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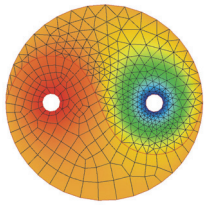

# AGENT-BASED INFORMATION PROCESSING IN A DOMAIN OF THE INDUSTRIAL PROCESS OPTIMIZATION

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**Abstract**

The paper presents the idea of an agent-based information processing system, which can be recognized as an alternative approach to the optimization of industrial processes. The main objective of the proposed approach is to find similarities between the current production and the production in the past. The goal of this search is to choose the period of the past production, which is characterized by the conditions similar to the current ones and simultaneously, which presents desired quality of production. The found period provides useful information on how to control the current production and can be used as the starting point for the additional optimization analysis. In order to verify proposed approach, an agent-based information processing system was developed, and tested on the real industrial process. Preliminary results were shown.

**Key words**: multi-agent system, agent-based information processing, control and optimization system of industrial processes

## 1. INTRODUCTION

There are still industrial processes that are controlled manually by qualified workers rather than by appropriate computer systems. The manual control is justified in cases of industrial processes that are difficult to model or which are characterized by irregular measurements of the process data. The idea of the proposed approach is based on the human, manual control, when the gained experience of the worker is often the inspiration for the proper action. Such approach appears in many applications of fuzzy logic or expert systems used in control systems. Proposed approach is based on the agent information processing and is similar to the way, how an expert uses his knowledge.

The proposed multi-agent system consists of two groups of autonomous agents. Agents of the first group represent information concerning the measured parameters of the past production and a quality criterion. The second group consists of only one agent that has to find such an agent of the first group, which represents the period of the most similar conditions to the current ones and which shows the best value of the quality criterion. The aim of the elaborated system is to analyze the history of the considered process, which is the source of knowledge. Results of this analysis, after additional processing, may be used in the process control or optimization.



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## 2. AGENT-BASED INFORMATION PROCESSING OF THE PAST PRODUCTION DATA

### 2.1. Agent technology

An agent is a computational entity like a software program or a hardware robot, which can act autonomously in its environment. An intelligent agent should operate flexibly and rationally in a variety of environment conditions in order to achieve some set of goals or perform some set of tasks (Cetnarowicz, 1999; Dobrowolski, 2004; Weiss, 1999; Wooldridge, 2001). The behaviour of an agent can be seen as behaviour of an intelligent entity, like a human, that is acting in its environment. An intelligent agent observes the environment and makes autonomous decisions concerning actions that are possible to be made in particular circumstances.

### 2.2. Idea of the agent-based approach information processing

Proposed approach assumes that the considered production process lasts for some time. The quality criterion is static and is measured several times a day. The historical data contains measured values of all input signals and values of the quality criterion of the final product. Some of the data are collected as the result of automatic measurements other are measured manually. Moreover, the sampling frequency varies from minutes to hours or even days for some parameters. The past production was considered as the series of the one-day periods. As the consequence, the data concerning past production are split between individual days of production. That enables to process whole information about the past production in decentralized way and allows using the multi-agent paradigm in the proposed approach

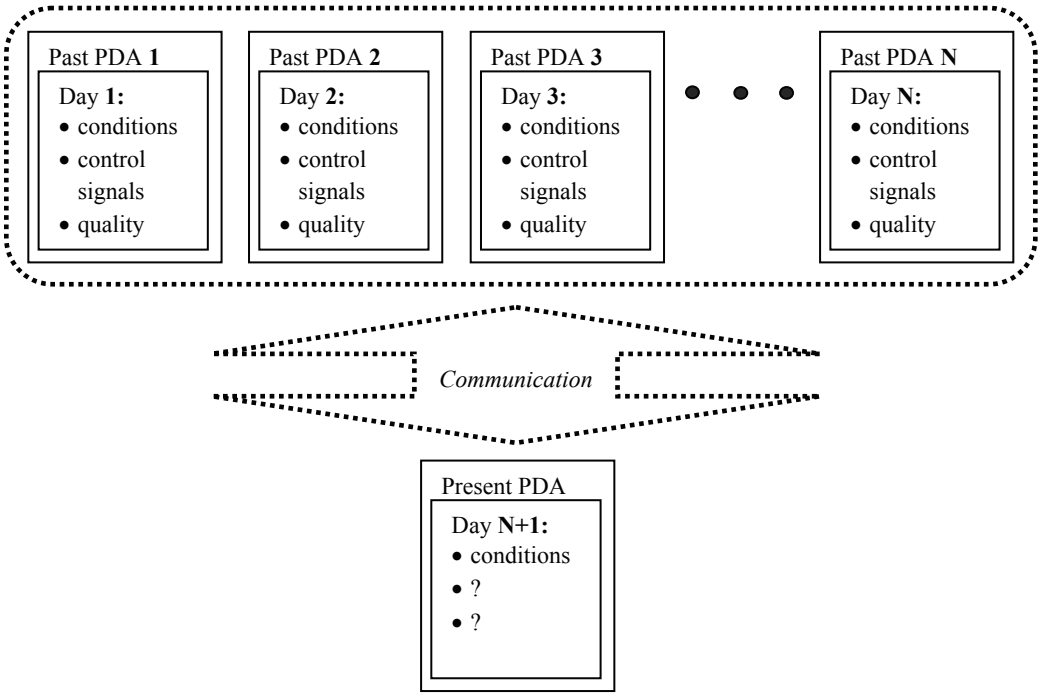



***Fig. 1.*** *The idea of an agent representing individual production days.*

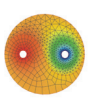
An agent can perform a variety of actions; some of them can be related to the interactions between the agents or interactions with humans. An interaction can take place indirectly, through the common environment (e.g. by observation of some ambient conditions which can be modified by another agent or agents) or directly through a communication. A communication is possible in a situation when all participating agents are able to operate the same communication's mechanisms - language or ontology.

(Kluska-Nawarecka et al., 2003, Nawarecki et al., 2002). The aim of the agent-based system is to find values of control signals for the present production day (day $N + 1$) using an agent, which can communicate with other agents providing information concerning individual $N$ days of the past production. That idea is shown in figure 1.

The proposed multi-agent system consists of two types of agents:

– Past Production Day Agents (number of the Past Production Day Agents corresponds to the num-





ber of the production days of a considered historical period). Each Past Production Day Agent (Past PDA):

- represents one day of the past production,
- provides information concerning:
  - conditions of productions,
  - control signals,
  - quality criterion – the daily average value of represented day.

– Present Production Day Agent (Present PDA – one single agent):

- represents the current production day,
- prepares an advice for the control signals of a current production.

These two types of agents are described further in details.

### 2.3. Past Production Day Agent (Past PDA)

The main task of a Past PDA is to provide information concerning one day of the past production using the communication system. At the beginning, all the Past PDAs register to the yellow pages service, which provides information about all services and agents. Due to that, all agents can be found by the Present PDA and can communicate with each other. The yellow pages service allows maintaining independent number of communicating agents.

The Past PDA responds only to two questions (which are in the form of requests) asked by the Present PDA:

– provide me conditions of production for the day of production you are representing,
– provide me a quality criterion value for the day of production you are representing.

The agent answers these questions immediately, sending messages with the proper information concerning the represented day.

Number of these agents can change during functioning of presented system, because the Present PDA creates the Past PDA at the end of a current day.

### 2.4. Present Production Day Agent (Present PDA)

The mission of a Present PDA is to elaborate the best values of the control signals for the current production. For that reason:

– it takes into account conditions of the present production,
– confronts these data with the data stored by all Past PDAs,
– selects these Past PDAs, which are characterized by the similar production conditions to these of the current day (*N_sim* – number of these agents),
– selects, among all *N_sim* Past PDAs, that one (*PDA**), which gives the best value of the quality criterion.

The production control signals corresponding to that best *PDA** correlate in some way with the optimal signals, and can give the useful information for a control of the current production.

The Present PDA uses the yellow pages service to communicate with all agents representing the past production. This allows operating in dynamic environment with varying number of agents.

## 3. FUNCTIONING OF THE AGENT-BASED INFORMATION PROCESSING – AN EXAMPLE

Functioning of the proposed agent-based information processing system can be explained by the practical case of the real industrial process of the fluidized-bed furnace for the oxidizing roasting process of zinc sulphide concentrates. The roasting process of the zinc sulphide concentrates is the first step in the hydrometallurgy-based technology of a zinc production, and tends to eliminate sulphur from the input concentrates and to achieve the minimal concentration of sulphide sulphur in the roasted products. The process is multidimensional with more than thirty input signals that can be classified into the following groups (Sztangret et al., 2011):

– independent signals – mainly related to the input zinc sulphide concentrate (chemical composition, humidity, etc.) and independent from the human control,
– dependent signals – parameters related to other input parameters. They influence the nature of the process e.g. temperature inside the furnace (depends on the material chemical composition, fed, air pressure, etc, and influence the capacity of sulphide sulphur in a final product),
– controllable signals – the set of signals (e.g. air pressure or material fed), which can be used to control the process. These signals are independent from the others.

The aim of optimization and control of considered production process is to achieve the minimal concentration of sulphide sulphur in the roasted products, which can be recognized as the optimization goal function. That concentration is measured



several times a day. But according to the day periods used by proposed agent-based information processing system, the goal of a system is to obtain minimal concentration in all products per single production day. Therefore, the day average of concentration of sulphide sulphur was used as the quality criterion for evaluation of a day period production.

Registered values of quality criterion and signals of mentioned above 3 groups provide full information about production process in a past day period. In case of the considered process optimization, the controllable signals are the only decision-making variables. The objective of research was to find values of these variables, which give the best value of the optimization criterion in the past production at similar conditions of production described by values of independent signals. While, the past production is represented by the Past PDAs, the information processing system has to find the respective Past PDA*, among all Past PDAs, which fulfil these requirements.

The system was created using the JADE which is a flexible agent platform allowing to create an agent-based system in various fields (Bellifemine et al., 2007). Ten-day production period was taken into consideration, so the platform consists of 10 Past PDAs (called: *1_day – 10_day*). These 10 Past PDAs were created according to 10 past day periods of the zinc oxidizing roasting process. Table 1 presents measured values of independent signals (which are also referred as conditions of production) and the average values of the quality criterion for agents representing individual past day periods of production. Conditions of production and average values of quality criterion are the most important information for the correct functioning of our agent-based information processing system.

Creation of a Present Production Day Agent involves interactions presented by a Sniffer Agent. The Sniffer Agent role is to present messages exchanged between sniffed agents (arrows in figure 2). The present PDA was created according to the new day period of production process. For this new day only conditions of production (independent signals) are known. These signals have the following values: Zn - 57,00; Pb - 2,42; Fe - 5,87; S - 34,1.

***Table 1.*** *Values of independent signals and quality criterion of considered 10 days of past production of the zinc oxidizing roasting process.*

| | Independent signals | | | | average values of the quality criterion |
|---|---|---|---|---|---|
| | Zn | Pb | Fe | S | |
| 1_day | 57,74 | 2,33 | 2,45 | 33,2 | 0,6983 |
| 2_day | 55,01 | 2,61 | 5,59 | 33,7 | 0,7333 |
| 3_day | 56,39 | 2,1 | 4,83 | 33 | 0,6373 |
| 4_day | 54,53 | 2,19 | 6,26 | 33,7 | 0,68 |
| 5_day | 54,85 | 2,41 | 6,44 | 33,7 | 0,6373 |
| 6_day | 53,1 | 2,29 | 7,65 | 35 | 0,645 |
| 7_day | 55,6 | 2,09 | 4,81 | 34,1 | 0,67 |
| 8_day | 56,59 | 2,54 | 5,29 | 34,5 | 0,6875 |
| 9_day | 59,57 | 1,95 | 5,22 | 34,6 | 0,6708 |
| 10_day | 58,6 | 1,95 | 4,16 | 33,7 | 0,5991 |

The new created Present PDA (*ppda_1*), first asks the yellow pages service (agent named *df*) about information concerning all Past PDAs existing in the environment (line 1 in figure 2.). The df agent responds him sending proper information that gives him the ability of communication with all agents representing past production days (line 2). Next, it sends requests (lines 3-12) to all Past PDAs in order to get values of independent signals representing conditions of production (lines 13-22). In the next step, *ppda_1* agent selects *N_sim* Past PDAs that have values of independent signals most similar to the current production (number *N_sim* was fixed to *N_sim* = 5 in the considered case, but can vary, depending of the length of the history of considered production). According to this step 5 Past PDAs were selected, representing days: 2, 3, 5, 7 and 8. Independent signals of these days are in closest geometrical distance to known signals of the current production. The geometry distance is measured with the Euclidean metric, however many modification of the metric are possible in proposed approach (e.g. it is possible to make some signals more important than others for the result of the measure).

The goal of next step is to find, among chosen earlier similar Past PDAs, an agent, which can be used as an example of the best production case (in the sense the quality criterion). The *ppda_1* sends to earlier chosen agents request for the feedback with the values of the quality criterion (lines 23-26 and 28 in figure 2.). The *N_sim* = 5 answers (lines 27 and 29-32) finish the exchange of messages between all agents.



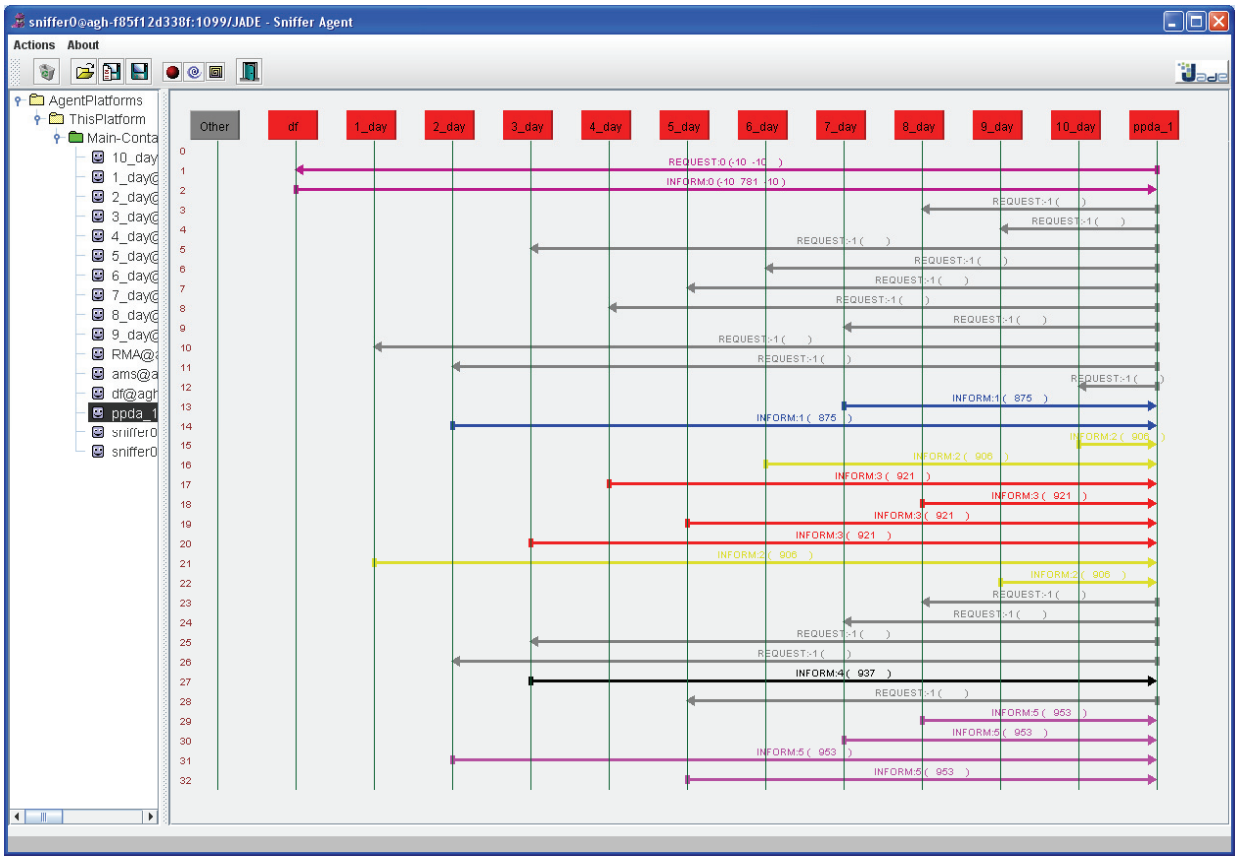



***Fig. 2.*** *Exchange of messages in the tested system using the Sniffer Agent.*

On the basis of the messages exchange, the Present PDA makes selection with respect to the best value of the quality criterion among the $N\_sim = 5$ most similar agents. In case of our example there are two agents, representing days 3rd and 5th, having the same, lowest values of the quality criterion. Because the answer of presented interaction should be unique that agent is chosen, which responds first to the last question. In our example, it was the *3_day* agent, which responded as the first (see figure 2). That agent becomes the Past PDA* and the controllable, dependent signals and other parameters of the 3rd day production can give a valuable information for the control of the current production. The found Past PDA* can be used in the advisory control system of the zinc production.

The proposed agent-based system of the information processing of the fluidized-bed furnace for the oxidizing roasting process of zinc sulphide gives the correct answer for the considered ten days production period. The found solution of the tested case can be useful for the operating of the current production. On that basis, it can be expected, that such approach can be a useful aid in the process control systems. It can be also used in finding the approximation of the starting point for further optimization. However, the proposed approach has to be validated with other methods (statistical techniques, expert systems, etc.) that is the objective of the future research.

## 4. SUMMARY

Presented agent-based information processing system was inspired by the way how humans use their knowledge and experience in the manual control of industrial processes. One of main issues of that approach is searching the information concerning the past production in order to find the case similar to the current production state of the best value of the given quality criterion. Such case gives useful information about the production in the past, which can be used in the control system and optimization of the considered process. The proposed system is based on the use of dedicated agents. Implementation of the agent technology makes, that the proposed system is flexible and can be easily updated and modified. Presented approach is a preliminary result of the research and will be further developed.

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**AGENTOWY SYSTEM PRZETWARZANIA INFORMACJI W ZAKRESIE OPTYMALIZACJI PROCESU PRZEMYSŁOWEGO**


Streszczenie

Praca jest próbą w zakresie badań alternatywnego podejścia do optymalizacji systemu przemysłowego. Główną ideą prezentowanego podejścia jest wyszukiwanie podobieństw pomiędzy okresem bieżącej produkcji a okresami produkcji wykonywanymi w przeszłości. Celem tego przeszukiwania jest znalezienie okresu z przeszłości, który byłby podobny pod względem warunków produkcji do bieżącej produkcji, a jakość produktu wytworzonego w tym okresie była najlepsza. Wskazany okres produkcji może być podstawą wspomagania systemu sterującego bieżącą produkcją lub może stanowić rozwiązanie początkowe dla dalszych etapów optymalizacji z wykorzystaniem innych technik. W celu weryfikacji wyników prezentowanej pracy zaimplementowany został agentowy system przetwarzania informacji, który następnie poddano weryfikacji z wykorzystaniem rzeczywistych danych przemysłowych. Zaprezentowano uzyskane wstępne wyniki.



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