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EMOTIONAL INTELLIGENT AGENT IN DECISION-MAKING PROCESS WITH IMPLICATIONS IN MANUFACTURING

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Abstract: In every part of the world, researcher from various domains, are looking for solutions to improve human life. Software products are developed in order to get a lot of features, or even to replace human component in different process. In manufacturing area, exist the same idea, to create artificial manufacturing systems. One of the challenges is to use concepts form another fields, for instances from artificial intelligence. Literature shows a lot of existing examples which were developed on these two segments: manufacturing and artificial intelligence. We have a lot of examples which are related on the following concepts: coordination and cooperation of entities, uncertainty and temporal dynamics, information sharing and distributed operation. Although, because the human component wasn't all the time detailed analyzed, still exist a lack. Human behavior is unpredictable, emotions have a certain role, and, for instance the mood can influence process of making-decisions which has direct implications in manufacturing. The proposed model from this paper tries to offer a solution. Combining concepts from psychology, emotions, with concepts from artificial intelligence, intelligent agents, result a personal assistant in decision-making process that constitute an added value, an advantage in manufacturing.

Keywords: decision-making, user behavior, manufacturing, intelligent agents.

1. EMOTION'S ROLE IN DECISION MAKING PROCESS

For a better view of the emotions in literature, we will start with a definition of emotional intelligence, according to Salovey and Mayer as an understanding of the impact that emotions have on the self and on others, or the manner in which emotions are created, and how this are able to use this knowledge to regulate emotions on the self and in others (Mayer, Caruso and Salovey, 1999).

From this definition from a psychological view, we are going to the idea that this theme of emotions constitutes an interesting area for research from multiple domains and at different level of abstraction. It is working on different approach: emotional experience as a result of environmental stimuli, the emotion history of a person, the behavioral reactions and a brain functions. Following these researchers, a lot of formalizations of this concept have been introduced in literature. In this paper we are interested in computational model of emotion. Emotions are strongly linked with human behavior.

A good understanding of human cognition means to be praised of a very good understanding of emotions because, according to a lot of specialists from these interconnected domains, the emotions influence the cognition. Human behavior represents an important component in decision making process. This is influenced by emotions. To refer to emotions, we have from two perspectives: extern and intern perspective. Referring to external, we can define emotions as a set of states of individuals which determine the configuration of some body characteristics as a nonverbal behavior: facial expressions, body postures, and voice intonation; these interact with others and relive different attitudes toward situations (Adam, 2007). Referring to internal process: perception, attention, decision making, the emotions stimulate and shape the normal stimuli (Rodríguez, Ramos, 2014). The subject emotions in decision-making were largely analyzed by different researcher from area. Firstly, into decision-making process, Loewenstein and Lerner have split emotions into two types: those anticipating future emotions and those immediately experienced while deliberating and deciding (Loewenstein and Lerner, 2003). Secondly, Damasio formulated the somatic marker hypothesis that proposes a mechanism by which emotional processes can guide behavior, particularly decision-making. The decisions, according to the somatic marker hypothesis are influenced by emotion-based signals in uncertain environments outside awareness. Some experiments show through a direct measure of conscious knowledge that implicit processes influence decision making under uncertainty (Bechara and Damasio, 2007).

2. INTELLIGENT AGENTS IN MANUFACTURING

Artificial intelligence represents an area of research in a continuous development. If on the beginning, the researchers have been focused, in time, on the automated demonstration of the theorems, game theory, commonsense reasoning, processing of the natural language, solves problems from specialized area as medicine, psychology, biology chemistry on so on (Stothert and Macleod, 1997). A particular domain of artificial intelligence and more recently is represented by intelligent agents. An agent can be defined as an autonomous software entity which is pro-active, reactive, social and able to take part to an organized activity, in order to achieve its goals, by interacting with other agents and users (Gâteau and Boissier, 2006). Moreover an agent AG is autonomous with respect to US for AC in situation S; where AG can be a user, another agent, a group of agents, or organization of agents. AC can be an action, a goal, a plan, a resource, a norm, a role. So, shortly an agent AG can decide locally to react to action AC in situation S and US has no certainty that AG is going to adopt AC in situation S.

A series of challenges in the development of autonomous agents are to create agents capable of exposing believable and human-like behaviors and to design and implement computational models of emotions. According to Scheutz, "emotion processing is crucial for the agent's action selection, adaptation, social regulation, sensory integration, motivation, learning, and strategic processing" (Scheutz, 2004).

The developments in information technology increase number of computer integrated manufacturing systems.

In the past decade various approaches from manufacturing systems, such as holonic, fractal, random, biological, and multi-agent manufacturing systems, are already underway (Monostori, Váncza and Kumara, 2006).

All these approaches are similar, dynamic, independent, open and reconfigurable systems where decisions are made and production is performed.

Manufacturing and artificial intelligence have been crossed to create an ongoing to success in commercial fields by increasing the productivity and reducing the costs. Nowadays, in universities and in industry, exists a lot of tentative to create and use embedded systems. The goal is to have a hardware and a software part for these complex systems.

In literature a lot of algorithms were developed to be used in manufacturing, to the every level, from the process planning, to manufacturing planning (production) and finishing with quality control. One of the most important applications from the information technology in industrial area is represented by the agents. Agents can be used in manufacturing fields to achieve more control with a minimum effort of working, minimum costs and more results, they provide an efficient design and implement into engineering environments.

Agents offer features in different software systems. Through these features, they were, are and will be used in manufacturing functionalities to accomplish some particular operations.

The reasons for using these agents in engineering are, firstly current computing environments, such as material databases and resource databases, tend to be distributed because of new needs in industry, secondly manufacturing cost has been increased because of the use of sub-optimal process parameters. Last, but not least important is the lack of web-based collaboration between the process planning activity and the process parameter optimization activity and thirdly because the lack of interoperability among heterogeneous software systems and tools. Web-based collaboration can improve the procedure as well as offer important services, such as video conferencing and electronic data interchange.

Agents and multi-agents systems are represented through a lot of examples which have been developed and used in control engineering.

An agent-based method for designing controllers for mobile robots was described by MacKenzie (MacKenzie and Arkin, 1997). The behavior of these agents is based on robotics paradigm. Mac-Leod and Stothert create an agent used in problem of controlling a mine refrigeration system (Stothert and Macleod, 1997). Another example of agents was used in highway systems, where vehicles can be viewed as agents competing for scarce highway space-time and air traffic management systems where aircraft compete for air space and runway space. Lygeros, Godbole and Sastry create this kind of agents (Lygeros and Godbole, 1996). In every moment, people have to select an alternative from a set of possible alternatives to be chosen to pursue their goals, that means the engine which is activated all the time, so the decisions are a component part of living and in the same time the decisions are important for the industrial sector. In this case, decisions vary with complexity, requirements, available information, and time. The human ability of solving problems, according to few methods and approaches, using both a rational dimension as an emotional dimension.

3. PROPOSED MODEL AND RESULTS

From previous part, we can see that is an issue that in manufacturing an important extension is

represented by agents. In the same time in manufacturing system, another important issue is represented by in modeling of human operators, moreover in decision-making aspects. According to these two hypothesis, an important point in research from these interdisciplinary fields consists in using agents and in human factors. Human component represented through behavior is important and can have a certain clear role in decision making and this implies to have some remarks in manufacturing process, respectively emotions influenced decision making process.

As we could see from previous sections, emotion component plays an important role in decision making process. Forward, decision making process has an important role in manufacturing process. Emotions influence the cognitive behavior in general and because of this, cognitive process as tasking, reasoning process, for example are affected. Because of this is important to pay attention to manner in which the decision making process impact in manufacturing process. One solution can be to create an intelligent agent with an emotional detection features and according to this to point out the user, offer an advice according to one important decision. For his we are working on an agent to assist the user, and interact with human in decision making process when the mood of the users has particular states. A perspective which can be approach is to implement an architecture that analyze the behavior and according to this analysis deliver an affective information, this response become an important component in decision making process. The result of this idea is a personal assistant, Emotional Intelligent Agents which detect and notify changes in user behavior which affect Decision-Making process and have implies in Manufacturing (in next sections, we will refer to this using the EIADMM). Base on emotional component, we have a series of operators that are important in the interpretation of the agent. The system analyze the stimuli from the users (perception system which analyze the internal representation of the stimuli) and environment, send the result to other component, which analyze these, establish if the behavior is included in normal parameters, base of these result react. The reactions of the system could be in agreement or disagreement with the users. In case in which the agent has a different opinion according to the users, send an alert message and an advice to user.

A structure of the algorithm for the EIADMM is:

```
Collect (dates);
Analyze (dates);
repeat
options := option_generator(dates);
selected := deliberate();
i := selected ∪ i;
execute(i);
action := result();
s:=update_state();
sa:=successful_attitudes();
ia:=impossible_attitudes();
forever
```

The average of final products resulted and marked as good products, after applying the EIADMM is shown in figure 1.

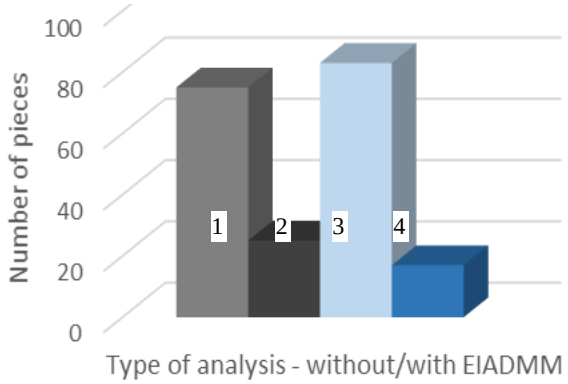

Fig. 1. The average of final products without/with EIADMM: 1-good pieces; 2-defective pieces; 3-good pieces with EIADMM; 4-defective pieces with EIADMM

As we can see, the percent of defective pieces has been decreased after applying the EIADMM, so, the average of the final products has been increased.

The EIADMM were applied for a many days, and the results are collected in table 1.

The results for an applying of this personal assistant in time relieve that with help of this personal assistant, humans are not so exposed to get some wrongs because of their internal states, the personal assistants can detect the changes in their mood and in case in which this is unstable, notify the users that exist a possibility to not do the task in a proper manner. The results from table 1 are relieved in figure 2.

The results collected for a period of time shows that notifies to changes in emotional behavior has an impact to people work. These results reveal in figure 3 and figure 4. These conclusions have to be considered in different aspects of management because, as an expected conclusion, the emotional state of the employers has a major impact of their work and using these kind of system, through notifications, will represent a good investment in the long term.

The proposed model has some limitations due to the different variables which will be analyzed and treated in another version of this model, as a future work.

In this moment, the EIADMM just notify a possible change in behavior of the user which can affect

decision-making process. According to this, the user can chose to be in line with the EIADMM or to ignore. One of the improvement on which we are thinking is that the EIADMM can inform and another person about this possible problem or to block the process until the user's behavior is included again in specified parameters.

Table 1. EIADMM applying results

without	good piec	75	80	73	70	72	70	71	90	87	81	83	79	73	82	79	86	85	86	89	87	82	83	78	81	84	87	80	87	85	90
EIADMM	defective	25	20	27	30	28	30	29	10	13	19	17	21	27	18	21	14	15	14	11	13	18	17	22	19	16	13	20	13	15	10
with	good piec	83	90	78	75	79	74	79	95	93	87	89	86	80	87	84	93	92	95	93	94	86	92	86	86	90	90	85	93	89	94
EIADMM	defective	17	10	22	25	21	26	21	5	7	13	11	14	20	13	16	7	8	5	7	6	14	8	14	14	10	10	15	7	11	6

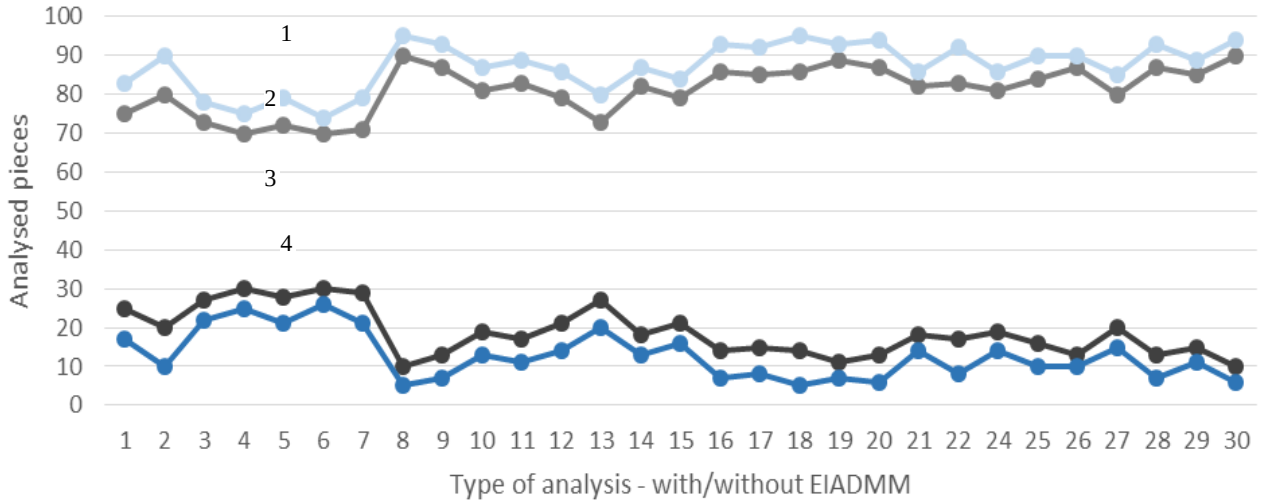

Fig. 2. EIADMM results for 30 days: 1-good pieces with EIADMM; 2-good pieces without EIADMM; 3-defective pieces without EIADMM; 4-defective pieces with EIADMM

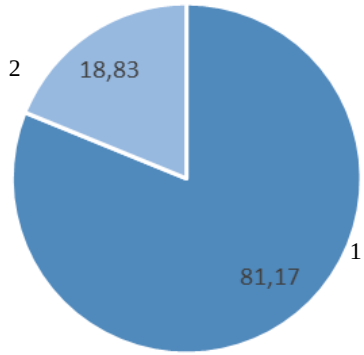

Fig.3. Good/defective pieces without EIADMM: 1-GP-EIADMM; 2-DP-EIADMM

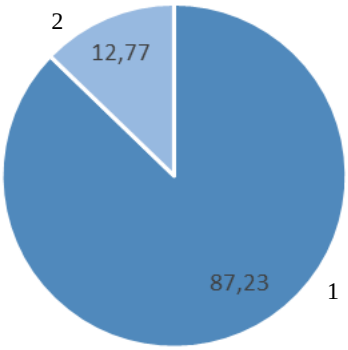

Fig. 4.Good/defective pieces with EIADMM: 1-GP+EIADMM; 2-DP+EIADMM

4.CONCLUSIONS

This paper presented another approach of applying concepts from different area of research, in order to create some applications to improve our life. Here we have been focused on concepts from tree different area: psychology, artificial intelligence and manufacturing. Artificial intelligence deals with "emotions": Simulates and recognizes them, trouble is there is no universally agreed count of the emotions and their relationship with motivation is not well defined. The emotions are the front end of all purposive behavior, emotions don't stand on their own except in the context of immediate self-preservation, that's why we feel their depth; they touch us in the sense of immediate peril of our existence. The results are auspicious and indicate the fact that using artificial emotions in autonomous decision-making systems represent an important future research area, improving the effectiveness of each decision. On the beginning, the paper presents, from a synthetic point of view, the theoretical aspects and some examples from previous works related to this approach. Then, we present the model on which we are working,

respectively the personal assistant with a certain role in manufacturing, and finally the results from an analysis of applied model in manufacturing. Also have been presented the limitation of this model and the future work plan.

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