DEVELOPMENT OF VOICE INFORMATION FORMALIZATION IN MOTOR TRANSPORT DISPATCHING CONTROL SYSTEMS

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NAYDONOV Ivan

PhD student, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine; ORCID: 0000-0002-2498-6375; **E-mail:** 1604102018@ukr.net

Abstract. Today, in the processes of delivery and distribution management, a large number of different information technologies are used, including the motor transport dispatching control systems. Voice interaction processes play an important role in delivery processes and distribution management, which are being actively automated to improve efficiency, save resources, etc. At the present stage of automation of voice control in organizational and technical systems, there is a problem of timely adjustment, if necessary, of planned routes of motor transport, which is sometimes time-consuming, and accordingly is the most grounded direction of voice interaction automation. In spite of the intensive development of motor transport dispatching control systems when interacting with the driver, it is the voice information that requires formalization in the case of automation of such systems. However, existing tools in the field of voice information formalization are not yet adapted for the analysis of the speech of drivers in order to improve and facilitate their interaction with the dispatching system, which urges the topic of developing the means of formalizing voice information in motor transport dispatching control systems. The objective of the paper is to develop a means for formalizing voice information in motor transport dispatching control systems. Research methods. The research is based on the main provisions of information theory, theory of non-force interaction and software for the development of means of voice information formalization. Research findings. The developed means of voice information formalization in motor transport dispatching control systems allows the driver to not distract from driving and monitor road conditions and situation that can accelerate the delivery of products in the process of distribution, as well as increase security level. The considered peculiarities of the use of the developed means of voice information formalization in motor transport dispatching control systems showed that the driver of the motor vehicle, who will deliver the products in the process of distribution, and will face for the first time a means of voice information formalization operating within the motor transport dispatching control system, should pre-check and, if necessary, "learn" the system to recognize his voice commands from relevant contexts. Scientific novelty. The means of voice information formalization in motor transport dispatching control systems which allows the driver to not distract from driving and monitor road conditions and situation that, in contrast to existing ones, can accelerate the delivery of products in the process of distribution, as well as increase security level was further developed. Practical significance. The developed means of voice information formalization of in motor transport dispatching control systems allow increasing the efficiency of management of the distribution process.

Key words: *means of formalization, voice information, motor transport dispatch control system, distribution process.*

Problem statement. Today, in the process of delivery, a wide range of information technologies such as RFID [1], GPS [1, 2] and GSM [1] trackers, the IoT [3] and "big data" [4] principles are used in the application of dispatch control systems for motor vehicles, applications on smartphones [2], web-system for managing the supply chain [5], and others are used in the motor transport dispatching control systems.

Information technology in distribution management in the application of motor transport dispatching control systems has already been adequately developed to provide the stages of receiving products and their safekeeping, therefore, the stage of delivery of products to end customers is being actively developed. In particular, systems for automation of building planned routes for motor transport [6], TMS (transport management) systems and real-time delivery monitoring are being developed.

Voice interaction processes play an important role in distribution management, which are now actively automated to improve efficiency, save resources, etc. Voice interaction is divided into direct and with the use of information technology. Information technology in this context can serve only as a means of communication, which can produce an effect itself, but the best result can be obtained through automation of voice interaction.

The voice information formalization in motor transport dispatching control systems is associated with information technologies in distribution management and is, to a large extent, designed to provide stages of product receipt and its safekeeping, but there is a problem with the stage of product delivery to end customers, especially as regards to the so called "last mile", which is one of the most expensive and complicated in the organization of distribution. During delivery, there are always some deviations from the plan, no matter how optimal it was, such deviations in each case require adjustments to the plan through communication with the dispatch operator. Drivers-freight forwarders and couriers are more likely to start delivering over and above the plan if communication with the dispatch operator and plan adjustment are not simple and effective. For a distribution problem, it can be difficult to provide permanent access to the Internet, since delivery can occur to places/regions where even mobile GPRS Internet is not available or it has too low data transmission rates for work with sound.

Significant role in distribution management is played by the voice interaction processes, whose automation can improve the efficiency of the distribution system.

At the present stage of voice control automation in organizational and technical systems, there is a problem of timely adjustment, if necessary, of planned routes of motor transport, which can be time-consuming, and accordingly is the most grounded direction of voice interaction automation.

Voice interaction automation for timely adjustment of the routes planned for motor transport should complement existing management automation tools in distribution systems, such as real-time vehicle tracking using a GPS track. The voice interaction automation system for storage management existing in the distribution is too simplified for use in delivery problems.

In spite of the intensive development of motor transport dispatching control systems when interacting with the driver, it is voice information that requires formalization in case of automation of such systems. However, existing tools in the field of voice information formalization are not yet adapted to the analysis of the speech of drivers, in order to improve and facilitate their interaction with the dispatching system.

The means of voice interaction formalization in distribution systems are not adequately developed. All this urges the topic of developing the means of voice information formalization in the systems of motor transport dispatching control.

Analysis of recent research and publications. Voice control already has a certain history of use in the transport sector. The leading automotive companies in the world, such as Ford Motor Company, BMW AG, Daimler AG, aim to increase driver's safety and comfort, thus creating the ability to control on-board electronics by voice [7]. The first such system, called Linguatronic, was presented by the engineers of Mercedes in the S-Class car in 1996 [8]. It implemented the voice control functions of the built-in phone and directory, radio and CD player, as well as air conditioning. Fiat, working jointly with Microsoft, developed a system with the driver-initiated Blue&Me system, in which it was necessary to press the button on the steering wheel before the start of the voice command. The BMW engineers have also developed a driver-initiated system

that was integrated with their iDrive on-board control system. Honda, using the IBM ViaVoice speech recognition system, provided the opportunity of GPS navigation control for voice indication of the destination [9].

In addition, provided a sufficiently powerful system, voice interaction with the driver can be used to maintain dialogue while driving at night in order not to let the driver fall asleep [10].

Studies were also conducted on the development of airborne equipment voice control systems, but due to high requirements for the speed and quality of recognition, especially in the conditions of powerful noise and interference, they have not yet been introduced [11].

The use of such partial voice control functions, which enhance the driver's comfort, should also have some positive effect. However, these functions do not provide optimization of the distribution processes.

In modern systems of automation of distribution, delivery and management of a vehicle fleet, the process of automation of building planned routes of motor transport is well developed [6]. It includes the components of the topology, the time parameters of the delivery point (time windows of availability and time required to service the point), the load of the motor vehicle, the number of available vehicles, etc. However, the communication for timely adjustment of the route in cases where the actual state of affairs does not match the planned route anymore is time-consuming. If these functions were implemented through automated voice interaction, this would have the maximum effect for improving distribution management.

To manage the delivery of cargoes in distribution, the stage of real-time monitoring the route of motor transport is extremely important. This allows analyzing the driver's performance, as well as predicting certain objectionable incidents.

GPS data of the vehicle route are used for such monitoring [12, 13].

Unfortunately, a GPS track alone is not enough for a clear understanding of the state of affairs. The track only shows that the driver was near the delivery point, but it is not clear whether the delivery has been performed or has been canceled for some reason. It is clear from the track that at the current speed the driver lags behind the plan and will not be in time for the next point, but the reason for the lag and whether the driver will be able to make up for the lost time is not clear. To obtain this information, additional communication between the driver and the dispatch operator is required. But the phone call or, even worse, the communication through a certain visual interface on the smartphone takes some time and reduces the concentration of the driver's attention on the road, which can cause an accident.

Therefore, it is necessary to have a system which would allow revealing the necessary information in the driver's voice data and sending it to the dispatch operator in a formalized form.

The most similar to the above-mentioned system is Pick-by-Voice [14]. This is a system used in another area of distribution management – management of warehouse processes. Pick-by-Voice allows the sorter to receive voice commands in turn in the following form: where, what and in what amount to be sorted, as well as in the form of a dialogue to report the need to repeat the task or go to the next, and so on. This system allows freeing sorter's hands and eyes and, in general, increases his efficiency by 35% [15].

Unfortunately, transport deliveries management requires a more complex system than the existing Pick-by-Voice capabilities, since it should have a significantly larger range of commands needed for recognition. In advanced urban freight distribution systems, time delivery windows are an important parameter [16, 17]. This parameter immediately introduces a whole range of additional information to be transmitted from the driver to the dispatch operator - how timely the delivery was made, how much time was spent on each of them, lagging behind the plan because of traffic jams or other unforeseen circumstances, etc. Moreover, the system should provide real-time interaction with the dispatch operator, and not to reproduce a predetermined list of tasks.

Thus, the obvious task is to develop a means for formalizing voice interaction between the driver and the dispatch operator to obtain the necessary information from the driver in a voice form and to automate distribution management.

In the works [18, 19, 20] the model of voice interaction of the driver in systems of motor transport dispatching control and the formalization of voice information with comparison of efficiency of two methods of voice interaction formalization is offered.

The objective of the study. On the basis of previous studies [18, 19, 20], it is necessary to develop means of formalizing voice information in the systems of motor transport dispatching control.

Research findings. In order to use the developed models, a mobile application for the Android platform was created, since it is more widespread, and the cost of smartphones on this platform is lower, which is important to reduce the cost of system implementation.

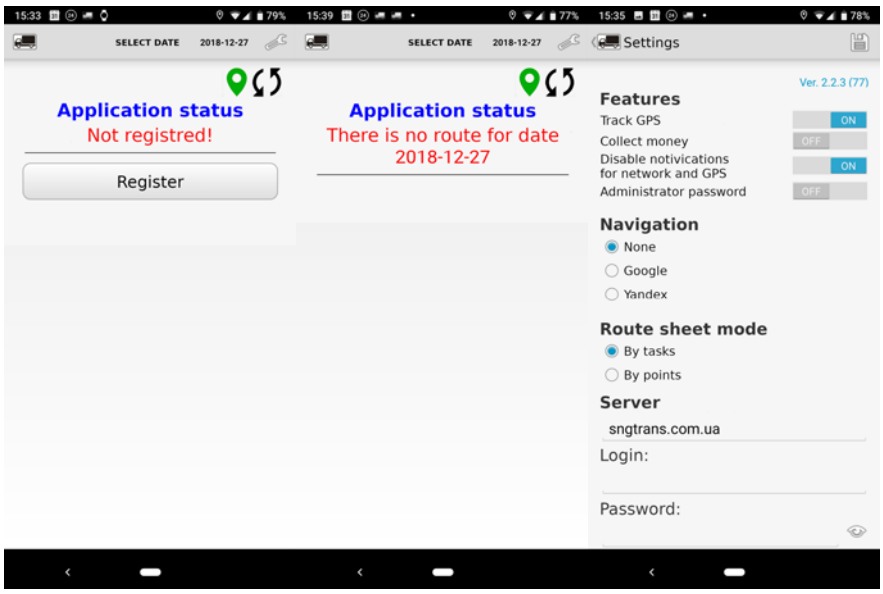
The application is available free of charge in the Google Play store and can be installed by any driver on his own Android smartphone. The application is called Plannary Last Mile.

Since the main way of managing an application is voice commands, the visual interface of the application is simple enough. In general, the interface consists of a settings window (Fig. 1, c), the window with general information about the route (Figure 2), driving directions (Figure 3), route map (Fig. 4, b and c) and the window with the information about the point (Fig. 4, a).

To successfully use the application, it must be registered on the system. The interface for the unregistered device is shown in Fig. 1, a. Self-registration by the driver is impossible, the system administrator shall register the application and the device in the motor transport dispatching control system. Upon registration, the login and password shall be entered in the settings window (Figure 1, c). In case of successful registration, the application will go to the general route information interface (Figure 2), or, if the route to the selected date does not exist, will report it (Fig. 1, b).

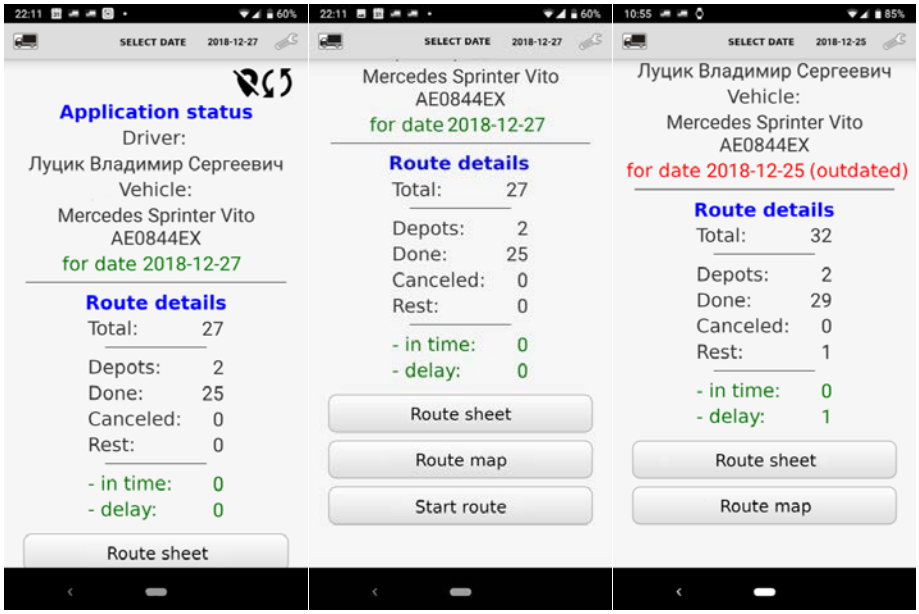
In addition to entering the login and password for registration in the system, the administrator can also set the administrator password to prevent the driver's access to the settings of the application. The main purpose of this function is to prevent the driver from interfering with the work of important components of the system, such as collecting GPS data.

The general view of the route information interface is shown in Fig. 2. This window shows the information such as the full name of the forwarding driver, the model and the vehicle identification number, the date of issue of the delivery route, etc. This window also shows the current and final number of delivery points by different categories, such as: total number of points in the route, number of arrivals to the warehouse, current number of successfully and unsuccessfully completed points, number of points to be completed and predicted values on how many of them the driver has time to complete on time, and to how many of them he is late (provided normal transport conditions).



а *б* *в*

Figure 1 – Application interface for unregistered device (a), for case when there is no route for the selected date (b) and the settings window (c)



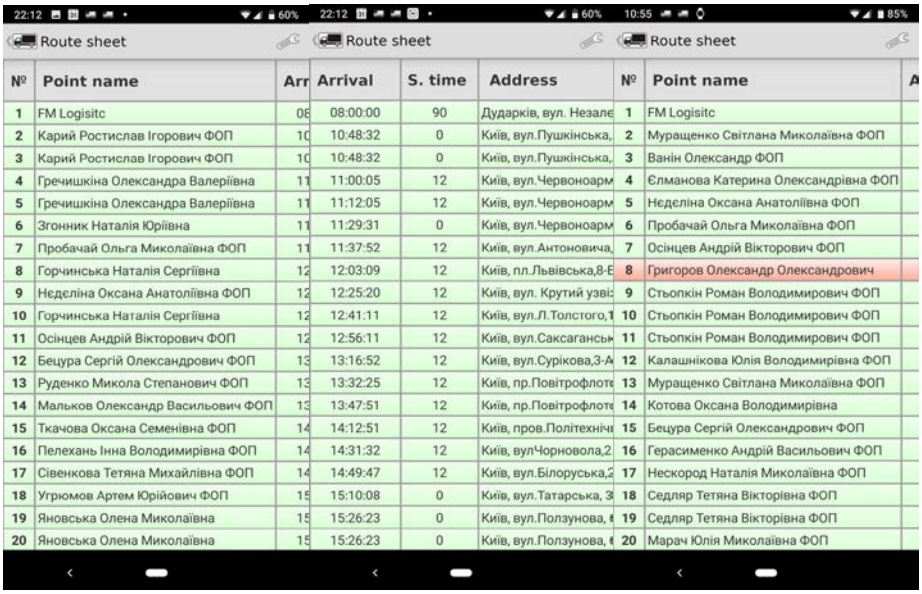
а *б* *в*

Figure 2 – Interface of general information about the route (a, b), including with the mark of uncompleted points (c)

Driving directions window is shown in Figure 3. This interface contains a table of delivery points in the required order of their completion. The table contains the following information about the points: the name of the point or contact name, address, estimated time of arrival and the estimated time of point service.

The rows of the table are highlighted with different colours depending on the different point status such as: warehouse, the point is successfully completed, the point is marked as not completed or cancelled, the point is scheduled for completion and the forecast shows the risk of being late to the point.

Clicking on any point of delivery, or when giving appropriate voice command, the window with the information about the point is displayed (Figure 4, a).



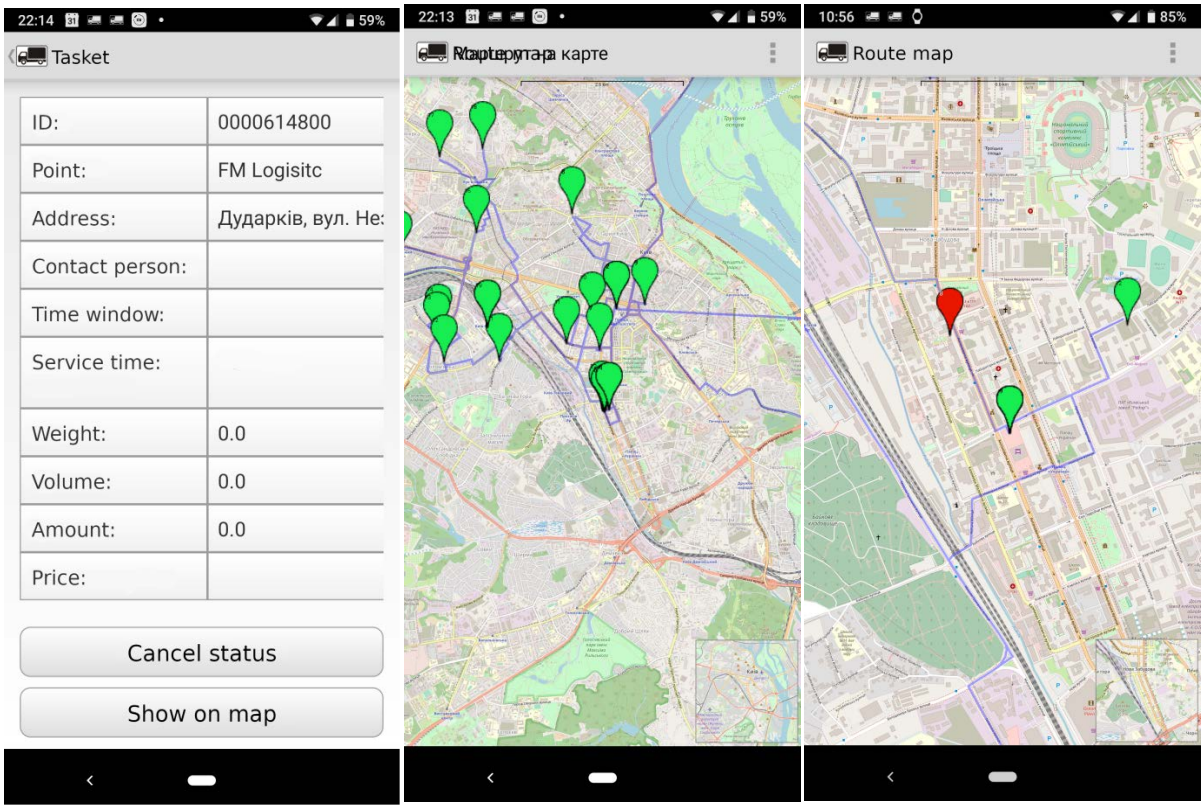
а *б* *в*

Figure 3 –Interface of the window of the driving directions (a, b), including with the mark of the non-completed point (c)

This interface contains the following information about the delivery point: identification number, delivery point name and contact name, address of the point, time within which the delivery to the point should be completed (for example, in case of delivery of goods to an individual before the beginning of the working day, this may be from 7:00 to 9:00) and the projected time of unloading. In addition, the interface shows the weight, volume and cost of the delivered goods, as well as any comments from the client or manager regarding this point.

The interface of the map of the route is shown in Figure 4, b and c. This window is a map showing the delivery points and the possible route between them in a different colour. The point colour depends on the delivery status, and matches the colour in the driving directions table.

An alien application, such as Google Maps, Yandex maps, or others, can be used to navigate to the point. The application for navigation can be selected in the settings window (Figure 1, c). When the corresponding voice command is received, the navigation will automatically begin for the address specified in the point information, and upon arrival at the destination the interface will return to the previous window.



а *б* *в*

Figure 4 – Interface of the information about the point (a) and the route map (b), including with the mark of uncompleted points (c)

As one can see from screenshots of the mobile application interface of the means of voice information formalization, most of the windows are informational in nature and are intended to show additional information in the process of voice control of the system.

Nevertheless, the main functions of changing between the windows of the software and navigation are duplicated in the form of touch buttons, which allows for a more fault-tolerant interface.

For the driver who will deliver the products during the distribution process, and will deal with a means of voice information formalization operating as part of the system of motor transport dispatching control for the first time, a training course on the operation of this system during

which he will need to teach this system to recognize his personal voice with appropriate specific words or commands will be integrated. The use of such means of voice information formalization aboard the vehicle allows extending the driver's performance in the process of distribution, providing and increasing the level of security.

Interactive interface in the system of voice information formalization allows the driver to talk with the vehicle (technical means), create requests, receive information and instructions, solving the tasks of delivery of products, as part of the system of motor transport dispatching control.

The accuracy of the driver's speech recognition is largely determined by the quality and stability of his pronunciation. Therefore, training information system is used for the preliminary training of drivers in the voice interface of this voice information formalization system with motor vehicles dispatching control. The resulting problem of pronunciation is of interest due to the large scope of practical application in various fields. In this case, there is a problem of variation of verbal communication of drivers for different carriers of the national language and is closely connected with it the problem of independent assessment of the quality of their pronunciation. There is an obvious contradiction in the very formulation of the task: one who is taught with insufficient language training at the moment and limited opportunities in the process of self-education should approach its pronunciation to some standard that it is poorly imagine. This contradiction is successfully overcome in the proposed system of formalization of voice information with control over the movement of motor vehicles based on the criterion of minimum information inconsistency - based on phonemes. In this approach, the availability of a reference pronunciation is ensured through the use of not one, but several "standards", which include the best samples of pronunciation from one or even several drivers who have successfully completed training earlier. Such a system for the formalization of voice information is able to memorize the best pronunciation by the driver of words and evaluate the quality of the subsequent proclamation of the same words in relation to these best words for the driver, and not only in relation to the default standards applied by the ideal driver (announcer). This system of voice formalization of supervisory control the movement of vehicles to assess the quality of pronunciation used test of distinguishing different sounds that can be made using one of the known methods of automatic speech recognition - speech recognition accuracy pofonemnoho.Sama driver is largely determined by the quality and the stability of his pronunciation. Therefore, for the preliminary training of drivers in the voice interface of this system of formalization of voice information with control over the movement of motor vehicles used information system training. The resulting problem of pronunciation is of interest due to the large scope of practical application in various fields. In this case, there is a problem of variation of oral speech of drivers for different carriers of the national language, and the problem of independent assessment of the quality of their own pronunciation closely connected with it. There is an obvious contradiction in the very formulation of the problem: one who is taught with insufficient language training at the moment and limited opportunities in the process of self-learning should approach with his pronunciation to some standard that he poorly imagines. This contradiction is successfully overcome in the proposed voice information formalization system of motor transport dispatching control based on the criterion of minimum information inconsistency - based on phonemes. In this approach, the availability of a standard pronunciation is ensured through the use of not one, but several "standards", which include the best samples of pronunciation from one or even several drivers who have successfully completed training earlier. Such a system for the formalization of voice information is able to memorize the best pronunciation by the driver of words and evaluate the quality of the further pronunciation of the same words in relation to these best for the driver words, and not only in relation to the default standards introduced by the ideal driver (announcer). At the same time, testing differentiation of sounds, which can be accomplished using one of the known methods of automatic speech recognition– phonemic – is used for assessing the quality of pronunciation in the system of voice information formalization with motor transport dispatching control.

Conclusions. The developed means of voice information formalization in motor transport dispatching control systems allows the driver to not distract from driving and monitor road conditions and situation that can acceler-

ate the delivery of products in the process of distribution, as well as increase security level.

The considered peculiarities of the use of the developed means of voice information formalization in motor transport dispatching control systems showed that the driver of a motor vehicle, who will deliver products in the process of distribution, and will deal with a means of voice information formalization operating within the motor transport dispatching control system for the first time shall pre-check and, if necessary, learn the system to recognize his voice commands from relevant contexts.

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РОЗРОБЛЕННЯ ЗАСОБУ ФОРМАЛІЗАЦІЇ ГОЛОСОВОЇ ІНФОРМАЦІЇ В СИСТЕМАХ ДИСПЕТЧЕРСЬКОГО КОНТРОЛЮ ЗА РУХОМ АВТОТРАНСПОРТУ

НАЙДЬОНОВ Іван Михайлович
аспірант Київський національний університет імені Тараса Шевченка ORCID: 0000-0002-2498-6375; E-mail: 1604102018@ukr.net

Анотація. На сьогодні у процесах доставки і управлінні дистрибуцією застосовується значна кількість різноманітних інформаційних технологій, у тому числі, і застосування систем диспетчерського контролю за рухом автотранспорту. Значну роль у процесах доставки та управлінні дистрибуцією відіграють процеси голосової взаємодії, які зараз активно автоматизуються для підвищення ефективності, збереження ресурсів тощо. На сучасному етапі автоматизації голосового управління в організаційно-технічних системах існує проблема своєчасного коригування в необхідних випадках планових маршрутів руху автотранспорту, що інколи призводить до достатньо великих витрат часу на комунікацію, і відповідно є найбільш обґрунтованим напрямом автоматизації голосової взаємодії. Не дивлячись на інтенсивний розвиток систем диспетчерського контролю за рухом автотранспорту при взаємодії із водієм, саме голосова інформація потребує формалізації у випадку проведення автоматизації таких систем. Проте існуючі засоби в сфері формалізації голосової інформації поки не пристосовані для аналізу мовлення водіїв, з метою покращення та полегшення їх взаємодії з диспетчерською системою, що робить тему розробки засобів формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту актуальною. Мета статті полягає у розробці засобу формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту. Методи дослідження. Дослідження ґрунтуються на основних положеннях теорії інформації, теорії несилової взаємодії та програмного забезпечення для розробки засобів формалізації голосової інформації. Основні результати дослідження. Розроблений засіб формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту дозволяє водію не відволікатись від управління автомобілем і слідкувати за дорожніми умовами та обстановкою, що дає змогу прискорити доставку продукції в процесі дистрибуції, а також підвищити рівень безпеки. Розглянуті особливості використання розробленого засобу формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту показали, що водію автомобіля, який буде здійснювати доставку продукції в процесі дистрибуції і вперше зіштовхнеться із засобом формалізації голосової інформації, що діє в рамках системи диспетчерського контролю за рухом автотранспорту, необхідно попередньо перевірити і при потребі донавчити систему розпізнавати його голосові команди з відповідних контекстів. Наукова новизна. Набув подальшого розвитку засіб формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту, який дозволяє водію не відволікатись від управління автомобілем і слідкувати за дорожніми умовами та обстановкою, що, на відміну від існуючих, дає змогу прискорити доставку продукції в процесі дистрибуції, а також підвищити рівень безпеки. Практична значимість. Розроблений засіб формалізації голосової інформації в системах диспетчерського контролю за рухом автотранспорту дозволяє підвищити ефективність управління процесом дистрибуції.

Ключові слова: *засіб формалізації, голосова інформація, система диспетчерського контролю за рухом автотранспорту, процес дистрибуції.*

РАЗРАБОТКА СРЕДСТВА ФОРМАЛИЗАЦИИ ГОЛОСОВОЙ ИНФОРМАЦИИ В СИСТЕМАХ ДИСПЕТЧЕРСКОГО КОНТРОЛЯ ЗА ДВИЖЕНИЕМ АВТОТРАНСПОРТА

НАЙДЁНОВ Иван Михайлович
аспирант Киевский национальный университет имени Тараса Шевченко ORCID: 0000-0002-2498-6375; E-mail: 1604102018@ukr.net

Аннотация. На сегодня в процессах доставки и управлении дистрибуцией применяется значительное количество разнообразных информационных технологий, в том числе и применение систем диспетчерского контроля за движением автотранспорта. Значительную роль в процессах доставки и управлении дистрибуцией играют процессы голосовых взаимодействий, которые сейчас активно автоматизируются для повышения эффективности, сохранение ресурсов и тому подобное. На современном этапе автоматизации голосового управления в организационно-технических системах существует проблема своевременного корректирования в необходимых случаях плановых маршрутов движения автотранспорта, иногда приводит к достаточно больших затрат времени на коммуникацию, и соответственно является наиболее обоснованным направлением автоматизации голосовой взаимодействия. Несмотря на интенсивное развитие систем диспетчерского контроля за движением автотранспорта при взаимодействии с водителем, именно голосовая информация требует формализации в случае проведения автоматизации таких систем. Однако существующие средства в сфере формализации голосовой информации пока не приспособлены для анализа речи водителей, с целью улучшения и облегчения их взаимодействия с диспетчерской системой, что делает тему разработки средств формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта актуальной. Цель статьи заключается в разработке средства формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта. Методы исследования. Исследования основываются на основных положениях теории информации, теории несиловыми взаимодействия и программного обеспечения для разработки средств формализации голосовой информации. Основные результаты исследования. Разработан способ формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта позволяет водителю не отвлекаться от управления автомобилем и следить за дорожными условиями и обстановкой, что позволяет ускорить доставку продукции в процессе дистрибуции, а также повысить уровень безопасности. Рассмотрены особенности использования разработанного средства формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта показали, что водителю автомобиля, который будет осуществлять доставку продукции в процессе дистрибуции и впервые столкнется со средством формализации голосовой информации, действующей в рамках системы диспетчерского контроля за движением автотранспорта, необходимо предварительно проверить и при необходимости доучить систему распознавать его голосовые команды из соответствующих контекстов. Научная новизна. Получил дальнейшее развитие средство формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта, который позволяет водителю не отвлекаться от управления автомобилем и следить за дорожными условиями и обстановкой, в отличие от существующих, позволяет ускорить доставку продукции в процессе дистрибуции, а также повысить уровень безопасности. Практическая значимость. Разработан способ формализации голосовой информации в системах диспетчерского контроля за движением автотранспорта позволяет повысить эффективность управления процессом дистрибуции.

Ключевые слова: *средство формализации, голосовая информация, система диспетчерского контроля за движением автотранспорта, процесс дистрибуции.*

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