USE OF NEURAL NETWORK TECHNOLOGIES FOR IMPROVING EFFICIENCY OF TRANSPORT AND LOGISTICS PROCESSES

Sergey V. Glushkov, Natalia G. Levchenko

The article reviews a method of development and modeling of information system in an enterprise providing a package of services in a multimodal transportation sphere. The model is developed for further research of the enterprise information system, its performance prediction and operations optimization. The method is based on the technique of fuzzy neural networks.

.

Keywords: information system, logistics, maritime transport, simulation modeling, expert system, intelligent control, artificial intelligence, neural information technology, fuzzy logic, neural network.

The complexity of modern transport-logistics information systems and their specialization has led to the necessity to use simulation modeling on the basis of artificial intelligence systems, including the neural network model construction for its research, characteristics analysis and behavior prediction Selection of certain technical equipment, systems and application software also plays an important role. Complication of the model objects as well as incompleteness and fuzziness of the initial information (the information that is blurry, vague, unclear or imprecise by nature) and growth of quantity of factors from different subject areas lead to the conclusion that the most appropriate and effective method is a method of modeling with the use of fuzzy neural technologies. The principal advantage of this method lies in the ability of the algorithm to adjust (to adapt) the structure of the network to the new observations (factors), to reduce the influence of unessential factors, to identify complex (non-linear) interrelations between the values of the input and

output data [1]. These are hybrid intelligent systems (HIS) that allow more effective connection between formalizable and non formalizable knowledge. They combine advantages of neural networks and fuzzy inference systems as well as allow developing and submitting graphic conceptual models of the systems in the form of fuzzy productions rules, using the methods of neural networks, which is more convenient and less time-consuming process for systems analysts [2].

While considering the process of fuzzy neural model construction for the specific logistic process, initially it is necessary to build an algorithm: cargo specifications, its origin and destination, batch and type of transportation.

In order neither to complicate the neural network nor to increase the network learning time, it is necessary to focus on transportation of certain type of goods (e.g. rice) from one point Alpha (e.g. Vietnam) to another point Bravo (e.g. the central part of Russia) by different ways of transport, including sea route, and, accordingly, by different means of transport.

This is the international multimodal transportation (mixed mode transportation). The most effective is conveyance under responsibility of one carrier according to a single transport document and per uniform and through rates. Multimodal transportation is the most efficient in the conditions of market economy, which is characterized by a large number of sellers and buyers, availability of goods and services, informational transparency and fair competition. Legal, commercial, economic and other conditions of such conveyances are being regulated by international institutions that have adopted a number of conventions, regulations, standards [3]. Such transportation is determined by variety of options with large number of complex interrelations. That's why the hybrid neural network is used as a modeling tool.

Choosing an optimal mode of transport for the particular shipment it is necessary to consider the following factors:

1. time of delivery;
2. frequency of shipments;
3. schedule of delivery guarantee;
4. various cargo transportation ability;
5. global range cargo delivery;
6. shipping costs.

Logistic scheming of goods movement from producer to consumer requires sequential use of means of delivery, according to compatibility of their technical and qualitative characteristics such as cargo capacity and weight-lifting ability of transshipment equipment and transport. It is necessary to correlate the cargo capacity/deadweight ratio of chosen transport means with the cargo stowage factor when planning transportation.

The selection of freight transport method is based on information about the characteristics of different modes of transport as follows:

– Automobile transport is characterized by several features such as high maneuverability, which allows arranging shipment with necessary level of urgency and ensures regularity of deliveries as well as less strict requirements to the freight package in comparison with other modes of transport. The speed of this conveyance, especially for short distances, is higher comparing to the railway/ water transport and shipping costs may be lower. During transportation over long distances the advantage of automobile transport may be lost due to high cost of conveyance.

– Railway transport is characterized by good adaptation for delivery of various consignments in any weather conditions. It provides the possibility of cargo long distances delivery and regularity of transportation. Railway facilities are capable to provide convenient cargo handling operations. A significant advantage of railway transport is relatively low cost of freight transportation.

– Air transport comparing to the other modes of transportation provides high-speed long-distance delivery. However, aircraft capabilities are limited by cargo space and load-carrying ability as well as by conditions and specifications of airport runways. Air transport has advantages in terms of losses during transportation. Due to the fact that this mode is very expensive, it is used only for nonrecurrent services.

– Means of water transportation include ocean and river cargo vessels. Maritime transport is the largest carrier in international freight traffic. Its main advantages are low freight rates and high carrying capacity. The disadvantages of maritime transport are low speed, strict requirements to freight packing and fastening, low frequency of shipments. Inland water transport is also characterized by low freight rates and, in addition to low speed of delivery, limited geographical accessibility [4].

Further we estimate the factors, which evaluate and influence the process of transportation and their relationships. Usually the overall quantity of influencing factors is unknown and not all of them are explicit. Therefore a certain set of criteria is to be allocated, which in the process of refining the model may be added without affecting the system itself, but qualitatively improving an «image» of the research object.

Then, the fuzzy product rules IF-THEN of the identified factors interaction are being composed and the samples for fuzzy neural network training are being formed. So, basing on the knowledge of experts, such as a director and a chief accountant of the company engaged in international cargo transport, there are 8 ways of transportation and their basic operations as follows:

1. Cargo is loaded in FESCO containers at warehouse of the supplier – sea transportation – unloaded to the open spot of the commercial port of Vladivostok – railway transportation to the warehouse of the consignee.

2. Cargo is loaded in SINOKOR containers at warehouse of the supplier – sea transportation – unloaded to the open spot of the fishing port of Vladivostok – railway transport to the warehouse of consignee.

3. Cargo is loaded in bulk by 3 000 tons at warehouse of the supplier – sea transportation – unloaded to the open spot of the commercial port of Vladivostok – railway transport to the warehouse of the consignee.

4. Cargo is loaded in bulk by 3 000 tons at warehouse of the supplier – sea transportation – unloaded to the open spot of the fishing port of Vladivostok – railway transport to the warehouse of consignee.

5. Cargo is loaded in FESCO containers at warehouse of the supplier – sea transportation – unloaded to the open spot of the commercial port of Vladivostok – truck transportation – unloaded at the warehouse in Vladivostok – railway transportation to the warehouse of the consignee.

6. Cargo is loaded in SINOKOR containers at warehouse of the supplier – sea transportation – unloaded at the open spot of the fishing port of Vladivostok – truck transportation – unloaded at the warehouse in Vladivostok – railway transportation to the warehouse of the consignee.

7. Cargo is loaded in FESCO containers at warehouse of the supplier – sea transportation – unloaded in the port of Novorossiysk – railway transport to the warehouse of the consignee.

8. Cargo is loaded in FESCO containers at warehouse of the supplier – sea transportation – unloaded in the port of Saint-Petersburg – railway transport to the warehouse of the consignee.

Thus, fuzzy neural network consists of six layers. Each of them represents one block respectively from the schemes 1-8 above. On each layer a certain number of factors, which influence efficiency of both a separate process-block and the whole transportation itself, are marked out. To determine quantity and value of each factor, as well as its significance at each layer it is necessary to rely on the opinion and experience of experts.

For description of the elements of the fuzzy neural system in the process of model building it is important to use the concept of a fuzzy set and a linguistic variable as well and to create a membership function of the fuzzy sets. Factors influencing the process of transportation are determined by the qualitative evaluation. So a linguistic variable «excellent» at the entrance of the network is limited by the value from 9 to 10, and a linguistic variable «good» is limited by the value from 7 to 8, etc.

To build the training samples, the IF-THEN fuzzy product rules are drawn up. The relationship and importance of the factors relative to each other in each process-block are also considered. Each layer at output determines effectiveness of a particular process, and it can be not only the cost of the process itself but the quality of goods at the output of this layer (for example, appearance of loss during road transport) as well or time of process that affects transportation speed that, in turn, affects cost-effectiveness of goods delivery. During the training process the neural network will adjust initially set priorities and correct possible errors of experts by weightings.

The first layer is the «Terms of shipment from a vendor». According to the experience of the experts, the most profitable terms of shipment from the supplier are container loading (for example, 20 containers of 25 tons each) that matches the specified options of transportation 1,2,5-10, and the worse terms of shipment are bulk loading (e.g. 2000-3000 tons) that are options 2 and 3 respectively.

The main factors affecting the effectiveness of the overall cargo delivery are «cargo readiness for loading» and «damage to cargo, losses». These inputs on this layer of the neural network are equal. The output of this layer is «evaluation of the shipment effectiveness».

The second layer is «sea transportation (freight) ». Factors affecting the efficiency of the process follow below in order of importance:

1. process costs;
2. possibility of transportation;
3. losses;
4. delivery time;
5. reliability of the carrier.

This layer has very complex interrelationships. For example, if cargo is transported by containers, the values of factors 1, 2, 3, and 4 are higher than in the case of bulk carriage. On the other hand values of factors 3 and 5 do not only depend on the method of transportation, but also are interrelated ones.

The experts consider that the maritime container transportation is more efficient than the same process of cargo loaded in bulk, as there is less risk of damage to goods; preparedness of the shipment is faster and freight is easier to implement.

The third layer is «Port and terminal capabilities». Factors affecting the efficiency of the process are shown below in order of importance:

1. terminal capabilities, free space in port;
2. process costs;
3. facilities.

The important point in determining the values of factors for this layer is the opinion of experts. They believe that the fishing port can be used more efficiently because it has a higher capacity and free spaces to unload cargo as well as lower cost of cargo handling. The cargo delivered to the port by containers can be processed more efficiently than the one loaded in bulk.

The fourth layer is «truck transportation». Factors affecting the efficiency of the process are listed below in order of importance:

1. process costs;
2. waiting period for cargo exportation;
3. carrier reliability.

In options of transportation 1 to 4 the process-block of truck transportations is missed, so the values of incoming and outgoing factors are equal to the maximum value of 10.

In other options, as per the experts' experience, the following links are identified: if trucking is carried out in Vladivostok, then it is cheaper, and waiting period for cargo exportation is shorter, because opportunity to choose a carrier is higher than in Novorossiysk and St. Petersburg.

The fifth layer is «Unloading and warehousing». Factors affecting the efficiency of the process are below in order of importance:

1. storage space;
2. process costs;
3. losses;
4. facilities and capabilities.

In options of transportation 1 and 2 the process of unloading and storage is missed, so the values of incoming and outgoing factors are equal to the maximum value of 10.

In other options we should rely on the opinion of experts that warehousing in Vladivostok is better than in Novorossiysk and St. Petersburg because it has higher capacity for processing and larger storage space, as well as in case of damage to cargo the losses are to be recovered in Vladivostok.

The sixth layer is «Cargo composition and its transport by railway». Factors affecting the efficiency of the process are listed below in order of importance:

1. cost of the process;
2. damage, losses;
3. travel time;
4. capacity (technical possibility to provide a train for shipment).

The experts' experience shows that the cost of transportation in a regular cargo car is cheaper than on a platform for containers but, nevertheless, the cargo damage risk is higher in the car. To send cargo from the own warehouse is easier and faster than from a warehouse in the port, to provide a train to the port is more difficult.

And the last, the seventh layer of the network is the accumulation of all previous layers. Using the MATLAB computing environment, Fuzzy Logic Toolbox package and method of identification of fuzzy

knowledgebase we create a neural network model of the process of cargo transportation. Further, on the test samples of real data, we check the work of the model and evaluate the results using such mathematical methods as SRME (method of least squares). Now, with the model of the transport-logistics information system, we can do a parametric optimization of the process (e.g. using a genetic algorithm), achieving the optimum of the multi-criteria objective function (losses minimization, delivery time decrease etc), and further, to conduct factor analysis on the model by changing the specific elements of the process for effects prediction to transportation conditions changing in reality.

REFERENCES

1. Круглов, В.В., Дли, М.И. Интеллектуальные информационные системы: компьютерная поддержка систем нечеткой логики и нечеткого вывода. М.: Издательство Физико-математической литературы, 2002. 256 с. (Russian). [Kruglov, V.V., Dli, M.I. Intellektualnyye informatsionniye sistemy: kompyuternaya podderzhka sistem nechetkoy logiki i nechetkogo vyvoda. M.: Izdatelstvo Fiziko-matematicheskoy literatury, 2002. 256 s.]. Kruglov, V.V., Dli, M.I. (2002). *Intelligent information systems: computer support for fuzzy logic and inference systems*. Moscow: Publishing House of Physical&Mathematical Literature.

2. Штовба, С.Д. Проектирование нечетких систем средствами MATLAB. М.: Горячая линия–Телеком, 2007. 288 с. (Russian). [Shtovba, S.D. Proyektirovaniye nechetkikh sistem sredstvami MATLAB. M.: Goryachaya liniya–Telekom, 2007. 288 s.]. Shtovba, S.D. (2007). *Fuzzy systems design by means of MATLAB*. Moscow: Hotline-Telecom.

3. Никифоров, В.С. Мультимодальные перевозки и транспортная логистика. М.: ТрансЛит, 2007, 272 с. (Russian). [Nikiforov, V.S. Multimodalnyye perevozki i transportnaya logistika. M.: TransLit, 2007, 272 s.]. Nikiforov, V.S. (2007). *Multimodal transportations and transport logistics*. Moscow: TransLit.

4. Москаленко, М.А., Друзь, И.Б., Москаленко, А.Д. Устройство и оборудование транспортных средств. 2-е изд., Спб.: Изд-во «Лань», 2013. 235 с.(Russian). [Moskalenko, M.A., Druz, I.B., Moskalenko, V.D. Ustroystvo i oborudovaniye transportnykh sredstv. 2-ye izd., Spb.: Izd-vo «Lan», 2013. 235 s.]. Moskalenko, M.A., Druz, I.B., Moskalenko, V.D. (2013). *Design and equipment of transport means*. (2nd ed.). St. Petersburg: Publishing House «Lan».