Auto-Identification in Mining Industry

Vladimír KEBO[1], Pavel STAŠA[2], Filip BENEŠ[3], Jiří ŠVUB[4]

[1] Doc. Dr. Ing.; Faculty of Mining and Geology, VŠB – Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic; email: vladimir.kebo@vsb.cz
[2] Ing., Ph.D.; Faculty of Mining and Geology, VŠB – Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic; email: pavel.stasa@vsb.cz
[3] Ing., Ph.D.; Faculty of Mining and Geology, VŠB – Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic; email: filip.benes@vsb.cz
[4] Ing., Ph.D.; Faculty of Mining and Geology, VŠB – Technical University of Ostrava, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic; email: jiri.svub@vsb.cz

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Summary

Automatic identification (AutoID) becomes an important part of control systems for movement control of objects in logistics. From the perspective of process control multi-agent systems are a distributed control system, which sets out the operational objectives of the daily production in different production segments that are controlled by the individual production units. Next very potential areas for the application of Smart technology are intelligent logistics and operations management using AutoID RFID technology that allows automatic identification and monitoring of any objects in the production networks. The next step of smart production control is the application of Holonic multiagent systems - HoloMAS. To understand the autonomous control processes and technology state, the use of augmented and virtual reality will be necessary.

Keywords: automatic identification, process control, holon, augmented reality, smart technology

Introduction

Automatic identification (AutoID) becomes an important part of control systems of movement control of objects in logistics/transportation networks. AutoID, for example, provides important data for monitoring the status and localization of means of transport and transported objects, information source for system control. The basic model for process control of mining production, understood as transport networks, contains several types of transformation and transportation elements. From the perspective of process control it is a distributed control system, which sets out the operational objectives of the daily production in different production segments that are controlled by the individual production units so, as to ensure a planned production rate. Sub-objectives of the various technology nodes and transport segments are pre-scheduled plan production, estimated by the central system or a supervisor.

Multi-Agent Systems (MAS) in Control

Quite different in comparison to central control will be the situation when using the principles of multi-agent control. Individual machines/technology nodes will be equipped with creative agents offering their services to the "yellow pages" while respecting the parameters and properties by "white pages". Individual agents then negotiate within the communication sub cooperation to meet the globally specified targets. The control is realized by creating an instance of virtually prototyped autonomous control elements. The basic control level of agents will be realized by Holons that are implemented in the PLC controllers, capable of solving relatively simple task of real-time response in milliseconds, fig. 1. Holon is one type of the Software agent: A distinct software process, which can reason independently, and can react to change induced upon it by other agents and its environment, and is able to cooperate with other agents [1], (O'Hare and Jennings, 1996).

The second level provides ability and skills of agents' negotiation in planning, scheduling and cooperation in the implementation of the production plan. For these tasks the agents are equipped with the necessary knowledge and algorithms that enable knowledge sharing and sharing of the current parameters of the model of outside world. One does not plan the tasks in advance for each node of production technology; these are controlled by multi-agent system with the aim of optimal fulfillment of specified production targets. New devices are incorporated into the system in the form of "plug and play" units; their utilization is balanced by the negotiation agents. To eliminate unwanted emergent behavior there are implemented special supervisory agents providing supervision and prediction of unwanted behavior with subsequent relocation of new targets to eliminate errors in behavior and system fault conditions.

In such composed Multi Agent Based Manufacturing Control - software agents correspond on a one-to-one basis with each machine and product (representing all or part of machinery or technology nodes) in the manufacturing networks. Using the appropriate distributed control algorithms, the individual machine and product agents can make their own manufacturing control decisions relating to negotiated scheduling, resource allocation, prioritization etc. For the decision they use an individual autonomous form of "negotiation". Algorithms implemented in multi agent software environments have been developed for planning, scheduling and production control applications [1].

To respond to current trends in advanced technologies control we can focus on several key areas of control application interrelated by common base - logistics processes. From this point of view the mining production process can, be in general form, converted into a network structure of transport and transformation processes. The common basis for control of such structures is high quality real-time information generated by smart sensors network, connected to technology and upper levels information structures by wireless technologies. One possible basis for information acquisition from the autonomous production technology can be a network of active RFID tags. In this way, it can be created and updated a symbolic model of the production environment for orientation and activities control of autonomous robotic machinery and processes, supplemented by fixed agents – Holons. The production mining technology of the future, we can then understand as Holonic Manufacturing System, completed at higher-level by management system which provides multi-layer multi-agent coordination and managerial control of the mining company. The whole structure can be, for the direct control, interpreted in the environment of virtual reality and then connected to the network environment of Internet of Things (IoT).

The importance of presented vision of autonomous robotic control of mining technology is that it will be possible to exploit the natural deposits below the threshold, hard to reach small deposits and also ore deposits imposed under the sea level [3].

One form of application of Multi-Agent systems in control are Holonic Manufacturing Systems (HMS), fig. 2. The HMS could be understood as a systems engineering methodology in comparison with a solution to a specific control problem. It is referred to as a bottom up approach because overall production control is developed through the integration of HOLONS - flexible, interchangeable manufacturing modules.

We can define a sharp direct contrast with conventional top-down methodologies for designing and specifying manufacturing control systems, like CIM – Computer Integrated Manufacturing systems). In such a system a control systems hierarchy is centrally devised to support the specific activities like planning, scheduling and control processes of the production in the mining deposit or production factory.

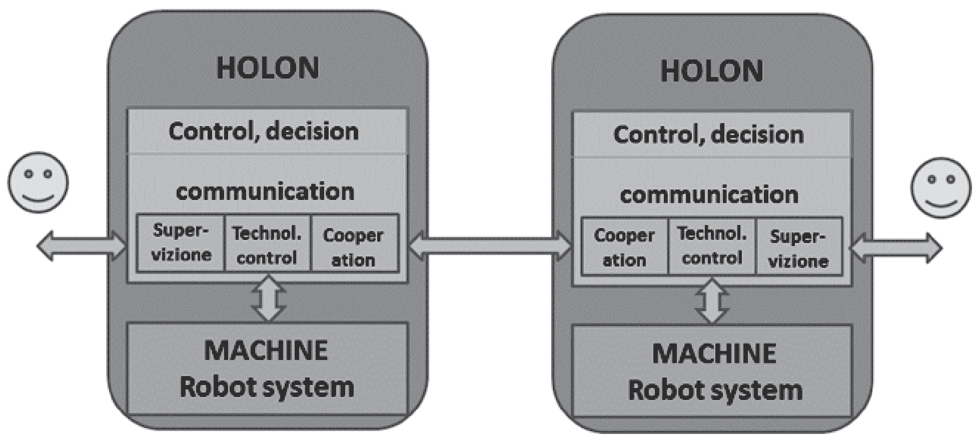

Fig. 1. Structure of holons [2]

Rys. 1. Budowa holonów [2]

Automatic Identification Technology and data capture

Classical technology of Automatic Identification (AutoID) is based on optical, inductive, radio frequency and other principles. The basis of these technologies is the fact that information from the data carriers can be obtained automatically by the readers (e.g., information about storage, movement or a description of observed events). The application is mainly in logistics systems to monitor and control processes in production lines, identification and retrieval of objects and products.

The term automatic identification and data capture (AIDC) can be defined as methods how to get information about objects without human intervention. The usage of barcodes to identify objects can be found most often. This method is widely used in industrial environments, where barcodes are used for applications such as: serial number, assets inventory, in-house label products storage card number, labeling of production cards, production operations. Other technologies typically regarded as part of the AIDC technology is radio frequency identification (RFID), biometric systems (fingerprint, etc.), magnetic stripes, optical character recognition (OCR), smart cards and voice recognition.

Technology of Automatic Identification AutoID

Nowadays, the traditional way of labeling of the objects is to mark them with their own alphanumeric code. In this case, identification can be performed either through an operator that reads and rewrites the text on the product or automatically using OCR (optical character recognition), which, however, has often a significant error rate and in comparison with other methods is slow and challenging computational capacity of handling systems.

The barcode is read only by optical way using automated systems. The error rate is already relatively small, but it depends strictly on the orientation of the bar code of the product with according to the reader, line of sight is required in the reading process and barcodes are also susceptible to get dirty. This method of marking and identification is now at the top of his epoch. Relatively significant limiting factor in the barcode is the data density of carried identifier.

The current identification system allows encoding of long numerical structures in barcodes but such a barcode is large, what can lead to complications when it has to be placed on the surface of small object (insufficient size of the object). The problem of low data density solves the two-dimensional structures of the data matrix or QR code. These methods allow us to put the object identifier of sufficient data capacity already onto a relatively small area. 2D codes are still just as prone to dirt and damage as barcodes and still require direct visibility while reading and it is practically impossible to process them in batches.

Relatively new and progressively developed identification technology is RFID - Radio Frequency Identification. RFID technology is based on the principle of radio frequency waves. Monitored objects (products, objects or components) are provided with a data carrier, which is called a transponder or tag. It is basically a device that consists of two main parts - the antenna and microchip (rarely without chip). The object identification occurs while detecting the presence of tags in the interrogation field of RFID reader and receiving the unique identifier. Compared to optical

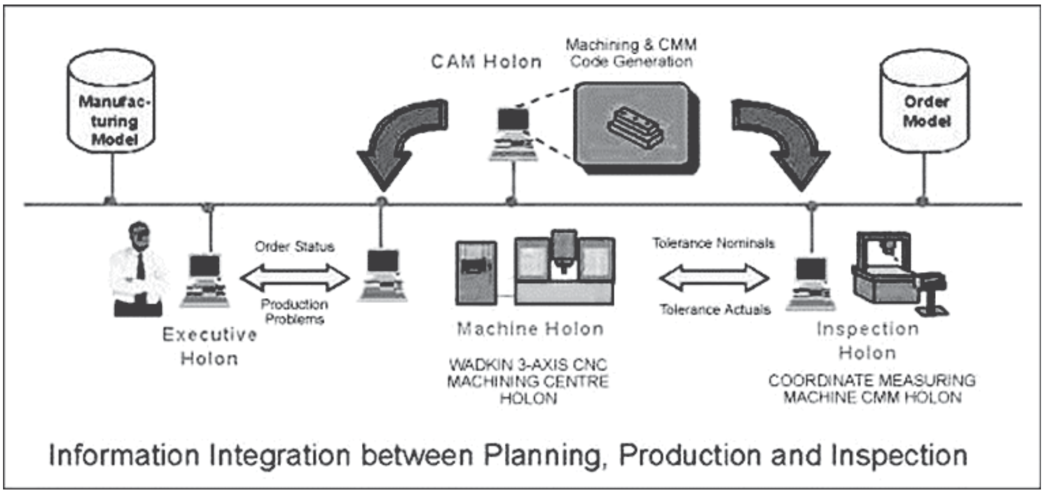

Fig. 2. Holonic Manufacturing Systems [1]

Rys. 2. Holoniczne Systemy Produkcyjne [1] labeling methods objects are identified much faster and we are able to use far longer unique identifiers that offer another bonus of the increased accuracy of identification of specific objects [6].

In our activity in mining applications we are focused on RFID technology using UHF (Ultra High Frequency) bands. Benefits of UHF band lies primarily in higher read range (few meters), relatively simpler antenna design, which reduces the cost of producing the entire tag and higher communication speed. UHF technology is widely utilized in logistic systems and increasingly used to transportation deliveries in supply-chain or in the traceability of consignments, where a longer reading distance allows identification without having to change working practices while implementation. An interesting challenge is, however, application of this technology in production areas, comprising among others mining.

RFID reader

The device, which performs the actual identification of the selected objects, is called RFID reader.

The reader is a radio device that provides the ability to broadcast and receive radio waves. The reader, however, not only allows communication with tags on selected objects, but in the case of passive or semi-passive solution also provides the energy that power up the chip of the tag and allows its function. Radio equipment in general may, depending on whether it transmits and receives simultaneously or sequentially, are operating at half duplex or full duplex. The device in full duplex design usually for receiving and transmitting use slightly different frequencies and for the distinguishing of signals leading to and from the antenna a special filter is used.

Reader, which is designed to communicate with a passive or semi-passive tag must inevitably work in full-duplex mode, because it transmits a carrier wave, which supplies the tag with enough power, and receives the tags response on the same time. Given that the tag transmits at the same frequency as the reader it cannot use a filter commonly used for example in systems of CDMA (Code Division Multiple Access). Signal transmitted by readers is much stronger than the signal transmitted by a tag and therefore it has a significant negative effect on the sensitivity of the receiver.

Identification transponder - Tag

As mentioned above, RFID is based on the principle of radiofrequency waves. Therefore, the element labeling the object must be some kind of radio transmitter and receiver. Tag is equipped with an antenna connected to the radio part. The logical subsystem follows to allow operation with the memory subsystem. In the case of a passive tag, the energy supply is obtained from the carrier waves emitted by the reader. If such a tag occurs in the interrogating field of the reader, the energy field activates both the power and the data part of the receiving circuit.

Active RFID has a battery power source designed either to strengthen the transmission power of the tag (semi-active tag) or for continuous transmission without reader. These tags can store the values of individual variables either in their memory and provide it to the system at the moment of appearance in the interrogating field of RFID reader (such as major nodes in the corridors. Alternatively, data distribution can be realized in a network infrastructure along the corridors while measured data are transmitted continuously in real time. The most interesting and challenging is probably to share or transmit measured values in networks such as the ring or mash, while the supporting infrastructure is formed by tags itself that retranslate the information with each other wirelessly to a central unit that is able to evaluate the information and store them [8].

Smart technologies and their applications

Extraction and exploitation of raw materials is an integral part of the mankind development since the beginning of history. The current need for energy and raw materials in all countries, encourage research in the field of mining and other forms of exploitation of the Earth's resources. Modern technology faces the challenge of developing a new "Smart technology" to facilitate the efficient acquisition of raw materials with no adverse impact on the environment. Such an approach is already a common part of modern production technologies.

Auto-ID RFID technology applications are based on product labeling by an identifier (RFID tag), reading the stored information at any point in the production process, processing and filtering of information and subsequent distribution to a higher layer of information system such as EPCIS and to Internet of Things (IoT). You can obtain the information content of the global character of different areas [7].

The smart production technologies are based on the application of intelligent transport systems and logistics elements forming a complex produc-

Fig. 3. Google Glass [4]

Rys. 3 Okulary Google

Fig. 4. Application of Maptek system [2]

Rys. 4. Zastosowanie systemu Maptek [2]

Fig. 5. System PerfectDig [5]

Rys. 5. System PerfectDig [5]

tion network, which in many cases require special security arrangements. Next step of smart production control is the application of holonic multiagent systems. Uses of Smart technologies enable deployment of intelligent autonomous MAS devices that eliminate the need for human presence in hazardous environments at operations control.

Application of augmented reality

Augmented Reality (AR) in control adds to real production scene elements that are generated by a computer. We can say that it adds to the real picture (production reality) additional artificial information. Currently could be additional information displayed in head mount displays such as Google glasses, Fig. 3.

For example the Maptek company is provider of software, hardware and services for the mining industry. It has created a system PerfectDig to shift the communication barriers between engineers, surveyors, supervisors and operators. These persons can access the data via smartphone, tablet or computer and create support for real-time decision making. The system allows you to view the design and progress of excavation in real time, using 3D laser scanning technology. The laser scanner scans the surface, which is then compared with the mining plans and the proposal of the trench. The system also allows visualizing the difference between the actual and required level of excavation. On the basis of this difference is reflected in the trench information about where the excavation is to be adjusted according to the required mining plans [5].

The use of virtual and augmented reality in the mining industry is very broad. The arrival of affordable display device naturally extended application potential in areas where it previously was not possible.

In opencast mines is the applications of these technologies much easier, as the device may not meet the strict rules for intrinsic safety, only need to be sufficiently robust to withstand dusty conditions.

However even in deep mines will AR find its application potential. For example in the field of planning and construction of the mine excavation may applications using augmented reality to assist in determining the course of digging tunnels, placing buckling of columns, laying down technological networks

Conclusion

Mineral resources are a strategic commodity for the development of advanced societies and their efficient extraction and effective use is a prerequisite for competitiveness. Mining activity significantly interferes particularly in the areas of energy, environmental protection and public life in general.

The growing potential of information technologies and their implementation in mining activities, as well as a detailed analysis of the properties of the rock material and knowledge of the behavior of soil and the processes going on within it, supports increasing the safety and efficiency in the extraction and utilization of mineral resources. Research on application in area of Smart technology creates a space for their effective use towards energy saving, environmental friendliness and increase the competitiveness of all institutions that these technologies will apply in the future.

Very potential areas for the application of Smart technology are intelligent logistics and operations control and management using AutoID RFID technology that allows automatic identification and monitoring of any objects in the production networks. The next step of smart production control is the application of Holonic multiagent systems - HoloMAS. To understand the autonomous control processes and technology state, the use of augmented and virtual reality will be necessary [2].

Using Smart Technologies we obtain more information about the raw materials processes - extraction, transportation and preparation, which can be applied at all levels of process control and management. These include the status of the technological process, technical security of production, models of behavior of individual parts of the technological complex, real-linking process simulation models, state of the landscape in the extraction and recovery of its management (use of virtual reality) as an important part of environmental protection.

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Literatura - References

1. *Virtual factory approach for implementation of holonic control in industrial applications: A case study in die-casting industry, Dept. of Mechanical Engineering, Eastern Mediterranean University, 2008, Turkey.*
2. *Kebo, V., Kodym, O. et.al. Virtuální realita a řízení procesů. Montanex 2011, ISBN 978- 80-7225-361-6.*
3. *Mařík, V. et.al.: IndustrialApplications of Holonic and Multi-Agent Systems, Proceedings of 6th International Conference, HoloMAS 2013 Prague, Czech Republic, Springer, e-ISBN 978-3-642-40090-2.*
4. *http://www.google.com/glass/start/what-it-does/*
5. *http://www.maptek.com/*
6. *Vojtěch, L.; Kahl, J.: Power Analysis of Communication of RFID Transponders with Password-Protected Memory; Networks, 2009. ICN '09. Eighth International Conference on, vol., no., p.116–120, 1-6 March 2009; DOI: 10.1109/ICN.2009.75 Available from: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4976661&isnumber=4976632*
7. *Vaculík, J., Michálek, I., Kolarovszki, P.: Principles of selection, implementation and utilization of RFID in supply chain management; Promet – Traffic & Transportation, Volume: 21, Issue: 1, Pages: 41-48, Published: 2009; ISSN 0353-5320.*
8. *Kang, YS., Lee, YH.: Development of generic RFID traceability services; Computers in industry, Volume: 64, Issue: 5, p. 609–623; DOI: 10.1016/j.compind.2013.03.004; Published: JUN 2013; ISSN: 0166-3615.*

Automatyczna identyfikacja w przemyśle górniczym

Automatyczna identyfikacja [Auto-ID] zaczyna być ważną częścią systemu kierowania ruchu obiektów logistycznych/sieci transpotowych. Z punktu widzenia kierowania procesem chodzi o rozprowadzony system kierowania, w którym dane operacyjne codziennej produkcji pojedynczych segmentów [odziałów] i pojedyncze węzły są kierowane tak, żeby zabezpieczona była planowana wydajność produkcyjna. Jednym z możliwych obszarów użycia aplikacji smart [mądrej] technologii jest logistyka i kierowanie produkcji z wykorzystaniem technologi RFID, umożliwiającej automatyczną identyfikację dowolnego obiektu. Prowadzi to do zwiększenia bezpieczeństwa i wydajności produkcyjnej procesów logistycznych. Dalszym krokiem inteligentnego kierowania produkcją jest wprowadzenie multiagentoweg systemu - holomas. Do zrozumienia autonomicznego kierowania procesem oraz statusu techniki konieczne jest użycie rozszerzonej rzeczywistości faktycznej [wirtualnej].

Słowa kluczowe: automatyczna identyfikacja, holon, rozpowszechniona rzeczywistość, smart [mądra] technologia