

The Algorithm of Artificial Intelligence for Transportation of Perishable Products

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The digital transformation of the world economy and the dynamics of colossal growth of the volume of supply chains have put companies in front of a new challenge, both in terms of economic and structural management. It has become necessary to use innovative technologies in the business management processes, which enables to assess the situation in companies in real time, also to take preventive measures and to optimally manage the current processes. Business process management is a systematic strategy that moves to a new, intelligent way of management, where modern data analysis technologies and artificial intelligence are actively used. Recently one of the most important problems is, that people should get a quality food product on time. Also food supply chains are considered to be more complex systems than other types of supply chains. This problem is due to the continuous changes taking place, particularly in ensuring the quality of food products throughout the entire supply chain, from growing, procurement of resources, production, and management of stock, to distribution to the final consumers. Implementation of export procedures, the correct selection of the type of transport, transportation environment and transit time is vital, because mainly everything depends on delivery of the safe products to the destination point. © 2022 Bull. Georg. Natl. Acad. Sci.

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During recent years, food safety issues forced people to pay special attention to food safety, as well as pay more attention to keeping perishable food at low temperatures and managing its transportation with care. Temperature controlled food requires a temperature monitoring system that ensures its production, storage and transportation porting and distribution.

In the process of globalization, a consumer has the priority due to which quality of service and

timely delivery of the required products determine the competition among the companies [1].

Planning of logistics processes is especially important when we are dealing with the transportation of agricultural products, because there are seasonal fruits such as raspberries, blueberries, strawberries, apricots, etc. that require special conditions during the transportation, special packaging and its transportation according to the correctly selected type of transport. According to

Table 1. Rates of cargo transportation

Type of Transportation	Shipping cost	Transit time
Sea	\$ 13000 – (1 container - 66 cbm, 21 ton)	USA 60 -70 days / Asia - 60 days / Europe - 30 days
Air	\$ 3.40/kg	7 days

this fact, import countries should be selected with special care, because due to the current political and pandemic circumstances, the most transport corridors of Central Asia are closed, the ports and ferry crossings of Kazakhstan, Azerbaijan, Georgia are congested, the customs points are not fully able to process the large flow of cargo, flights are limited in many Asian and European airports. Increasing globalization process requires permanent transformation in the supply chain management to meet present-day challenges and improve competitiveness of the local economy [2].

There are changes in the Chinese market as well, which is currently the largest trading country in the world. The flow of cargo in all its ports, railway stations and airports is increasing day by day, which leads to delays in cargo bookings, untimely transportation of cargo, high shipping rates and an overall unsimplified logistics chain.

The longer the shipping time, the higher the transport costs, and as a result, the fast delivery of cargo is accompanied by additional costs, which ultimately increase the price of the products, therefore, in the purchasing process, the optimal type of transport should be selected, taking into account the relevant transit times, which will maintain the competitive value of the products in the local market. The most important precondition for line balancing is its modern and complete provision with the necessary technological, labor, material and financial resources [3].

According to the Georgian research and statistics of Georgian Agrocompanies, they actively arrange transportations of their cargos to the markets of China, America and Europe. Accordingly, by use sea and air transportation (Table 1).

The transportation of perishable cargo is arranged over long distances in a frozen condition. Fruits are placed in plastic containers, then in boxes and finally placed on pallets, the required temperature regime during transportation is -18° . The period of transportation of the cargo in frozen condition is 2 months, the exporter must have determined in advance which route to send the cargo to the receiving port, in order to avoid the risk of delay and damage of the cargo, as well as place an appropriate reporting device on the cargo, which fully records the temperature indicator during the shipment.

Research Methods

As a result of our research, a digital information monitoring system for transportation of perishable products was developed.

In the research the issue of transportation of perishable berry plants is discussed. The main idea of the research is to analyze the information received by the monitoring system: where the information about the temperature, humidity and visual condition of product and the importance of using an artificial intelligence system to foresee how safe it is to deliver the products to the customer. Using IoT technology, the transportation process is monitored based on its temperature, humidity and visual side indicators. According to the result of data analysis we obtained that using the classified logistics algorithm it can be concluded how safe it is the delivery of product, and as a result, it will be strictly determined, whether a specific product will be delivered to the customer or not. The incorrect transportation and distribution of food products regime will cause

not only economic losses, but it can jeopardize the health of the consumer. Accordingly, in order to meet people's requirements for food quality and safety, we can control the temperature of perishable foods during the transportation, its humidity and mechanical damage. For process modeling we can use different models [4].

In the first stage of the research, we defined the methods of data collection, which is very important for the proper functioning of the monitoring system [5, 6]. Data collection can be done in the way, that necessary information should be obtained using IoT sensors. As the result it is possible to enter next necessary information provided by IoT sensors include:

- Real-time location of the carrier;
- Deviations from the planned route;
- Pickup/delivery to warehouses;
- Temperature/humidity.

In the second stage of the research, we defined implementing AI ensuring identification of the following factors:

- Estimated delivery time;
- Driver behavior analysis;
- Quality of perishable goods;
- Differences between planned route and the actual route.

The most important is if logistics chain is not stable, in particular for agro products, we will get delays in shipping, long-term transport routes, untimely delivery of products and damage of burden.

The automatic classification algorithm, logistic regression allows the manager to predict the transportation process and take preventive measures.

In the research, we used logistic regression. Binary logistic regression is used to test the relationship between a binary dependent variable and more than one independent variable. Dependent binary variable means that it has only two values 0 and 1, which means the operation was successful or completely failed. In the logistic regression analysis, we determine the probability that the independent variables get the value of the dependent variable, 1. This means that it is not the value of the dependent variable that is predicted, but the probability that the dependent variable takes the value 1.

In our research, the company sends products to 750 customers in different locations (see the table), the probability of product delivery is related to several factors such as the decision to buy (which is influenced by the customer's income), the cost of

Table 2. Assessment of risks and consumer interest in the product

ID	Dependent Variable	Independent Variable		
	Delivery	Income	Risk	Interest
1	0	1260.00	12.90	9.50
2	0	782.00	2.65	25.75
3	1	844.00	8.15	18.55
4	0	1325.00	21.50	38.00
5	1	528.00	3.60	63.80
6	0	1101.00	2.15	30.60
7	1	1479.00	7.90	42.50
8	0	1350.00	6.45	8.70
...
745	0	268.00	12.32	7.50
745	1	115.00	32.45	9.30
747	0	215.00	4.96	16.80

the products, the product deterioration risk factor (from 0 to 35), customer interest in the product (Table 2).

Logistic regression analysis, as mentioned, is based on the maximum likelihood assessment of product acceptance and it only takes the values 1 and 0, i.e. the product was accepted by the customer or not.

The values of the logistic function are interpreted as the probability that the dependent variable y will take the value 1 (given the independent variables x_k), because the logistic regression model does not take into account the values of the dependent variable y , but there is a probability that, y will occur. A value close to 0 means that y ($y = 1$) is unlikely to occur, and a value close to 1 means that y is very likely to approach the value 1.

Logistic regression is calculated by the function:

$$P(y = 1) = \frac{1}{1 + e^{-z}},$$

where $P(y=1)$ is the probability that $y = 1$;

e = base of natural logarithm, Euler's number

z = Logit (independent variable linear regression model)

z , the so-called "logit", is a linear regression model, where, x_k = independent variables;

β_k = regression coefficients;

ε = error value.

Taking into account the entered values, the result is obtained:

$$P(y = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \beta_3 * x_3 + \dots + \beta_k * x_k + \varepsilon)}}$$

$$P(\text{delivery} = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 * \text{income} + \beta_2 * \text{interest} + \beta_3 * \text{risk})}}$$

Using the Python programming language, we have implemented a function whose initial value is a sinusoid:

After assigning specific values and running the code, a logistic regression is obtained, where it is possible to determine exactly which and how many people are real users.

Logistic regression analysis is based on maximum likelihood estimation and differs from the least squares method used in linear regression analysis.

Conclusion

AI monitoring system ensures that a deviation from the threshold norm related to the quantitative indicators of the visual, chemical and biological elements of the food products is detected in real-time.

The monitoring system also ensures to determine transportation time and the route about which information is provided in real-time to the relevant services, facilitating various preventive measures. This system is integrated with the cloud platform, allowing us to conduct various types of experiments, where machine learning can be presented as a web service that will be accessible all stakeholders. The use of artificial intelligence algorithms presented in the SCM to monitor and control of perishable products management operations in real time, simplify the decision-making process and make the optimal decision. Based on the use of artificial intelligence during information processing, companies are given the opportunity to accurately determine customer requirements and offer them new and healthy products.

ინფორმატიკა

ხელოვნური ინტელექტის ალგორითმის გამოყენება მაღფუჭებადი პროდუქტის ტრანსპორტირებაში

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მსოფლიოში მიმდინარე გლობალური პროცესები ახალი გამოწვევების წინაშე აყენებს ადამიანებს. ერთ-ერთი ყველაზე მოთხოვნადი პროდუქტი, რომელიც წარმოადგენს ადამიანისთვის სასიცოცხლოდ მნიშვნელოვან რესურსს არის კვების პროდუქტები, რომელთა ჯანსაღი და დროული მიწოდება ძალიან მნიშვნელოვანია ადამიანების ჯანმრთელობისა და ეფექტურობისთვის. ნაშრომში განხილულია მაღფუჭებადი პროდუქტის ტრანსპორტირების საკითხი. ჩვენ მიერ შემუშავდა მონიტორინგის ღრუბლოვანი პლატფორმა, სადაც IoT ტექნოლოგიის გამოყენებით რეალურ დროში ვიღებთ ინფორმაციას პროდუქტის ვარგისიანობის შესახებ. სისტემაში ასევე ინტეგრირებულია ხელოვნური ინტელექტი, რომელიც ლოგისტიკური რეგრესიის კლასიფიცირებული ალგორითმის დახმარებით განსაზღვრავს, უნდა მიეწოდოს თუ არა პროდუქტია მომხმარებელს. მონიტორინგის სისტემა ასევე უზრუნველყოფს ტრანსპორტირების დროისა და მარშრუტის განსაზღვრას, რომლის შესახებ ინფორმაცია რეალურ დროში მიეწოდება შესაბამის სამსახურებს. აღნიშნული სისტემა საშუალებას იძლევა ჩატარდეს სხვადასხვა ტიპის ექსპერიმენტები, სადაც მანქანური სწავლება შეიძლება იყოს წარმოდგენილი, როგორც ვებ სერვისი, რომელიც ხელმისაწვდომი იქნება ყველა დაინტერესებული მხარისთვის. მიწოდების ჯაჭვში წარმოდგენილი ხელოვნური ინტელექტის ალგორითმების გამოყენება უზრუნველყოფს რეალურ დროში მაღფუჭებადი პროდუქტების მართვის ოპერაციების მონიტორინგსა და კონტროლს, რათა გადაწყვეტილების მიღების პროცესი გამარტივდეს, ზუსტად განსაზღვროს მომხმარებლის მოთხოვნები და შეთავაზებულ იქნეს ახალი და ჯანსაღი კვების პროდუქტები.

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