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Formation of a knowledge base to analyze the issue of transport and the environment

Ilyas Idrisovich Ismagilov[1]*, Aynur Ayratovich Murtazin[1], Dina Vladimirovna Kataseva[2], Alexey Sergeevich Katasev[2], Anastasia Olegovna Barinova[2]

1. Department of Economic Theory and Econometrics, Institute of Management, Economics and Finance of Kazan (Volga Region) Federal University, Kazan, Russia
2. Department of Information Security Systems, Institute of Computer Technologies and Information Security, Kazan National Research Technical University, Kazan, Russia

** Corresponding author's E-mail: iiismag@mail.ru*

ABSTRACT

The environmental impact of transport is significant because transport is a significant user of energy, and burns most of the world's petroleum. This issue creates air pollution, including nitrous oxides and particulates, and is a substantial contributor to global warming through emission of carbon dioxide. This article analyzes the Issue of Transport and the Environment, then solves the evaluation problem of the functional state of vehicle drivers based on the formation and use of a fuzzy knowledge base. The provided the classification of human functional state types. The expediency of using pupillometry as an objective method to analyze the pupillary reaction of a human eye to illumination change is pointed out to assess its functional state. The Analysis of the neural network approach is carried out to determine the functional state of a person's intoxication. It points out its main drawback associated with the impossibility of interpreting the solution obtained using a neural network. To eliminate this drawback and improve the efficiency of decision support to assess the functional state of vehicle drivers, it is proposed to use the mathematical apparatus of fuzzy neural networks to form fuzzy knowledge bases and provide their use in inference mechanisms. In this case, the solution to the problem will be a binary answer ("drunk", "not drunk") with the interpretation of the solution obtained in the form of a set of fuzzy rules written in a natural language understandable to humans. The tasks are set for the formation of a knowledge base to assess the functional state of drivers. The scheme of pupillogram initial data collection is described, as well as the stages of their preparation for Analysis. Pupillogram parameters that significantly characterize the pupillary response of a person to illumination change were identified by an expert method using the methods of correlation analysis: the minimum diameter of the pupil, the diameter of its half constriction, the amplitude of constriction and the time of half expansion. The structure of the generated data sample with the volume of 1000 records is described. A knowledge base was formed after their Analysis, consisting of 2632 fuzzy production rules. To assess the accuracy of determining the functional state of a person based on the knowledge base, a balanced test sample of 400 records (200 records of each class of functional state) was compiled. The test results showed that the number of type 1 errors was 1%, and the number of type 2 errors was 3%. The overall accuracy of determining the functional state of a person based on the generated knowledge base was 96%. The generated fuzzy knowledge base can be effectively used in decision support systems to assess the functional state of vehicle drivers when they undergo a pre-trip medical examination.

Keywords: Environment, Functional state, Transport safety, Knowledge base, Fuzzy production rule, Decision support, Pupillometry, Pupillary response.

INTRODUCTION

The issue of transportation and the environment is paradoxical since transportation conveys substantial socioeconomic benefits, but at the same time, transportation is impacting environmental systems. Transport is now an integral part of the world infrastructure. No type of professional activity is possible without road transport.

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Transport has become a paramount need for almost every person, so the issue of transport security concerns everyone. For safe operation of the vehicle, the driver must be in a normal functional state (F.S.). All types of F.S. can be reduced to the following classes (Chernorizov *et al.* 2016): normal, borderline and pathological. Normal F.S. is understood as a state when all physiological systems of a person are in the most favourable state. The presence of functional disorders is characteristic for borderline and pathological F.S. For borderline F.S., disorders can be "background" for some time and have no effect on a person's performance (fatigue, stress, etc.), and being in a pathological F.S.; a person cannot work (severe overwork, intoxication, stress etc.). Strolling and cycling for transport have picked up impressive significance in examination and strategy making as of late. Exact examination on connects of dynamic travel is expanding at a critical speed. Consideration has spread from an at first very overwhelming spotlight on cycling presently additionally to incorporate strolling and coordinated methodologies (Gerike *et al.* 2019). The dependability misuse examination of electronic vehicle frameworks was led with the thought of electromagnetic obstruction (Siergiejczyk *et al.* 2016).
A huge test in creating and applying a vehicle model for various situations is the need to guarantee that the model can evaluate a wide scope of strategy measures. These incorporate for example changes in foundation, expenses of various modes, mode accessibility, etc. In addition, the venture situations include metropolitan and interregional angles, which require more than one single model (Winkler & Mocanu 2017). The global experience (Europe, USA) of the effective usage of electric vehicles in the current «fabric» of a thickly developed metropolitan foundation was dissected (Kysil 2017). One of the significant symptoms of a person's functional disorder is the deviation of the temporal characteristics during the narrowing or dilation of his pupils, as the reaction to illumination changes. This pupillary response is an unconditioned reflex that cannot be controlled by the brain. Therefore, the method for determining a person's functional disorder by the pupil is objective. Pupillometry approaches are used to detect violations of the vision organs and the nervous system. Pupillometry is the research method using the registration of the pupil size and the dynamics of its change (Zheng *et al.* 2020). For such registration, electronic devices are most often used - videopupillographs, which consist of a camera, a light source and a computer for diagnostics. Thus, pupillometry is based on the Analysis of pupillograms (Watanabe *et al.* 2008) time series of data characterizing the dynamics of pupil size changes, as the result of their unconditional response to illumination changes. As a rule, the size of a person's pupil in a state of intoxication is less than usual, while the amplitude of his pupillary reaction is reduced.
The solution to the problem of the functional state determination is relevant in various subject areas, in particular, in the field of transport security (Mazhari & Ferguson 2018; Varshney & Singh 2020). People in a state of alcoholic intoxication often sit down to drive vehicles. This can lead to tragic consequences: the accidents accompanied by the injury or death of people. This problem is complex. One of the approaches to its solution is the development and application of intelligent systems to assess the functional state of vehicle drivers during the pre-trip medical examination procedure (Chibisov *et al.* 2016; Mousavi *et al*. 2018).
So in work (Akhmetvaleev & Katasev 2018), a neural network method was used to assess the functional state of an intoxicated person. This method has a significant drawback associated with the fact that the result of the neural network is a binary response ("drunk", "not drunk"). The final decision, in this case, is made by a person. Therefore, such a result of the neural network is not efficient enough to make a final informed decision. The decision-maker needs to understand what criteria the system used to produce a particular result. This problem can be solved by forming and using a fuzzy knowledge base to assess the functional state of drivers. In this case, the solution to the problem will be a binary answer ("drunk", "not drunk") with the interpretation of the solution obtained in the form of a set of fuzzy rules written in a natural language understandable to humans (Katasev 2019).
To form a knowledge base for assessing the functional state of vehicle drivers, it is necessary to solve the following tasks:
- Collecting and preparing initial data for the formation of the knowledge base;
- Analyzing the prepared data and form a knowledge base to assess the functional state of drivers;
- Conducting research to assess the accuracy of a person functional state determination based on the generated knowledge base.

Let us consider the solution of these problems in more detail.

MATERIALS AND METHODS

The initial data is a set of pupillograms. To collect them, a laboratory stand was used, which consisted of a light source, a Full HD camera, a network switch and a computer (Akhmetvaleev & Katasev 2018). To obtain

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pupillograms, it is necessary to position the tested person in front of the video camera and apply a short-term light pulse. Within three seconds, the camera selects, determines and captures the size of the pupils. The data obtained is displayed in the form of a pupillogram.

Each pupillogram can be represented as a time series (Perfilieva *et al.* 2016):

$P = \{(t_0, D_0),\dots, (t_i, D_i),\dots, (t_k, D_k)\}$,

where t_0 is the initial moment of time, D_0 is the initial diameter of the pupil, t_k is the final moment of time, D_k is the final diameter of the pupil, and t_i and D_i are the moment of time and the diameter of the pupil in the i-th interval of the time series. The resulting pupillograms may contain noise, missing values and deviations in the measurement of pupil size. The changes in these parameters by more than 2 pixels will lead to significant changes in pupillograms, which will make further Analysis impossible (Watanabe *et al.* 2008). There are various ways to smooth out pupillograms (Agranovich *et al.* 2014; Smyl 2020). In this work, the method using the wavelet transformations (Shleymovich *et al.* 2018; Ismagilov *et al*. 2019; Ji & Shen 2020) is chosen to correct the initial data. The processed pupillogram is smoother due to the elimination of noise, anomalies and missing values (Lomakin *et al*. 2019). Thus, on the basis of the obtained pupillograms, it is possible to calculate the values of its parameters accurately and form a data table for subsequent intellectual Analysis and the formation of a knowledge base.

The following parameters of pupillograms were identified expertly, which significantly characterize the pupillary response of a person to illumination change (Akhmetvaleev, & Katasev 2018):

- D_{min} – minimum pupil diameter ($D_{min} = \min(D_i),\ i=1..k$);
- D_{ps} – the diameter of half pupil constriction ($D_{ps} = (D_0 + D_{min})/2$);
- A_s – pupil constriction amplitude ($A_s = D_0 - D_{min}$);
- t_{pr} – the time of half pupil dilation ($t_{pr} = t_i - t_s \mid D_i = D_{ps},\ t_i > t_s$), where t_s – the time of pupil constriction ($t_s = t_i \mid D_i = D_{min}$).

To confirm the assessment of the selected parameter significance, the correlation analysis was performed (Abro *et al.* 2011), the results of which are presented in Table 1.

Table 1. Values of correlation coefficients of pupillogram parameters.

No.	Parameter name	Correlation coefficient
1	Minimum pupil diameter	0,999
2	The diameter of the half narrowing of the pupil	0,832
3	Pupil constriction amplitude	-0,596
4	Pupil half time	-0,582

The table shows the calculated values of the Pearson correlation coefficients between the input parameters and the output result according to the assessment of the person's F.S. ("drunk", "not drunk"). The value of the correlation coefficient confirmed the significance of the selected input parameters for the output result. Thus, the data sample is formed for Analysis, consisting of the values of four input parameters and one output parameter. The sample size was 1000 records, half of which characterize people in a normal functional state ("not drunk"), and the rest of the records are the people in a state of intoxication. Of the total amount of data, 60% of the records were randomly selected for training and forming the knowledge base, the remaining 40% were selected for testing it and assessing the classifying ability. During data selection, the balance of solution classes was controlled both in training and in the test samples. Intellectual Analysis of the obtained data was carried out on the basis of a specially developed software package that implements the stages of building and training a model of a collective of fuzzy neural networks to form fuzzy knowledge bases to assess the state of objects (Chupin *et al.* 2019).

RESULTS AND DISCUSSION

After the intellectual Analysis of the obtained data, the knowledge base was formed, consisting of 2632 fuzzy-production rules (Katasev 2019).

The rules of the knowledge base consist of four fuzzy conditions and one conclusion that determines the solution class. In this case, the numbers 1, 2, 3, 4, 5 in the requirements of the rules coded the names of fuzzy gradations, for example, "small", "medium", "large", etc. In the conclusion of the rules, the number "0" means the functional state "not drunk", the number "1" - "drunk". The value of the "w" parameter characterizes the weight (significance)

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of the condition in the rule, and the value of the "C.F." parameter characterizes the reliability (importance) of the entire rule.

For example, the rule written in the first row of the table looks like this:

If D_{min} is "small" (w = 0.497) and D_{ps} is "small" (w = 0.128) and A_s is "small" (w = 0.282) and t_{pr} is "small" (w = 0.04) Then *Class* is "0" (CF = 0,013).

The rules of this kind can undergo simple linguistic interpretation and help the decision-maker to form a final conclusion about the functional state of a particular person. To assess the accuracy of a person, functional state determination based on the formed knowledge base, a balanced test sample of 400 records (200 records for each class of functional state) was compiled. The results of the accuracy assessment are presented in Table 2.

Table 2. Test data classification results.

Actual values	Classified		
	0	1	Total
0	194	6	200
1	2	198	200
Total	196	204	400

On the basis of the results obtained, we calculated the errors of the 1st and the 2nd kind, as well as the general classification error (Zhang *et al*. 2017) (Table 3).

Table 3. Classification errors.

1st kind errors, %	2nd kind errors, %	Total error, %
1	3	4

As can be seen from the table, the number of type 1 errors was 1%, and the number of type 2 errors was 3%. In addition, the general classification error on the rules of the knowledge base was 4%, which does not exceed a 5% error rate and is a high result in fuzzy modelling systems. Thus, the overall accuracy of a person's functional state determination based on the generated knowledge base was 96%. The generated knowledge base can be effectively used in decision support systems to assess the functional state of vehicle drivers, for example, during the procedure for pre-trip medical examination.

At the initial stage of the examination, the medical professional assesses the general condition of the driver according to the following criteria:

- the adequacy of behaviour;
- the presence of lethargy, drowsiness or excitement;
- acceleration or deceleration of thinking pace;
- the presence of hyperemia;
- increased breathing rate;
- speech disorders.

Next, a video record of a person's pupillary reaction to the illumination change takes place. After that, the video image is analyzed, and a pupillogram is formed. The values of its parameters enter the knowledge base, on the basis of which a recommendation is issued to assess the functional state of a person. Based on the data received, the medical professional makes a conclusion. If the functional state is normal, then the driver is allowed to drive the vehicle; otherwise, he is removed from control. Notably, employing decision support system based on the formed knowledge base is an important stage of medical examination in addition to laboratory and other instrumental diagnostic methods.

SUMMARY

As shown in this study, it is advisable to use modern methods of machine learning - fuzzy neural networks to form fuzzy knowledge bases and assess the functional state of vehicle drivers. Learning from the initial data of pupillometry, such networks form the systems of fuzzy-production decision-making rules that have a good linguistic interpretation. This factor is significant for those who make decisions about assessing the functional state of a person. The results of the studies and experiments carried out to allow us to conclude that a formed knowledge base is a useful tool for assessing the functional state of vehicle drivers. It will enable you to minimize the number

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of errors in the first and second kind. In addition, the overall classification error does not exceed 4%, which is an acceptable result.

CONCLUSIONS

Thus, the work has solved the problem of assessing the functional state of vehicle drivers based on the formation and research of a fuzzy knowledge base. The results of the experiments showed the effectiveness of the proposed approach to solve the problem. The formed knowledge base has shown high classification accuracy in terms of error reduction of the first and second kind, as well as the general error of the model. This indicates its effectiveness and the possibility of practical use as the part of intelligent decision support systems (Dagaeva *et al.* 2019; Alekseev *et al*. 2020) to assess the functional state of drivers in the field of transport security.

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REFERENCES

Abro, AG, Mohamad Saleh, J, Bin Masri, S 2011, Features selection for training generator excitation neuro controller using statistical methods. *Communications in Computer and Information Science*, 179 CCIS(PART 1): 353-364.

Agranovich, YYu, Kontsevaya, NV, Podvalny, SL, Khatskevich, VL 2014, A synthesis of statistical and deterministic methods in problem of smoothing for time series. Automation and Remote Control, 75: 971-976.

Akhmetvaleev, AM, Katasev, AS, 2018, Neural network model of human intoxication functional state determining in some problems of the transport safety solution. *Computer Research and Modeling*, 10: 285-293.

Alekseev, A, Katasev, A, Kirillov, A, Khassianov, A, Zuev, D 2020, Prototype of the classifier for the decision support system of legal documents. CEUR Workshop Proceedings, 2543: 328-335.

Chernorizov, AM, Isaychev, SA, Zinchenko, YP, Gradoboeva, ON, Galatenko, VV 2016, Psychophysiological methods for the diagnostics of human functional states: New approaches and perspectives. *Psychology in Russia: State of the Art*, 9: 23-36.

Chibisov, SM, Dementiev, MV, Meladze, ZA, Skorik, AS, Neborak, EV 2016, Evaluation of A 24-hour blood pressure profile in persons with high intensity of work and shift schedule based on the pre-trip medical check-ups. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 7: 2208-2213.

Chupin, MM, Katasev, AS, Akhmetvaleev, AM, Kataseva, DV 2019, Neuro-fuzzy model in supply chain management for objects state assessing. *International Journal of Supply Chain Management*, 8: 201-208.

Dagaeva, M, Garaeva, A, Anikin, I, Makhmutova, A, Minnikhanov, R 2019, Big spatiotemporal data mining for emergency management information systems. *IET Intelligent Transport Systems*, 13: 1649-1657.

Gerike, R, de Nazelle, A, Wittwer, R & Parkin, J 2019, Special Issue "Walking and Cycling for better Transport, Health and the Environment". *Transportation research Part A: Policy and practice*, *123*.

Ismagilov, II, Mustafin, AN, Shleymovich, MP, Katasev, AS, Lyasheva, SA, Kataseva, DV 2019, Methods and algorithms for solving problems in the automatic recognition of license plates. Journal of Advanced Research in Dynamical and Control Systems, 11(8 Special Issue): 1732-1736.

Ji, K, Shen, Y 2020, Dyadic wavelet transform and signal extraction of GNSS coordinate time series with missing data. *Cehui Xuebao/Acta Geodaetica et Cartographica Sinica*, 49: 537-546.

Katasev, AS 2019, Neuro-fuzzy model of fuzzy rules formation for objects state evaluation in conditions of uncertainty. *Computer Research and Modeling*, 11: 477-492.

Kysil, S 2017, The issue of transport infrastructure organization for storage of electric vehicles in the urban environment of the largest cities.

Lomakin, N, Shokhnekh, A, Sazonov, S, Lukyanov, G, Gorbunova 2019, Hadoop and Deductor based digital ai system for predicting the cost of innovative products in conditions of digitalization of the economy. *ACM International Conference Proceeding Series:* 3373810.

Mazhari, M & Ferguson, J 2018, Bacterial responses to environmental herbicide pollutants (glyphosate and paraquat), *Caspian Journal of Environmental Sciences*, 16: 35-43

Mousavi, SN, Mozaffari, Z & Motamed, MK 2018, The effect of higher fuel price on pollutants emission in Iran, *Caspian Journal of Environmental Sciences*, 16: 1-10.

Perfilieva, IG, Yarushkina, NG, Afanasieva, TV, Romanov, AA 2016, Web-based system for enterprise performance analysis on the basis of time series data mining. *Advances in Intelligent Systems and Computing*, 450: 75-86.

Shleymovich, MP, Dagaeva, MV, Katasev, AS, Lyasheva, SA, Medvedev, MV 2018, The Analysis of images in control systems of unmanned automobiles on the base of energy features model. *Computer Research and Modeling*, 10: 369-376.

Siergiejczyk, M, Pas, J & Rosinski, A 2016, Issue of reliability–exploitation evaluation of electronic transport systems used in the railway environment with consideration of electromagnetic interference. *IET Intelligent Transport Systems*, *10*(9), pp.587-593.

Smyl, S 2020, A hybrid method of exponential smoothing and recurrent neural networks for time series forecasting. *International Journal of Forecasting*, 36: 75-85.

Varshney, N, Singh, JP 2020, Road transport safety: VANET using cluster identity and digital certification. *International Journal of Advanced Science and Technology*, 29: 6482-6489.

Watanabe, T, Utsumi, T, Sugiyama, T, Sugasawa, J, Ikeda, T 2008, Analysis of pupillary light reflex alternation caused by artificial afferent defects using infrared video-pupillogram and recently developed reflex factors. *Neuro-Ophthalmology Japan*, 25: 260-265.

Winkler, C & Mocanu, T 2017, Methodology and application of a German national passenger transport model for future transport scenarios. In *Proceedings of the 45th European Transport Conference*.

Zhang, Q, Xia, D, Wang, G 2017, Three-way decision model with two types of classification errors. Information Sciences, 420: 431-453.

Zheng, LJ, Mountstephens, J, Teo, J 2020, Four-class emotion classification in virtual reality using pupillometry. *Journal of Big Data*, 7: 43.

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تشکیل پایگاه دانش برای تجزیه و تحلیل رابطه حمل و نقل و محیط زیست

ایلیاس ادریسوویچ اسماگیلوف*[1]، عینور آیراتوویچ مورتازین[1]، دینا ولادیمیروونا کاتاسهوا[2]، الکسی سرگئیویچ کاتاسف[2]، آناستازیا اولگوونا بارینوا[2]

۱- گروه تئوری اقتصادی و اقتصاد سنجی موسسه مدیریت، اقتصاد و دارایی دانشگاه فدرال کازان (منطقه ولگا)، کازان، روسیه

۲- گروه سیستم‌های امنیت اطلاعات، انستیتوی فن‌آوری‌های رایانه‌ای و امنیت اطلاعات، دانشگاه فنی تحقیقات ملی کازان، کازان، روسیه

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چکیده

اثرات زیست‌محیطی حمل و نقل، بسیار چشمگیر و قابل توجه است زیرا بخش حمل و نقل، یکی از بخش‌های پرمصرف انرژی است و بیشتر سوخت (بنزین) جهان را مصرف می‌کند. این مسئله موجب بروز آلودگی هوا ازجمله نیتروز اکسید و ذرات معلق شده و نقش مهمی در افزایش گرمایش جهانی از طریق انتشار دی اکسید کربن ایفا می‌کند. این مقاله به تجزیه تحلیل مسئله‌ی حمل و نقل و محیط‌زیست پرداخته و مسئله ارزیابی وضعیت کارکردی رانندگان وسایل نقلیه را بر اساس تشکیل و استفاده از پایگاه دانش فازی حل می‌کند. سپس طبقه بندی انواع وضعیت کارکردی انسان ارائه می‌شود. از پاپیلومتری یا مردمک سنجی به‌عنوان روش عینی و هدفمند برای تحلیل واکنش مردم به تغییرات نوری و روشنایی، برای ارزیابی حالت کارکرد استفاده می‌شود. تحلیل رویکرد شبکه‌ی عصبی برای تعیین وضعیت کارکردی مسمومیت انسان انجام می‌شود. در این مطالعه منابع اصلی مربوط به عدم امکان تفسیر راه حل به دست آمده با شبکه‌ی عصبی ارائه می‌شود. به‌منظور حذف این مانع و بهبود اثر بخشی پشتیبان تصمیم گیری برای ارزیابی وضعیت کارکردی و عملکردی رانندگان خودرو، استفاده از شبکه‌های عصبی فازی برای ایجاد پایگاه‌های دانش فازی و استفاده از آن‌ها در مکانیسم‌های استنباط پیشنهاد می‌شود. در این حالت، راه حل مسئله، پاسخ دودویی (مست، غیر مست) با تفسیر راه حل به دست آمده در فرم قواعد فازی نوشته شده در زبان طبیعی قابل درک برای انسان است. وظایف، برای تشکیل پایگاه دانش به‌منظور ارزیابی وضعیت عملکردی رانندگان تعیین می‌شوند. طرح جمع آوری داده‌های اولیه‌ی پاپیلوگرام و نیز مراحل آماده سازی آن‌ها برای تحلیل توصیف می‌شود. پارامترهای پاپیلوگرام برای شناسایی پاسخ مردمک انسان به تغییرات نور با یک روش تخصصی و تحلیل همبستگی شناسایی شدند: قطر حداقل مردمک، قطر مردمک منقبض شده، بزرگی انقباض و زمان انبساط مردمک. ساختار نمونه داده‌های تولید شده با حجم ۱۰۰۰ رکورد یا داده توصیف می‌شود. پایگاه دانش بعد از تحلیل، شامل ۲۶۳۲ قاعده‌ی تولید فازی است. برای ارزیابی صحت تعیین حالت عملکردی فرد بر اساس پایگاه دانش، نمونه‌ی آزمایشی متعادل ۴۰۰ رکورد (۲۰۰ رکورد برای هر دسته) جمع آوری شد. نتایج آزمایش نشان داد که تعداد خطای نوع ۱، ۱ ٪ و تعداد خطای نوع ۲، ۳ ٪ است. صحت کلی تعیین حالت کارکردی فرد بر اساس پایگاه دانش تولید شده ۳ ٪ است. صحت کلی تعیین حالت کارکردی فرد بر اساس پایگاه دانش ۹۶ ٪ بود. پایگاه دانش فازی تولید شده را می‌توان به طور مؤثر در سیستم‌های پشتیبان تصمیم برای ارزیابی وضعیت عملکردی رانندگان خودروها، تحت آزمایش پزشکی قبل از سفر استفاده کرد.

*مولف مسئول

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