



# Review of the Study on the Cognitive Technologies of Transporting Waste from Mining Industry

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**Abstract.** The following article studies research on cognitive technologies and their application in the transportation of mining waste. Special attention is paid to the development and implementation of intelligent systems which are able to automate the processes of monitoring, analysis and waste recycling. There were discussed the examples of using machine learning and artificial intelligence to improve the efficiency of waste management, minimize their negative impact on the environment and improve the economic indexes of companies. Cognitive technologies allow transport companies to expand their functions in summarizing and processing huge volumes of structured and unstructured data, use machine learning tools for data analysis, execute queries and get the most accurate answers, at the same time ensuring the safety of cargo. In order to increase the effectiveness and speed of transportation, customer service at all stages and at the same time reduce the effect of the “human factor”, it is necessary to develop an offer that will be most optimal for everyone.

**Keyword:** cognitive technologies · transportation · waste

## 1 Introduction

Waste from the mining industry includes ore enrichment tailings, slag, and other materials. These waste materials can be repurposed to create new facilities, such as road construction or waste storage sites.

Nowadays, in Kazakhstan, waste disposal and recycling of the mining and metallurgical industry byproducts are acute issues.

Efficient supply chain management for waste processing involves considering ecological and economic factors, developing optimal transportation routes, implementing paperless technology, accounting for the chemical and physical composition of waste, risks during transportation and assessing the condition of transportation infrastructure and rolling stock.

By using cognitive technologies, artificial intelligence complements and extends human capabilities, assisting organizations to implement innovations, improving efficiency, and making conscious decisions about capital projects.

## 2 Research Methods

The integration of IoT technology in cargo transportation offers promising solutions. A key stage in supply chain management is appropriate transportation and waste collection from the generating node to the regeneration center or disposal site [1].

In the article [2] a link between two areas of study was identified: sustainability and cognitive studies.

The study [3] presents the significance and application of technologies enabling Industry 4.0, such as the Internet of Things, AI, cloud computing, blockchain, big data and digital twin, to achieve sustainable supply chain management (SCM).

Protecting confidential data to enable seamless collaboration and sharing is studied in [4]. Integration of registry systems involves ensuring interoperability between multiple platforms, facilitating the seamless exchange of information between subjects of green and blue economy initiatives.

By using recycling methods, waste can be used as an energy resource [5]. Therefore, recycling is a great way to promote sustainable development because it can reduce environmental impacts and economic costs, and increase employment of the population, so waste recycling is an important technological task.

In different mining locations, waste mass can fluctuate depending on the time of year. One effective solution to this problem involves precise information systems and intelligent planning [6]. For instance, managers can utilize Internet of Things (IoT) systems to track waste shipments. IoT facilitates communication between various electronic devices using diverse identification methods.

Blockchain is one of the excellent technologies for digitizing and decentralizing freight supply chain data, as it can simultaneously use QR codes [7, 8] to make digital data more accessible to consumers, especially through smartphones.

## 3 Results

QR code [9–11] is an efficient means of information transmission that is now widely used in various applications including freight tracking, mobile payments for transportation, advertising, shipping documents, and many other areas. The QR code consists of 40 characters (to convey various useful data) and 4 user-selectable error correction levels (ECLs). L, M, Q and H, which can be changed by 7%, 15%, 25%.

Cloud computing (cloud) [12, 13] is a computing model that provides universal and convenient on-demand network access to a shared network of computing resources such as networks, servers, storage, applications and services. It can be quickly delivered and launched with minimal administrative effort or interaction with service providers [14]. Key features of cloud computing include broad network access, on-demand self-service, fast fault tolerance, resource pooling, and measured service [15].

In the context of Industry 4.0, production systems have been upgraded to an intelligent level. Intelligent manufacturing uses advanced informational and manufacturing technologies to provide flexible, intelligent and reconfigurable production processes in line with dynamic global markets [16]. This provides access to all physical processes and information flows when and where they are needed, in the entire production supply

chain, various industries, from small and medium-sized enterprises to large corporations [17, 18]. Some technologies also support artificial intelligence (AI), allowing production systems to learn from their own experiences and eventually implement interconnected, intelligent and universal manufacturing practices.

Intelligent manufacturing is a production concept which is aimed at optimizing the production and transportation of products by maximizing the use of advanced information and manufacturing technologies [19]. It represents a new production model based on intelligent science and technology, significantly improving production, transportation, management and integration throughout the supply chain. This leads to increased production efficiency, product quality and service levels [20]. The competitiveness of manufacturing companies can be improved by their ability to adapt to the dynamics and fluctuations of the transport market. One of the realizations of this concept is the Intelligent Production System (IMS), which is considered the next generation of production systems created through the introduction of new models, forms and methodologies to transform traditional production systems into intelligent systems [21]. In the era of Industry 4.0, IMS uses service-oriented architecture (SOA) over the Internet to create highly integrated systems of controlling people and machinery, which provides end users collaborative, configurable, flexible and reconfigurable services [22].

Information and communication technologies (ICTs) refer to advanced information technologies in which special attention is given to the integration of unified communications and telecommunications and other technologies that can store, transmit, and manipulate data or information [23]. It has been found that ICTs have a clear impact on the organization of companies, so the best ICT for business managers and employees is associated with greater autonomy and a wider range of control [24]. For example, ICT enables the safety of the transportation process.

## 4 Discussion of the Results (Discussion)

In the context of Industry 4.0 people and machines work together using cognitive technologies in the production sphere. Intelligent machines utilize speech recognition, computer vision, machine learning and advanced models of synchronization [25] to help people do most of their work.

If waste transportation is taken as an example, then multi-agent technology can be used for parallel control of robots with agent architecture and distributed agents to facilitate the implementation of intelligent production [26].

Artificial intelligence plays a revolutionary role in modern transport systems. The article [27] discusses the role of artificial intelligence in rail transport and its potential effect on the sector. There are different types of artificial intelligence technologies used in this sector, the benefits of artificial intelligence in this field are explored and the challenges in the use of artificial intelligence in rail transport are discussed. Artificial intelligence is found to be revolutionary in rail transport systems, increasing efficiency, safety and overall productivity. There are several ways of how AI impacts rail transport and its effect on the cognitive load of human resources.

In a waste transportation there may be a situation of using multimodal transportation: road transport – rail transport – water transport. In that case paperless document management technology will play an important role here [28].

At the same time, attention must be paid to reducing carbon dioxide emissions into the atmosphere. The article [29] questions if it is possible to completely reduce CO<sub>2</sub> emissions, especially in the transport sector. In the article special attention is given to the problems of achieving a high level of sustainability, as the United Nations defined. Mini of sustainability in rail and road transport are analyzed and described. The results show the benefits, the dangers and the problems of the given solutions.

The peculiarity of the cognitive multimodal transport system is that in addition to the first cognitive cycle which covers each type of transport, the 2nd contour of the cognitive cycle appears, covering all types of transport at the same time.

The study [30] focuses on policies that can enhance sustainable mobility, increase energy efficiency and reduce environmental pollution. The results can help optimize hybrid vehicle technologies in an environmentally friendly manner and study possible new paths for sustainable transport solutions.

The main advantages and disadvantages of the MACC tool are shown in [31], where they identify if the curve is the only method for analyzing and developing political and business decisions or if the tool should enhance the methodology to increase scientific consensus.

Analysis of studies shows that using cognitive technologies in industrial waste management opens up new opportunities to increase the efficiency and sustainability of production processes. The integration of artificial intelligence and machine learning can significantly improve the monitoring, forecasting and waste recycling, minimizing its negative influence on the environment. Furthermore, the use of these technologies optimizes resources and reduces operating costs, which makes them economically profitable

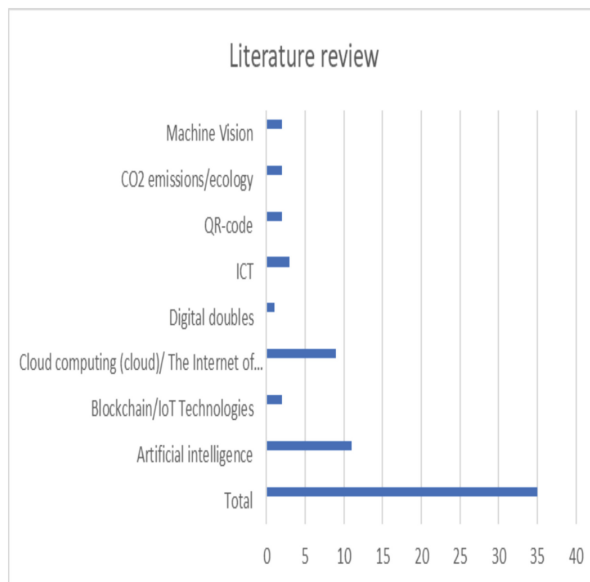


**Fig. 1.** Literature review

for companies. Future perspectives show that the further development and implementation of cognitive technologies will be a key factor in forming more environmentally responsible and sustainable industrial practices.

Figure 1 presents the areas of research on the application of cognitive technologies in waste transportation. Analysis of the reviewed literature shows that the largest number of studies on Artificial intelligence. It is necessary to more thoroughly analyze the research on Digital doubles.

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