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An efficient intelligent task management in autonomous vehicles using AIIOT and optimal kernel adaptive SVM

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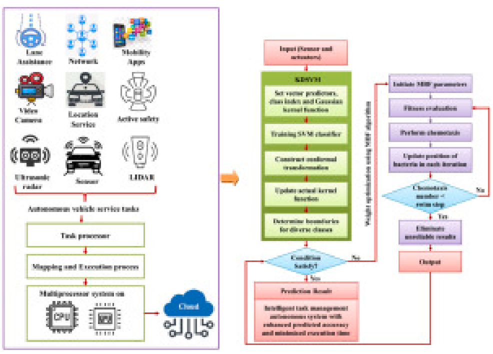
Highlights

- The fast evolution of AI and IoT gained interest in developing autonomous vehicles.
- Accident rate by autonomous vehicles are increasing due to unrestrained traffic.
- Intelligent task managing system for autonomous vehicle is proposed in this paper.
- KDASVM-MBF intelligent task scheduling method is proposed to distribute all the task.
- The model is implemented in Python 3.8 and examined using two multicore processors.

Abstract

The fast evolution of artificial intelligence (AI) and the IoT gained more interest in the development of autonomous vehicles. The main challenges faced by autonomous car manufacturers are high computation costs and the lag of intelligent task management systems. The accident rates created by autonomous vehicles are increasing rapidly due to their unrestrained traffic, inaccurate location, and mapping methods. So, secure driving becomes the main concern in self-driving vehicle design. Moreover, the inadequate battery life and computation power made the system complex to minimize execution time as well as resource computation. Therefore, to handle all these complications, an intelligent task-managing system for autonomous vehicles is proposed in this paper. In this, each task is optimally executed by invoking the supervised resource predictor kernel data adaptive support vector machine-based multimodal bacterial foraging (KDASVM-MBF) method. The KDASVM-MBF intelligent task scheduling method is proposed to distribute all the tasks to the suitable processor based on central processing unit (CPU) usage and emergency. The proposed model is implemented in Python IDE-version 3.8 and examined using two multicore processors (Nvidia and AIIoT). The potential capability of the introduced type is evaluated by computing the performance methods such as response time, resource utilization, CPU utilization, execution time, prediction accuracy, and task miss rate. The experimental results reveal that the established KDASVM-MBF method accomplishes prediction accuracy of about 97% and 98% for Nvidia and AIIoT processors respectively with minimum task miss rate and execution time.

Graphical abstract



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Introduction

The third industrial revolution is mentioned as the IoT. Universally the automotive industry confronting more challenges regarding emissions, traffic congestion, pollution, and mobility services. Autonomous Vehicles (AV) is operated and controlled by human to reduce road accidents and maximize the safety of vehicles (Dachyar et al., 2019). Autonomous vehicles are used by institutions, universities, and companies for safe driving. The sensors and devices in the IoT frequently collect and interpret temporal data and spatial data for environments and specific events which address a variety of difficulties. Things have become smarter as a result of the IoT, treatment has become more intelligent, and communication has become more instructive (Chaabouni et al., 2019). Vehicle-to-infrastructure (V2I) communications, IoT, industrial internet, and vehicle-to-vehicle (V2V), as well as the requirement for the new wireless communication standard called 5G, the requirement obtain by the industrial revolution, has been confirmed. Area capacity of 1 Tbps/km^2, support for a 100x enhance, and Latencies of less than 1 ms in connected devices over LTE-A (Long Term Evolution-Advanced) are standard expectations established by users and entrepreneurs for 5G. 50 Mbps minimum user throughput for everyone is also a popular criterion for 5G (Kela et al., 2016). The development of self-driving cars and brilliant driver support devices has recently received a lot of interest from the general public. The low performance of self-driving vehicle as well as driver assistance system in unfavorable weather conditions like snow, hail, rain, and fog is a major problem due to the introduction of self-driving vehicles and driver support devices (Zang et al., 2019). Several tasks in a self-driving vehicle have strong scheduling limitations due to severe deadlines, and if any unique task is missed, major accidents would occur.

Self-driving vehicles need capable software and hardware to handle several jobs concurrently and efficiently to reduce accident rates. The path of the driving is tracked for a safe and comfortable driving experience in real-time applications. The combination method of the AV is determined by the feedback–feedforward controller (Abduljabbar et al., 2019). The expansion of the AV in real-time applications is manipulated by using the Multiprocessor System-on-Chips (MPSoCs). The hardware technological revolution shifted from Single-Processor to MPSoC (Multi-Processor System-On-Chip) (Paraskevas, 2021). Homogeneous Multi-processor and heterogeneous Multi-processor are the categorizations of MPSoC. The development of MPSoC obtains maximum scale integration, Quality of Service and enhances performance. Heterogeneous MPSoC (HMPSoC) incorporates distinct categories including Graphics Processing Units (GPUs), Artificial Intelligence (AI) techniques as well as Central Processing Units (CPUs) on a similar SoC, whereas homogeneous multiprocessor chip contains a group of Central Processing Units (CPUs) that are all on the same chip (Zhang et al., 2020). Also, these asymmetric multiprocessors are low-power consumption and energy-efficient multitaskers (Antolak and Pułka, 2022).

Various real-time IoT applications have recently adopted Multi-Processor System-On-Chip which increases performance levels while consuming less energy (Yu et al., 2020). The goals are to create a self-driving car capable of overcoming product delivery failures while avoiding road accidents, to create a low-cost infrastructure capable of producing effective results, and to create a deep learning model equipped with a self-driving car prototype (Tripathi and Gupta, 2020). The significant role of this article involves making use of novel technologies namely IoT for making the generic system to avoid traffic crashes and to contribute an important deal to economy. Various other similar systems are more accurate but the time execution was very high. The major challenges faced by car manufacturers are high execution time and high costs. In addition to this, the accident rate developed by autonomous vehicle has been increasing rapidly because of inaccurate location as well as uncontrolled traffic. In addition to this, inadequate battery consumption as well as power consumption made the entire system more complex. Therefore, an intelligent task managing system is developed to manage all such complications for autonomous vehicle system.

Integration of Kernel Data Adaptive Support Vector Machine (KDASVM): The algorithm incorporates KDASVM, which is a variant of the support vector machine (SVM) algorithm. KDASVM adapts the kernel function based on the characteristics of the input data. This adaptability enhances the algorithm's ability to handle diverse and complex data patterns, making it well-suited for the task management problem in autonomous vehicles.

Multimodal Bacterial Foraging (MBF) Optimization: The algorithm utilizes the MBF optimization algorithm to refine the weight coefficients of the support vectors in the KDASVM framework. This optimization technique helps improve the prediction accuracy and reliability of the algorithm by eliminating unreliable results. By combining KDASVM with MBF, the algorithm achieves more accurate and robust predictions.

Task Allocation based on CPU Usage and Emergency: The proposed algorithm considers two crucial factors, CPU usage, and task emergency, for task allocation. By incorporating these factors, the algorithm intelligently distributes tasks to suitable processors. This approach improves the efficiency and effectiveness of task management in autonomous vehicles.

The IoT-based self-driving vehicle tasks are executed under two diverse hardware configurations namely Nvidia and AIIoT with combined processing of both CPU and GPU. The benchmark procedures of both IoT and autonomous vehicles are performed continuously on the hardware clusters and the execution features are investigated. Based on execution characteristics, the workload features are extracted. Initially, the periodic, aperiodic, and complex tasks of the sensor and actuator are inputted into the Kernel-Based Data-Adaptive Support Vector Machine (KDSVM) framework. The soft margin parameter is used to balance the tradeoff between margin combinatorial choice and misclassification error. This framework predicts the optimal hardware configuration cluster for the entire task that is to be performed to optimize resource usage and energy usage. Depending on task emergency and core usage values, the best hardware suitable for each task is preferred. However, this prediction performance is influenced by the weight coefficients of the support vectors. These weight coefficients are optimized using the multi- modal bacterial foraging (MBF) optimization algorithm by removing unreliable results. Thus, the proposed KDSVM-MBF technique optimally selects the hardware processors for each task with less task miss rate, high prediction accuracy, and less execution time.

The major contribution of this article is explained as follows.

- An intelligent task-managing system named kernel data adaptive support vector machine-based multimodal bacterial foraging (KDASVM-MBF) for autonomous vehicles is proposed for the execution of each task.
- The KDASVM-MBF intelligent task scheduling method is proposed to distribute all the tasks to the suitable processor in accordance with emergency as well as central processing unit (CPU) usage.
- The proposed KDASVM-MBF approach predicts the appropriate processor to execute each task and the weight coefficient of the KDASVM framework is organized by the MBF method which manages the prediction accuracy.
- To compare various state-of-art methods with the proposed method to determine its effectiveness using two embedded multicore boards like Nvidia and AIIoT.

The remaining section of the paper is explained as follows: Section 2 analyzes the illustration works related to self-driving cars. Section 3 obtains the system model and describes the concept involved. Section 4 illustrates the proposed depth along with the algorithm utilized in it. Section 5 illustrates the result and the discussion. Finally, Section 6 outlines the conclusions of the paper and some ideas for future work.

Section snippets

Literature survey

In a self-driving car, deep learning techniques based on computer vision were introduced by Kanagaraj et al. (2021) for detecting traffic signs and lanes. The Convolution Neural Network (CNN) along with Spatial Transformer Network (STN) was used in this scheme for detecting autonomous vehicles in lanes. Adam optimizer uses LeNet-5 architecture for detecting the traffic sign. The experimentation result revealed that the scheme attained better accuracy of 97% than the feed-forward neural network. …

System model

The five different modules of autonomous vehicles consist are perception, actuator and sensor, mapping and localization, control module, and path planning (Balasekaran et al., 2021). Every module is composed of complex tasks, monitoring, and the controller. Fig. 1 depicts the design of the task management system.

Let us assume the CPU is indicated by the little cores $[Li_1, Li_2, \ldots, Li_l]$ and the GPU is represented by big cores $\mathrm{B}i_1, \mathrm{B}i_2, \ldots\ldots, \mathrm{B}i_h$ regarding voltage levels and operating frequencies. Two …

Proposed methodology

In this division, an intelligent task scheduling KDASVM-MBF approach is proposed that predicts the optimal processor for each task to be executed. Here, the tasks of sensors and actuators are given as input to the proposed framework. The proposed KDASVM-MBF is an integrated form of the KDSVM and MBF algorithms. The MBF technique was developed to enhance the weighted coefficients of the KDSVM method thus it provides optimal prediction results. The predicted solutions are updated to the cloud …

Results and discussions

We have developed the kernel data adaptive support vector machine-based multimodal bacterial foraging (KDASVM-MBF) method for the intelligent autonomous vehicle. In this division, the efficiency of the established KDASVM-MBF method is determined by examining various performance metrics and by performing a comparative analysis described below. …

Conclusion

The rapid development of IoT and artificial intelligence applications has increased the demand for autonomous vehicles in recent times. Here, the sensors and actuators play a vital role as the key component of these applications. In real-world applications, the software issues such as distribution of tasks, task allocation, and execution time are yet NP-hard complexities. Therefore, we introduced intelligent task management for autonomous vehicles using the KDSVM-MBF method. This proposed …

CRediT authorship contribution statement

Ravikumar Sethuraman: Data curation, Writing – original draft, Writing – review & editing. **Jeyalakshmi S.:** Visualization, Investigation. **Sekar Sellappan:** Software, Validation. **Chitra Sundramiah:** Conceptualization, Methodology, Software. **Isaiyarasi Thangarajan:** Writing – review & editing. **Nagarani Velusamy:** Supervision. …

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

Human and animal rights

This article does not contain any studies with human or animal subjects performed by any of the authors. …

Informed consent

Informed consent was obtained from all individual participants included in the study. …

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