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MATHEMATICS AND SOFTWARE OF VEHICLE COMPUTER CONTROL SYSTEM

123 «Computer systems and networks»

Abstract
to the diploma thesis for the master's degree

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The work was done at the Faculty of Computer Systems and Networks of the Ivan Pulyu Ternopil National Technical University of the Ministry of Education and Science of Ukraine

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The colloquium will be held on December 26, 2019 at 9.00 am at the meeting of the Examination Committee №37 at the Ternopil Ivan Pulyy National Technical University at 46001, Ternopil, Ruska st. 56, educational building №1, aud.1-603

GENERAL CHARACTERISTICS OF THE THESIS

Relevance of research. Nowadays, one the most important and discussed issues all over the world is the topic of environmental protection in the conditions of climate change and global warming. Currently, people are actively looking for different ways of reducing the level of pollutions in order to prevent possible catastrophic consequences. Among others, one of the best solutions is to focus on the reduction of energy use.

One of the biggest consumers of energy is transportation industry, especially personal transport like cars. According to the study made by the US Department of Transportation "Average occupancy remains unchanged from 2009 to 2017" with an average of 1.54 people staying in one car. At the same time for one route taxi this number varies between 20 and 40 people, for bus it is 30-150 people, for tram it is 30 - 250 people and subway train can contain up to 1000 people at one time. Accordingly, it seems that the best kind of transportation for the city is the subway. However, this is not always the case, because the metro is effective only in big cities of the metropolitan level, and only in conjunction with other modes of public transport. Besides, the construction and operation of metro branches requires large investments, taking into the consideration that the distances between stops should be large enough and finally, only the big city has enough population to fill subway trains. Looking back to the figures mentioned above, it's obvious that the second-most efficient kind of transportation is tram. Thanks to the rail track, the tram can reach a considerable length, which is not possible for the bus because of the geometric features of the trajectory of turning. However, the construction of tracks and other infrastructure is quite expensive and what is more, during the construction works causes damage both to the city's transportation system and to businesses that are close to construction. Other disadvantages of the tram are the noise and vibrations from its movement as well as its attachment to the infrastructure. Noise and vibration are partially overcome by the rubber inserts in the wheels, but because of the large mass that presses on the small contact area, the rubber quickly wears out and needs replacement. Which in turn complicates and makes more expensive operation. Besides, the mass and small contact area of the wheels have two other disadvantages, such as high road pressure and the inability to climb steep climbs.

Buses and trolleybuses as kinds of public transportation fit good for the small town. But both of them are not capable to provide with high passenger traffic.

With modern computer technology, it is possible to build a hybrid bus and tram. This vehicle will have dimensions, geometric cornering and passenger tram capacity, as well as the flexibility of use, simplicity and cheap operation of the bus. To accomplish this, it is necessary to develop a computer system that controls the angle of rotation of the wheels of each axle of the vehicle to simulate line or rail driving.

The purpose and objectives of the study. The purpose of the study is to develop mathematical approach and respective software for a computer system to control the rotation of all wheels of the vehicle in order to simulate ride on rails.

Achieving this goal requires the following tasks:

- Analyze key inputs for system operation.
- Develop a general scheme of the system.
- Justify the algorithmic support of the system's operation.
- Investigate performance.

- Develop a prototype system.

The object of study is a neural network that controls the behavior of a vehicle.

The subject of study is the neural network, the behavior of the rail transport, the behavior of the wheel transport, navigation systems, dead reckoning systems, trajectory building.

Scientific novelty of the obtained results:

- The use of a neural network to control the rotation of transport wheels according to a given behavior is analyzed.

The practical significance of the results obtained.

An experienced computerized vehicle control system, after real testing and refinement, involves its continued use in real vehicles.

Testing the results of the thesis.

The results of the master's thesis work were tested at international conferences:

VIII International Scientific and Technical Conference of Young Scientists and Students "Actual Problems of Modern Technologies"

VII Scientific and Technical Conference "Information Models, Systems and Technologies"

Structure of work. The work consists of an explanatory note and a graphical part. The explanatory note consists of an introduction, 3 parts, conclusions, a list of references and appendices. Scope of work: explanatory note - sheet. A4 size, graphic part - 5 sheets A1.

MAIN CONTENT OF THE THESIS

The introduction substantiates the relevance and importance of this research and provides a brief overview of the current state of the art in computerized vehicle control systems. The main tasks that need to be solved in the master's thesis are described.

In chapter 1 «Analysis of the subject area of computerized vehicle control systems» discusses computer systems integrated in the car, the levels of automation of the vehicle, the difference between automated and autonomous vehicles. The computer systems involved in steering the wheels of the vehicle are analyzed. Multi-unit systems and the existing multi-section, all-wheel-drive vehicle that moves toward special road marking through the streets of a Chinese city are also considered.

In chapter 2 «Analysis and research of vehicle computer steering systems»

Methods of obtaining and calculating coordinates are analyzed, and optimal input data are selected. The neural network is considered as a vehicle control tool. The behavior of a vehicle with only front, rear, steering, rear and all steered wheels is considered. Bezier curves are considered as a basis for constructing a trajectory of motion.

In chapter 3 «Implementation of computer software for the vehicle computer steering systems» the basic algorithm of the program operation and the initialization process are described. A thought experiment was conducted on the implementation of a neural network. According to the experiment, a neural network was developed and a companion program was described. A training and test dataset for the neural network was developed and its training and testing were conducted accordingly.

In chapter 4 «Rationale of economic efficiency» the expediency of carrying out research works on this subject is shown and the expediency of using the proposed means is economically substantiated. The cost and price of the research work have been calculated.

In chapter 5 «**Occupational safety and health in emergency situations**» discusses the requirements for the protection of the work of specialists in the field of neural networks when working with computer systems, these specialists include scientists, software developers, users. This provided an adequate level of working conditions. Behavior in the event of an emergency is also considered.

In chapter 6 «Ecology» discusses reduced energy consumption and energy savings. Comparatively environmentally friendly use of bus and tram for transportation of 1000 passengers. And also the use of computer systems to process environmental information.

In the general conclusions about the thesis

CONCLUSIONS

In this thesis was research the mathematics and software of vehicle computer control system:

1. Modern computer systems involved in vehicle control have been analyzed. Various driver assistance systems have been considered to improve safety and facilitate the routine process. Automation and levels of automation of driving from zero to full were considered. Autonomous vehicle is found to be the car with the highest level of driving automation. Various computerized vehicle steering systems have also been analyzed. An example of the implementation of multi-unit system, with automatic control of the rotation angle of the wheels of all vehicle axles in the form of a trackless tram was presented.
2. This thesis discusses how to obtain location information and how to process it. Neural networks, perceptron and their application in the task were also considered. The behavior of the vehicle under different rotary axle configurations was investigated.
3. Natural language processing hardware using neural networks has been analyzed. Efficiency of use of tensor processors in comparison with traditional server CPUs and GPU was investigated. Also, the structure of the tensor processor which is intended for the training tasks of neural networks, was considered.
4. In this thesis explores and describes the algorithm for operating a vehicle control program. The logic and construction of the corresponding neural network were described. A training model for network training has been developed. Successful training and network performance was checked.
5. The costs of the study were also estimated and justified. The normative acts for the working month are considered. And the environmental aspects of the work were analyzed. Further development of the project will be the implementation of a layout managed by Raspberry Pi. Neural network training based on real data, with changes to the training algorithm. Ideally seeking investors and implementing a full-scale model.

LIST OF PUBLISHED BY THE AUTHOR WORK ON THE TOPIC OF THE THESIS

1. Луцків А.М., Форись І.А. Mathematics and software of vehicle steering computer System. Актуальні задачі сучасних технологій : Збірник тез доповідей Том II VIII Науково-технічна конференція «Міжнародної науково-технічної конференції молодих учених та студентів», 27-28 листопада 2019 року. ТНТУ. Тернопіль 2019. с.64.

2. Луцків А.М., Форись І.А. Математичне та програмне забезпечення комп’ютерних систем керування транспортним засобом. Матеріали VII Науково-технічної конференції «Інформаційні моделі, системи та технології», 11-12 грудня 2019 року. ТНТУ. Тернопіль 2019. с.16.

АНОТАЦІЯ

Математичне та програмне забезпечення комп’ютерних систем керування транспортним засобом // Форись Іван Анатолійович // Тернопільський національний технічний університет імені Івана Пулюя, факультет комп’ютерно – інформаційних систем та програмної інженерії, група СІм – 61 // Тернопіль, 2019 // с. – 105я, рис. – 35, табл. – 6, аркушів А1 – 10, додат. – 6, бібліогр. – 42.

Ключові слова: НЕЙРОННА МЕРЕЖА, ТРАНСПОРТНИЙ ЗАСІБ, ПОВЕДІНКА, КРИВА БЕЗЬЄ, ТРАЄКТОРІЯ.

Дипломну робота магістра присвячено створенню комп’ютерної системи керування поворотом всіх коліс транспортного засобу, згідно заданої поведінки. Розглянуто комп’ютерні системи автоматизації керування транспортним засобом, рівні автоматизації. Розглянуто і проаналізовано системи задіяні у керуванні поворотом коліс транспортного засобу, а також актуальні транспортні засоби із усіма керованими колесами.

Проаналізовано поведінку транспортних засобів, що рухаються по рейках та звичайних дорожніх автомобілів, автобусів та вантажівок із різною кількістю поворотних осей. Також розглянуто криві Безьє для побудови траєкторії руху транспортного засобу. Розглянуто та проаналізовано апаратне забезпечення нейронних мереж.

Розроблено, проведено навчання та протестовано нейронну мережу, що керує всіма осями транспортного засобу задля реалізації поведінки руху по колії. Також розроблено та описано алгоритм та логіку визначення початкових координат осей та траєкторії руху транспортного засобу.

ANNOTATION

Mathematical support and software of vehicle computer control system // Forys Ivan Anatoliyovych // Ternopil Ivan Puluj National Technical University, Faculty of Computer Information Systems and software engineering, group CIm – 61 // Ternopil, 2019 // p. – 105, fig. – 35, tab. – 6, Sheets A1 – 10, Add. – 6, Ref. – 42.

Key words: NEURAL NETWORK, VEHICLE, BEHAVIOR, BEZIER CURVE, TRAJECTORY.

The Master's Thesis is devoted to the creation of a computer system to control the rotation of all wheels of the vehicle, according to a given behavior. Computer control systems for vehicle control, levels of automation are considered. The systems involved in the steering of the wheels of a vehicle are considered and analyzed as well as the actual vehicles with all the steered wheels.

The behavior of rail vehicles and conventional road vehicles, buses and lorries with different number of axles is analyzed. Bezier curves are also considered to construct the trajectory of the vehicle. The hardware of neural networks is considered and analyzed.

A neural network that manages all axes of the vehicle to implement track behavior has been designed, trained and tested. The algorithm and logic for determining the initial coordinates of the axes and the trajectory of the vehicle are also developed and described.