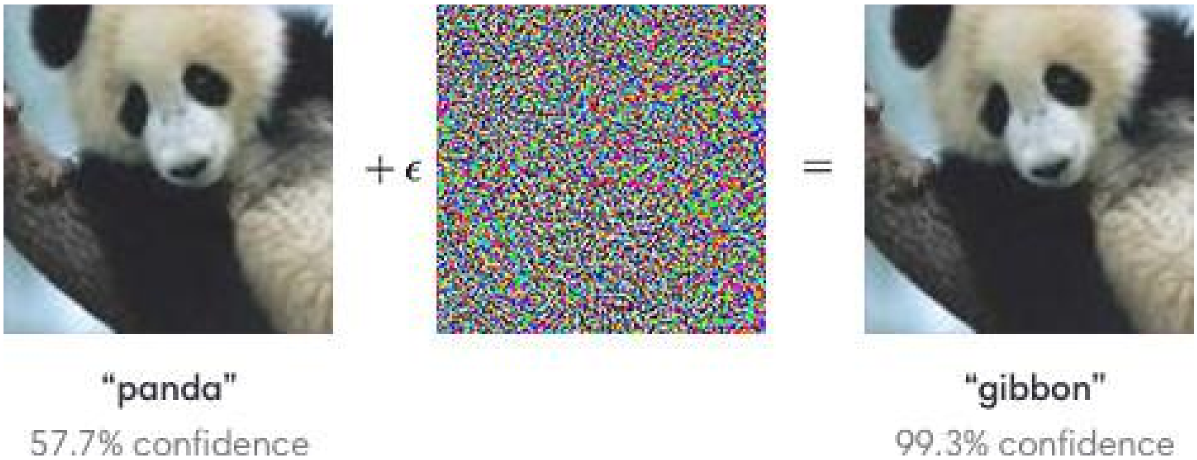

Figure 2: Results before and after image processing by computer vision technology

2.3 Enhancement of Image

Image enhancement is used to adjust the image's contrast, highlight important details in the image, and improve visual quality. The gray histogram modification technique is usually used for image enhancement. The gray histogram of an image is a statistical characteristic chart representing the gray distribution of an image, which is closely related to contrast [18]. The shape of the gray histogram can judge the sharpness and black-and-white contrast of the image. If the histogram effect of an image is not ideal, it can be appropriately modified by histogram equalization processing technology, that is, the gray level of pixels in an image with known gray probability distribution is mapped to transform it into a new image with uniform gray probability distribution, to achieve the purpose of making the image clear.

2.4 Image Smoothing

Image smoothing processing technology, that is, image noise removal processing, mainly removes the image distortion caused by imaging equipment and environment in the actual imaging process and extracts useful information [19]. As we all know, in the actual image in the formation, transmission, reception, and processing process, there is inevitably external interference and internal interference, such as the photoelectric conversion process of the sensitivity of the non-uniformity, digital process quantization noise, transmission process error and human factors. It can degrade the image. Therefore, removing noise and restoring the original image is important in image processing.

2.5 Image Data Encoding and Transmission

The amount of data in digital images is quite large; the amount in a 512*512-pixel digital image is 256 K bytes if it is assumed that 25 frames of images are transmitted per second, the transmission channel rate is 52.4M bits/second [20][21]. A high channel rate means high investment, but the difficulty of popularization increases. In the transmission process, it is very important to compress image data. Data compression is mainly accomplished by image data encoding and transformation compression. Image data coding generally adopts prediction coding, that is, the spatial and serial change rules of image data are expressed by a prediction formula. If you know the value of each adjacent pixel in front of a pixel, you can use the formula to predict the pixel value. This method can compress the data of an image into a few tens of bits, then transform it back at the receiving end.

2.6 Edge Sharpening

Image edge sharpening processing mainly strengthens the contour edges and details in the image to form a complete object boundary [22]. The object can be separated from the image or the area representing the same object surface can be detected. It is a fundamental problem in early vision theory and algorithms. It is also one of the important factors in the middle and late visual success or failure.

2.7 Image Segmentation

Image segmentation divides the image into several parts, each corresponding to a certain object's surface. In the division. The grayscale or texture of each part conforms to some uniform measure measure. One essence is to classify pixels. The classification is based on the gray value, color, spectral, spatial, or texture characteristics of pixels. Image segmentation is one of the basic methods of image processing technology applied to such aspects as chromosome classification, scene understanding systems, machine vision, etc. [23] There are two main image segmentation methods: the gray threshold segmentation method in view of the metric. It uses a gray-level histogram to determine image spatial domain pixel clustering. The second is the segmentation method of regional growth in the spatial domain.

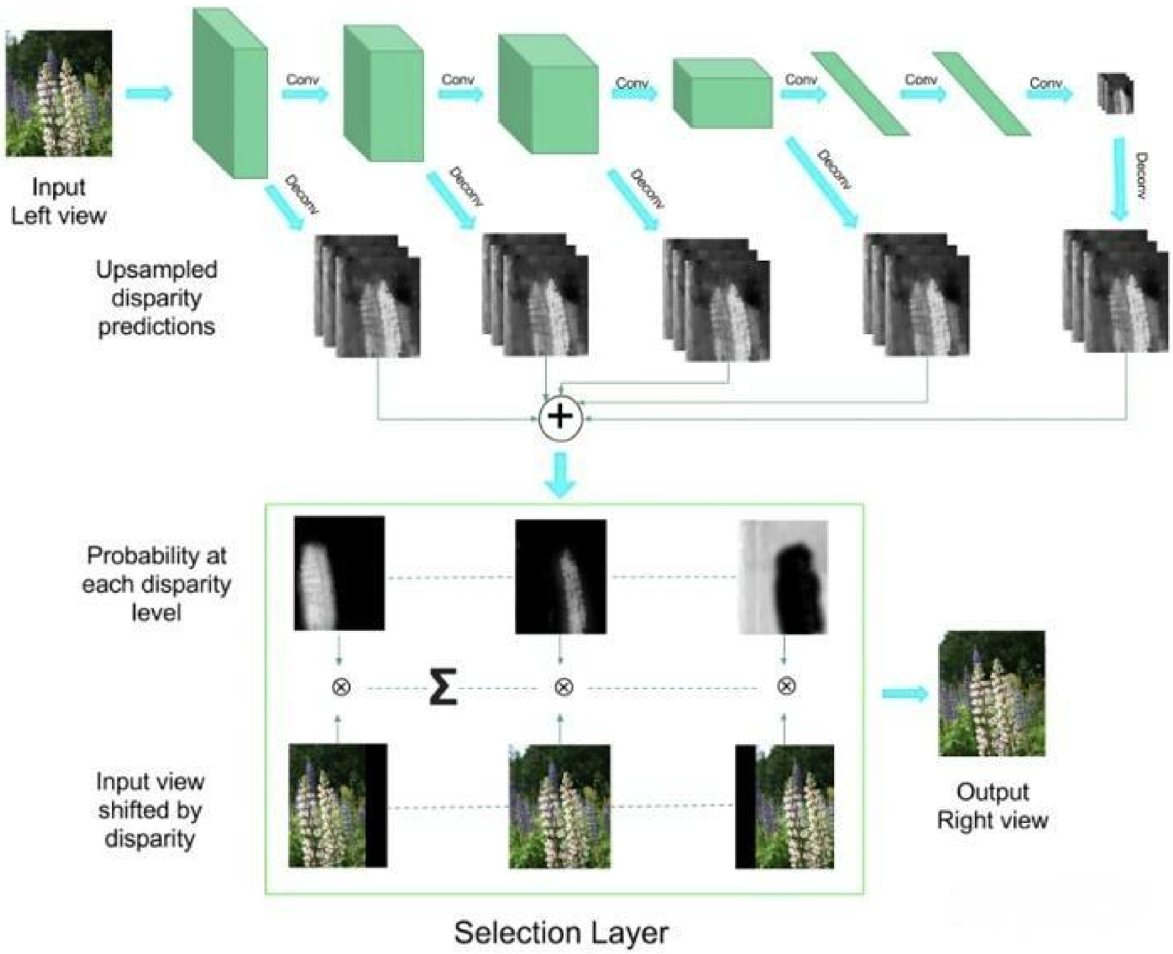

Figure 3: Computer vision technology image processing flow

The pixel is connected to form a segmentation region in a certain sense (such as gray level, organization, gradient, etc.) [24]. This method has a good segmentation effect, but the disadvantage is that the operation is complex and the processing speed is slow.

3. The Key Role of Computer Vision in Autonomous Driving

Visual object detection plays an indispensable role in the environment perception system. As one of the research hotspots of image processing and computer vision direction, it can help autonomous driving system detect target objects such as vehicles, pedestrians and traffic signs, and is one of the important technologies to realize autonomous navigation and improve traffic safety [25]. Therefore, it is of great significance to optimize and improve the research and application of vision-based object detection technology. In the current field of autonomous driving, image-based object detection technology is one of its core and most challenging problems [26]. Effectively solving this problem will promote the development of the entire autonomous driving technology and further improve the safety and intelligence of autonomous vehicles on the road [27]. At the same time, due to the accuracy and high reliability of autonomous vehicles in following traffic rules and reducing accidents, it is expected to prevent millions of lives from disasters and save billions of yuan, realizing this dream is a major progress in the field of transportation. With the continuous innovation and efforts of researchers and industry, it may soon become a reality.

3.1 Computer Vision Data Entry

Computer vision, as a direct input to data processing, is an indispensable part of automatic driving. In addition, most transportation authorities around the world promote the concept of "defensive driving." Defensive driving is a mechanism to anticipate and help avoid crises, which requires drivers to prevent other traffic accidents caused by their own negligence or violations in addition to obeying traffic rules [28]. Assisted autonomous driving is based on a number of highly innovative integrated applications whose key modules can be summarized as environment awareness, behavioral decision making, path planning, and motion control. The primary problem facing assisted automatic driving is how to effectively collect and quickly process the environmental data around the vehicle and the internal data of the vehicle, which is also the basic data support of automatic driving. Therefore, the study of this paper has important research significance.

3.2 Automatic Driving Environment Perception and Detection

Visual object detection is an indispensable part of environment perception system and an important direction of computer vision and image processing [29-33]. The technology is widely used in many fields, such as object detection in autonomous driving systems, intelligent transportation, robotic path planning, and video surveillance. In recent years, with the development of big data and the improvement of computational performance, deep neural networks have achieved unprecedented success, surpassing traditional methods in various fields and ranking first, especially in image classification, object detection and semantic segmentation [34][35]. In recent years, the development of deep learning technology has promoted the global Internet giants to take autonomous driving as an important strategic direction for future development, pushing the autonomous driving industry into a new historical period. Waymo and Uber, along with other foreign companies, began working on self-driving technology as early as 2017. Waymo has tested self-driving [36-38] cars in the Phoenix area and announced in November 2022 that it would open its self-driving ride-hailing service to the public in downtown Phoenix.

3.3 Important Application

This study comprehensively discusses the application and importance of computer vision in automatic driving technology, emphasizing that computer vision is an indispensable part of automatic driving, which enables the vehicle to perceive and understand the surrounding environment and make intelligent decisions and controls [39]. Especially in object detection, image segmentation, and feature extraction, computer vision technology is important in improving traffic safety and realizing automatic navigation. With the development of deep learning and big data technologies, the accuracy and reliability of these systems continue to improve, heralding major advances in the future of autonomous driving [40][41]. Based on the principle of computer vision detection and vision direction segmentation, this paper introduces the principle of the correlative algorithm of automatic driving and its application in automatic driving. Then, some distance estimation algorithms and some visualization solutions are introduced. Currently, the industry's mainstream obstacle perception of unmanned vehicles relies on lasers, and its vision scheme is relatively immature [42]. However, we still prefer visual solutions because they are low-cost and can reduce the reliance on highly refined maps.

In short, the future development direction of autonomous driving technology mainly includes the following aspects:

1) Algorithm optimization: With the continuous development of deep learning, computer vision, machine learning, and other technologies, the algorithm of the automatic driving system will be continuously optimized to improve its accuracy, real-time, and reliability.

2) Sensor technology: [43] Future autonomous driving systems will rely more on multi-modal sensor technology, such as lidar, ultrasound, etc., to provide more accurate environmental understanding and decision support.

3) Safety and reliability: The safety and reliability of autonomous driving systems will become a key issue for future development, requiring more rigorous testing and verification.

4) Laws and regulations: [44-45] With the development of autonomous driving technology, relevant laws and regulations will continue to improve to regulate the use and management of autonomous driving systems.

5) Social acceptance: The popularization of autonomous driving technology requires social acceptance and support, and issues such as safety, road traffic, and occupational structure need to be addressed.

4. Conclusion

In assisted driving and automatic driving, many targets need to be identified and estimated, including motor vehicles, non-motor vehicles, pedestrians, road signs, the road itself, lane lines, etc., which makes the learning algorithm based on target monitoring and recognition very complicated. In automatic driving and robot navigation, another method is to find paths and avoid obstacles by directly learning the forward direction from video images, as well as Yann Lecun's work [46-47], that is to avoid obstacles on non-roads through end-to-end learning. Using the 6-layer CNN to learn people's driving behavior can help learn the features of the lower and upper layers while crossing the area in the field of vision, eliminating manual calibration, correction, parameter adjustment, etc. The main advantage of this system is that it is very robust to various non-road environments.

Autonomous driving technology is one of the research hotspots of future automobile intelligence. It can be concluded from the review articles that automatic driving technology based on traditional target detection with the most effective HOG features, SIFT features, CSS, and other features have achieved good results.

Due to the extremely complex actual road conditions, it is difficult to greatly improve the performance of the traditional driving assistance technology based on target detection. The existing automatic driving technology generally relies on advanced radar systems, which significantly increases the cost of system implementation. Deep driving technology can sense the road and various targets on the road simultaneously and provide driving logic support for the autonomous driving system, which is one of the directions of future autonomous driving technology research.

In the specific assisted driving algorithm, if there is no overall perception of road conditions and objectives, it is difficult to reach the practical and commercial level. It is a good solution for absorbing the essence of traditional autonomous driving technology, learning from the latest achievements of deep learning research, and integrating traditional and deep learning features to provide more information. Designing new algorithms for autonomous driving technology to enhance the personification and practicality of deep driving is a path worth exploring further.

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In addition, I would like to give special thanks to Ping, Gang et al for their Research in their article [2]"Research on Optimizing Logistics Transportation Routes Using AI Large Models". They deeply discussed the methods and applications of optimizing logistics transportation routes using AI large models and proposed a series of innovative strategies based on AI technology. Their work not only provides a new theoretical basis for optimizing logistics efficiency, but also demonstrates the effectiveness of these methods in practical applications through empirical analysis, which provides an important reference and inspiration for future research and application.

References

[1] Ding, W., Tan, H., Zhou, H., Li, Z., & Fan, C. Immediate Traffic Flow Monitoring and Management Based on Multimodal Data in Cloud Computing.

[2] Ping, Gang, et al. "Research on Optimizing Logistics Transportation Routes Using AI Large Models." Applied Science and Engineering Journal for Advanced Research 3.4 (2024): 14-27.

[3] Zhan, X., Ling, Z., Xu, Z., Guo, L., & Zhuang, S. (2024). Driving efficiency and risk management in finance through AI and RPA. Unique Endeavor in Business & Social Sciences, 3(1), 189-197.

[4] Zhan, X., Shi, C., Li, L., Xu, K., & Zheng, H. (2024). Aspect category sentiment analysis based on multiple attention mechanisms and pre-trained models. Applied and Computational Engineering, 71, 21-26.

[5] Liu, B., Zhao, X., Hu, H., Lin, Q., & Huang, J. (2023). Detection of Esophageal Cancer Lesions Based on CBAM Faster R-CNN. Journal of Theory and Practice of Engineering Science, 3(12), 36-42.

[6] Liu, B., Yu, L., Che, C., Lin, Q., Hu, H., & Zhao, X. (2024). Integration and performance analysis of artificial intelligence and computer vision based on deep learning algorithms. Applied and Computational Engineering, 64, 36-41.

[7] Li, A., Yang, T., Zhan, X., Shi, Y., & Li, H. (2024). Utilizing Data Science and AI for Customer Churn Prediction in Marketing. Journal of Theory and Practice of Engineering Science, 4(05), 72-79.

[8] Wu, B., Gong, Y., Zheng, H., Zhang, Y., Huang, J., & Xu, J. (2024). Enterprise cloud resource optimization and management based on cloud operations. Applied and Computational Engineering, 67, 8-14.

[9] Guo, L., Li, Z., Qian, K., Ding, W., & Chen, Z. (2024). Bank Credit Risk Early Warning Model Based on Machine Learning Decision Trees. Journal of Economic Theory and Business Management, 1(3), 24-30.

[10] Xu, Z., Guo, L., Zhou, S., Song, R., & Niu, K. (2024). Enterprise Supply Chain Risk Management and Decision Support Driven by Large Language Models. Applied Science and Engineering Journal for Advanced Research, 3(4), 1-7.

[11] Song, R., Wang, Z., Guo, L., Zhao, F., & Xu, Z. (2024). Deep Belief Networks (DBN) for Financial Time Series Analysis and Market Trends Prediction.

[12] Bai, X., Zhuang, S., Xie, H., & Guo, L. (2024). Leveraging Generative Artificial Intelligence for Financial Market Trading Data Management and Prediction.

[13] Zhang, Y., Liu, B., Gong, Y., Huang, J., Xu, J., & Wan, W. (2024). Application of machine learning optimization in cloud computing resource scheduling and management. Applied and Computational Engineering, 64, 9-14.

[14] Huang, J., Zhang, Y., Xu, J., Wu, B., Liu, B., & Gong, Y. Implementation of Seamless Assistance with Google Assistant Leveraging Cloud Computing.

[15] Liu, B. (2023). Based on intelligent advertising recommendation and abnormal advertising monitoring system in the field of machine learning. International Journal of Computer Science and Information Technology, 1(1), 17-23.

[16] Wu, B., Xu, J., Zhang, Y., Liu, B., Gong, Y., & Huang, J. (2024). Integration of computer networks and artificial neural networks for an AI-based network operator. arXiv preprint arXiv:2407.01541.

[17] Feng, Y., Qi, Y., Li, H., Wang, X., & Tian, J. (2024, July 11). Leveraging federated learning and edge computing for recommendation systems within cloud computing networks. In Proceedings of the Third International Symposium on Computer Applications and Information Systems (ISCAIS 2024) (Vol. 13210, pp. 279-287). SPIE.

[18] Liu, S., Yan, K., Qin, F., Wang, C., Ge, R., Zhang, K., Huang, J., Peng, Y. and Cao, J., 2024. Infrared Image Super-Resolution via Lightweight Information Split Network. arXiv preprint arXiv:2405.10561.

[19] Zhao, F., Li, H., Niu, K., Shi, J., & Song, R. (2024, July 8). Application of deep learning-based intrusion detection system (IDS) in network anomaly traffic detection. Preprints.

[20] Liang, P., Song, B., Zhan, X., Chen, Z., & Yuan, J. (2024). Automating the training and deployment of models in MLOps by integrating systems with machine learning. Applied and Computational Engineering, 67, 1-7.

[21] Shi, Y., Li, L., Li, H., Li, A., & Lin, Y. (2024). Aspect-Level Sentiment Analysis of Customer Reviews Based on Neural Multi-task Learning. Journal of Theory and Practice of Engineering Science, 4(04), 1-8.

[22] Zheng, H., Wu, J., Song, R., Guo, L., & Xu, Z. (2024). Predicting Financial Enterprise Stocks and Economic Data Trends Using Machine Learning Time Series Analysis.
[23] Guo, L., Song, R., Wu, J., Xu, Z., & Zhao, F. (2024). Integrating a Machine Learning-Driven Fraud Detection System Based on a Risk Management Framework.
[24] Li, H., Wang, S. X., Shang, F., Niu, K., & Song, R. (2024). Applications of large language models in cloud computing: An empirical study using real-world data. International Journal of Innovative Research in Computer Science & Technology, 12(4), 59-69.
[25] Gong, Y., Liu, H., Li, L., Tian, J., & Li, H. (2024, February 28). Deep learning-based medical image registration algorithm: Enhancing accuracy with dense connections and channel attention mechanisms. Journal of Theory and Practice of Engineering Science, 4(02), 1-7.
[26] Li, J., Wang, Y., Xu, C., Liu, S., Dai, J., & Lan, K. (2024). Bioplastic derived from corn stover: Life cycle assessment and artificial intelligence-based analysis of uncertainty and variability. Science of The Total Environment, 174349.
[27] Yuan, J., Lin, Y., Shi, Y., Yang, T., & Li, A. (2024). Applications of Artificial Intelligence Generative Adversarial Techniques in the Financial Sector. Academic Journal of Sociology and Management, 2(3), 59-66.
[28] Xiao, J., Wang, J., Bao, W., Deng, T. and Bi, S., Application progress of natural language processing technology in financial research.
[29] Fan, C., Li, Z., Ding, W., Zhou, H., & Qian, K. Integrating Artificial Intelligence with SLAM Technology for Robotic Navigation and Localization in Unknown Environments.
[30] Li, Zihan, et al. "Robot Navigation and Map Construction Based on SLAM Technology." (2024).
[31] Fan, C., Ding, W., Qian, K., Tan, H., & Li, Z. (2024). Cueing Flight Object Trajectory and Safety Prediction Based on SLAM Technology. Journal of Theory and Practice of Engineering Science, 4(05), 1-8.
[32] Wang, B., Lei, H., Shui, Z., Chen, Z., & Yang, P. (2024). Current State of Autonomous Driving Applications Based on Distributed Perception and Decision-Making.
[33] Jiang, W., Yang, T., Li, A., Lin, Y., & Bai, X. (2024). The Application of Generative Artificial Intelligence in Virtual Financial Advisor and Capital Market Analysis. Academic Journal of Sociology and Management, 2(3), 40-46.
[34] Xu, J., Jiang, Y., Yuan, B., Li, S., & Song, T. (2023, November). Automated Scoring of Clinical Patient Notes using Advanced NLP and Pseudo Labeling. In 2023 5th International Conference on Artificial Intelligence and Computer Applications (ICAICA) (pp. 384-388). IEEE.
[35] Yuan, B., & Song, T. (2023, November). Structural Resilience and Connectivity of the IPv6 Internet: An AS-level Topology Examination. In Proceedings of the 4th International Conference on Artificial Intelligence and Computer Engineering (pp. 853-856).
[36] Sha, X. (2024). Research on financial fraud algorithm based on federal learning and big data technology. arXiv preprint arXiv:2405.03992.
[37] Yuan, B., Song, T., & Yao, J. (2024, January). Identification of important nodes in the information propagation network based on the artificial intelligence method. In 2024 4th International Conference on Consumer Electronics and Computer Engineering (ICCECE) (pp. 11-14). IEEE.
[38] Yuan, B. (2024). Design of an Intelligent Dialogue System Based on Natural Language Processing. Journal of Theory and Practice of Engineering Science, 4(01), 72-78.
[39] Zhan, T., Shi, C., Shi, Y., Li, H., & Lin, Y. (2024). Optimization Techniques for Sentiment Analysis Based on LLM (GPT-3). arXiv preprint arXiv:2405.09770.
[40] Lin, Y., Li, A., Li, H., Shi, Y., & Zhan, X. (2024). GPU-Optimized Image Processing and Generation Based on Deep Learning and Computer Vision. Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023, 5(1), 39-49
[41] Chen, Zhou, et al. "Application of Cloud-Driven Intelligent Medical Imaging Analysis in Disease Detection." Journal of Theory and Practice of Engineering Science 4.05 (2024): 64-71.
[42] Wang, B., Lei, H., Shui, Z., Chen, Z., & Yang, P. (2024). Current State of Autonomous Driving Applications Based on Distributed Perception and Decision-Making.
[43] Yao, J., & Yuan, B. (2024). Research on the Application and Optimization Strategies of Deep Learning in Large Language Models. Journal of Theory and Practice of Engineering Science, 4(05), 88-94.
[44] Yao, J., & Yuan, B. (2024). Optimization Strategies for Deep Learning Models in Natural Language Processing. Journal of Theory and Practice of Engineering Science, 4(05), 80-87.
[45] Xu, X., Yuan, B., Song, T., & Li, S. (2023, November). Curriculum recommendations using transformer base model with infonce loss and language switching method. In 2023 5th International Conference on Artificial Intelligence and Computer Applications (ICAICA) (pp. 389-393). IEEE.

[46] Yang, P., Chen, Z., Su, G., Lei, H., & Wang, B. (2024). Enhancing traffic flow monitoring with machine learning integration on cloud data warehousing. Applied and Computational Engineering, 67, 15-21.
[47] Jiang, W., Qian, K., Fan, C., Ding, W., & Li, Z. (2024). Applications of generative AI-based financial robot advisors as investment consultants. Applied and Computational Engineering, 67, 28-33.