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Soft Computing for HR Uncertainty Management in Steel Industry

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Abstract - This paper discussed possible application of soft computing methods in uncertainty management of the HR component in steel industry during automation period. It explained the importance of HR and the concept of uncertainty management. Then it discussed what to look in soft computing for uncertainty management.

Keywords-HR, Soft Computing, space mapping, surrogate model, uncertainty management

I. Introduction

The human resource management in any organization is related to its functional areas responsible for all aspects of hiring and supporting employees. There are two types of human resource components in an organization. The first category is the work force, which will be termed as soldiers in this article. The soldiers are technically competent in respect of the production coming out of the organization. The second category is termed here as the executive. They are not directly linked with the production. They primarily work as facilitator for the soldiers. Their job includes finding the competence level of soldiers for different types of production jobs, determining the level of interest of different solders in different types of jobs irrespective of their competence level for that job, find out the right type & amount of incentive to keep soldiers motivated as well as a plethora of such other things.

Therefore, the organization must have executives and soldiers. However, sometimes one may overpower the other. This overpowering can be fatal for the organization, since gradually it becomes suicidal. Hence, a proper balance is to be maintained between the soldiers and the executives. In practice it is impossible to demarcate an exact boarder line between the soldiers and the executives.

In this paper we have tried to identify the sources of uncertainties involved in the above areas and possible formulation of optimization problem, particularly during the period of automation in steel industry. We provide the manpower distribution in two different periods in the Rourkela Steel Plant of Orissa and discuss how to formulate the uncertainty analysis as an optimization problem.

II. Uncertainty in Steel Industry

The term *uncertainty* is mostly concerned with risk management in literature. Theoretically it can be defined as a lack of certainty involving variability and/or ambiguity. Similarly, *uncertainty management* is related to managing supposed threats and opportunities as well as their risk implications. Also, it includes managing of various sources of uncertainty which give rise to and shape risk, threat and opportunity Chapman and Ward [1].

In *risk* situations, there are uncertain parameters controlled by probability distributions which are *a priori* known to the decision maker [2]. Therefore, in *uncertainty* situations, parameters are uncertain, without any information about probabilities and in risk situations the intent is to optimize the expected value of some objective function. So, problems under uncertainty often try to optimize the worst-case performance of the system. The goal of optimization is to find a solution that will perform well under any possible realization of the random parameters. In our case it describes uncertainties in HR management of Steel Plant during transition to automation.

As is known to us traditional HR management in Steel industry lack properly formatted data for exhaustive and precise information, especially regarding making long-term plans. However, it may be possible to determine some parameter probability characteristics from experience or statistical data in certain situations of transition process. But in other situations there may not be any data making it possible to determine statistical peculiarities of parameters in uncertain situations.

In practice probability parameters are considered to be known and equal to average of probable result. However, this substitution of probability processes with determined models is not always right. *Stochastic programming* is planning and management tasks which describe processes going under risk and uncertainty conditions, it examines tasks with random coefficients and finds solutions when the information on the task conditions is insufficient.

In compilation of stochastic problems and their analysis it is very important to know if it is necessary to get only one solution which cannot be changed or a solution which can be adjusted [3] according to newly obtained information.

Every automation problem is unique, with unique data, environment. It includes a high degree of uncertainty in information. They all experience many unexpected situations and uncertainties, during implementation, and due to this process managers must be ready for it. They must be supported by risk management to identify, analyze, control, and report risks [4]. A process risk management can use three basic sources [2, 1] to explain such uncertainty phenomenon [5-6] using:

• *Known-unknowns:* These are explicit assumptions or conditions which, if not valid, could have uncertain, significant consequences and can be analyzed and managed. These represent identified potential problems, such as possibility of a strike when a soldier is redeployed or sudden break-down of a plant. One does not know exactly what will happen, but knows that there can be a potential damaging danger and hence can prepare for it;

• *Unknown-unknowns:* These are implicit assumptions or conditions which, if not valid, could have uncertain, significant consequences, i.e. the problems that arrive unexpectedly. These are "the ones that couldn't be seen as coming", but they can be expected and foreseen as a general contingency based on the experience;

• *Bias:* These are systematic estimation errors which have significant consequences. The bias are *static* risks maintaining their characteristics during their period of existence, but almost all other risks are *dynamic* and can change their probability and impact during the process life cycle.

Risks arise from uncertainty and are generally interpreted as factors which have an adverse effect on the achievement of the process objectives. These are the reasons why process risk management must be a continuous process with feedback, from the beginning to the end of the process. Smith [7] proposed to separate the more general risks, which are influential but uncontrollable, from the risks associated with key elements; referred to as global and elemental risks. The source of global risks [8] may be located outside the purview of the plant management like political, legal, commercial and environmental risk. The source of elemental risks are located within the purview of plant management like implementation and operational risks, and financial and revenue risks [9]. The likelihood of controlling such risks are more.

II. Importance of Uncertainty Reduction

The transition into automation can be described as a model covering all stages of its implementation [10-11]: development and planning, design and economic assessment, installation and handover, maintenance and utilization. In these stages certain participants (technocrats, labourers, worker's representative, department, designer, implementing agency, plant management) perform the appropriate actions. The information collected through earlier stages [12] is transferred to the next stages.

The lack of information exchange among the participants negatively affects the implementation process [2]: increasing the execution times, being the reason for the demand of non-scheduled resources, including ruined human resource management (HRM) and planned resource supply chain.

It is possible to imagine technical, economical or a daily life situation where the consequences of not fulfilling of one or another restriction can be very unwelcoming or even tragic. In the model of such tasks, it should be required that a set of variable parameters would satisfy all limitations in presence of any kind of fortuitous coefficients.

Kleim and Ludin [4] spotlighted several factors that can raise risk: team size; history and process similarity; staff expertise and experience; complexity; management stability; time compression; resource availability.

Uncertainties often rise due to the lack of qualification and competence of the personnel from the process manager's team. Qualification and competence of Steel Plant workers has to be reviewed and the importance of appraisal and planning processes has to be emphasised in the planning stage of the automation process.

So the uncertainty in undertaking a automation process in Steel Industry comes from many sources and often involves many participants in the process. Since each participant tries to minimize its own risk, the conflicts among various participants can be crucial to the process. Failure to recognize this responsibility by the Steel Plant Management or the implementing agency, often leads to undesirable results.

Uncertainties related with Force Major situations cannot be evaluated in process evaluation, because the factors of an influence can be disastrous and the process won't be available to implement.

Estimation and evaluation of uncertainty are core tasks in any decision support process [13]. The greatest influence to Automation cost estimation (appraisal procedures) occurs at the front end of the process [2].

Migilinskas, Ustinovièius and Popov noticed that sometimes assumptions made by designer during the conceptual and design phases may, restrict the best and most cost-effective solutions from being utilized [10].

Estimation can't foresee all deflections from evaluated process especially changes of cost and implementation time. If the Steel Plant can derive reasonable profits from the early operation of a completed facility, the process is considered a success even if automation costs far exceed the estimate based on an inadequate scope definition. However, inadequate planning and poor feasibility studies can lead to unsuccessful and abandoned processes.

III. Some Uncertainty Reduction Strategies

Automation process can be described as a unique set of co-ordinated activities, with a definite start and finish, performed by an individual or agency to meet specific objectives with defined schedule, cost and performance parameters. It is a dynamical process constantly influenced by various factors and treats. Risk threats can be kept under control by systematic practice of identifying and reducing the uncertainties in the process and the process's environment during whole process life cycle. The purpose is to make better decisions on a real process under conditions of uncertainty. It is a continuous and dynamic process which is necessary from process initiation until process conclusion, contrary to the belief that it is undertaken in the early stages of a process.

Furthermore, an uncertain event, in case of its occurrence, can either have a positive effect (opportunities) or negative effect (threats) on the automation process objective. The uncertainty inherent to any process determines the risks. Every risk is associated with (at least) a cause, a consequence (if it occurs), and the probability or likelihood of the occurrence of the event.

That is why optimization of risk is the means by which uncertainty can be systematically managed to increase the likelihood of meeting process objectives. The key word is *systematic,* because the more disciplined the approach, the more we are able to control and reduce the risks. This optimization of risk can be achieved using unambiguous obligations with risk divided between soldiers and executives.

This can be done on condition that the implementing agency takes all the responsibility for the automation and control of those who implement the automation process, which should be done according to a documentation prepared by designers and approved by the Steel Plant. It is a more positive situation when a building process is realized in accordance with *Design-Build* or *Turn-Key* basis. In these cases process stages, chain processes, responsibility for the work performed, and the management are clearly defined by obligations which are clearly documented and are exercised by a responsible implementing agency. Only *Turn-Key* projects describe obligations to the implementing agencies to accept all the process's risks. Alternative analysis and decision making before the work phase is most often met while performing the automation on *Design-Build* and *Turn-Key* basis.

During the period of the realization of these processes the alternatives should be analyzed, and rational as well as effective decisions upon building process should be made in accordance with requirements of the Steel Plant and design conditions. Automated and prepared-in-advance means for making these decisions should be preferably applied. One of the solutions to solve problem of uncertainty is the development of an automation execution plan. Its preparation is very much analogous to the development of a good facility design. The planner must weigh the costs and reliability of different options while at the same time insuring technical feasibility and making a decision. Automation planning is more difficult in some ways since the process is dynamic as the physical facilities change over time as Automation proceeds.

A survey of most of the literatures shows that they generate a specific attitude on the process management under risk and uncertainty [10]:

• The "life cycle" of costs and benefits from initial planning through operation and disposal of a facility are relevant to decision making. Automation costs represent only one portion of overall life cycle costs.

• In corporate sectors there can be several alternative processes competing for available resources. A choice or prioritisation of processes according organisation priorities and strategic goals has to be made.

• Optimizing performance at one stage of the process may not be beneficial overall if additional costs or delays occur elsewhere, the analysis of all scope of process is advisable.

• Fragmentation of process management among different specialists is necessary, but good communication and coordination among the participants is essential to accomplish the overall goals of the process.

• Productivity improvements are always of importance and value. As a result, introducing new materials and Automation processes is always desirable.

• Quality of work and performance are critically important to process's success (especially for managing body).

A constructively simple approach to estimating uses a decision support modelling paradigm based on process risk management and operational research concepts. It employs probability models selected from a set of alternative stochastic models of uncertainty with a view to maximizing the insight provided, given an appropriate level of complexity. Ranking of alternatives under uncertainty is fundamentally important in decision-making process, especially at the multiple criteria decision-making situations. To compare the Automation processes and to select the most economically effective process implementation alternative, it is advisable to use the multiple criteria decision support software. Decision making problems have always been significant for Steel Plant, at all levels of management, either strategic or functional. Therefore, much time and energy have been expended in investigating these problems all over the world.

Process management techniques are methods for reducing uncertainty and, therefore, improving the odds of success. Process management techniques reduce risk in three fundamental ways:

• Active planning and future simulation (when you can see the future, you improve your odds dramatically).

• Early problem recognition (structured tools for process management to recognize problem earlier).

• Improved communication (common cause of process failure is communication breakdowns).

IV. Conventional Implementation Strategies

Automation consulting and contracting organizations can fill the information lack ensuring coordination of works and information feedback in development, design and Automation stages. In order to determine theoretical values of the process's parameters during appraisal phase as precisely as possible and to reduce errors in the field of Automation, the use of Product Lifecycle Management (PLM) or the so-called four-dimensional (4D) concept [10] is recommended. The feedback from the participants is ensured by using a 4D concept for the management of Automation processes combined information flows inside enterprise.

The exact demand for process resources can be established due a thorough calculation of the process related quantities. In most cases this manual work is time consuming.

To reduce the time needed for this the calculation of the required quantities and to avoid mistakes and inaccuracies caused by manual calculation, the 4D concept model can be used. Main conclusion of the previous research [10] is – the time saved to complete calculation procedures using 4D concept, compared to calculation procedures made in ordinary way, can be used for managing a larger amount of Automation process proposals with a possibility to perform a more thorough analysis and a comparison of more alternative solutions for each Automation process [10].

Matching of HR component selection and the choice of HR component is met in every process of design. The selection of HR component parts can be performed by choosing several suitable composition alternatives from the available solutions from "tree" shape database. The generation of these variants is called synthesis of alternatives.

Manually gathered data can be collected by a general calculation pattern from conceptual HR deployment schemes. Work amounts can be obtained and estimated values for implementation can be calculated from the established specifications. All expenses can be brought to attention in the analysis of economic parameters of the implementation. Also, a work process timetable can be designed and the duration of development of each intermediary process can be established. Expenditures can then be determined for every intermediary process according to various parameters involved in it.

By an application of multi-criterion synthesis an opportunity to make a right decision can be given to decision maker. It is to be done when several different possibilities need to be evaluated. In general, it is not possible to determine a solution which would be the most rational in all aspects while dealing with this kind of tasks.

Thus, those multi-criterion methods which do not require the objectively best solutions (if they exist at all) have been selected. The main task of the multi-criteria synthesis is to link various tasks into a general process.

In the case of uncertainty and resulting risk the appropriate methods and rules are to be used to find optimal strategies.

Fig. 1. Illustration of PSO using swarm of bees searching for flowers [7]

Some works describe these main decision support stages: the formation of a matrix of alternatives, the selection of criteria, the selection of optimum criteria, the validation of criteria compatibility estimated by experts, decision matrix normalization, evaluation of alternatives rationality, multi-criteria evaluation and the final decision.

V. Soft Computing as a Strategy

Current software packages cannot handle the inherent subjectivity in effective risk assessment. Nevertheless decision-making process must be supported with developed software for multiple criteria evaluation of alternatives in Automation.

As discussed above, the efficient HR administration during the transition to automation of Steel Plant is a multi-objective optimization problem. Not only that, out of these multiple objectives, a few can be optimized in a traditional deterministic way. Therefore, the involved optimization boils down to choosing a stochastic method. One of the popular stochastic methods at present is the Particle Swarm Optimization known as PSO.

The PSO technique is a powerful and effective optimization method. PSO is similar in some ways to Genetic Algorithms (GA) and other evolutionary algorithms, but requires less computational bookkeeping and generally fewer lines of code, including the fact that the basic algorithm is very easy to understand and implement.

Consider an optimization problem that requires the optimization of a specific fitness function which depends on M variables. A collection or swarm of particles is defined, where each particle is assigned a random position in the M-dimensional problem space so that each particle position corresponds to a candidate solution to the optimization problem. Each of these particle positions is scored to obtain a scalar cost based on how well it solves the problem. These particles then fly through the *M*-dimensional problem space subject to both deterministic and stochastic update rules to new positions, which are subsequently scored.

As the particles traverse the problem hyperspace, each particle remembers its own personal best position that it has ever found, called its local best and each particle also knows the best position found by any particle in the swarm, called the global best. On successive iterations, particles are "tugged" toward these prior best solutions.

Overshoot and undershoot combined with stochastic adjustment explore regions throughout the problem hyperspace, eventually settling down near a good solution.

This process can be visualized as a swarm of

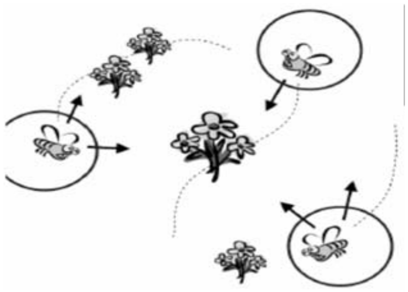

Fig. 1. Illustration of PSO using swarm of bees searching for flowers [7]

bees in a field [7]. Their goal is to find the location with the highest density of flowers. Without any knowledge of the field *a priori*, the bees begin in random locations with random velocities looking for flowers. Each bee can remember the locations where it found the most flowers, and somehow knows the locations where the other bees found an abundance of flowers. Torn between returning to the location where it had personally found the most flowers, or exploring the location reported by others to have the most flowers, the ambivalent bee accelerates in both directions altering its trajectory to fly somewhere between the two points. Along the way, a bee might find a place with a higher concentration of flowers than it had found previously. It would then be drawn to this new location as well as the location of the most flowers found by the whole swarm. Occasionally, one bee may fly over a place with more flowers than had been encountered by any bee in the swarm. The whole swarm would then be drawn toward that location in additional to their own personal discovery. In this way, the bees explore the field.

Constantly, they are checking the territory they fly over against previously encountered locations of highest concentration hoping to find the absolute highest concentration of flowers. Eventually, the bees' flight leads them to the one place in the field with the highest concentration of flowers. Soon, all the bees swarm around this point.

Unable to find any points of higher flower concentration, they are continually drawn back to the highest flower concentration (Fig 1).

The following steps are accomplished on each particle individually (see Fig. 2):

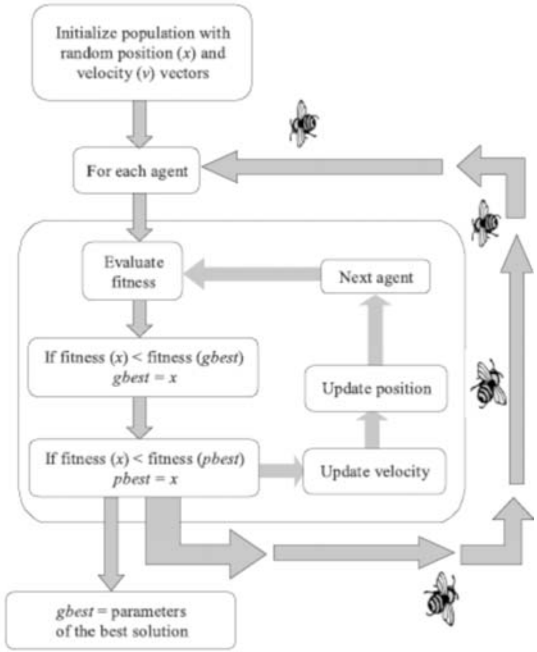

Fig. 2: PSO algorithm flow-chart

1. Initialize a population of particles with random positions and velocities in *M* dimensions in the problem space.

2. For each particle, evaluate the desired optimization fitness function in *M* variables.

3. Update the particle velocity. The velocity of the particle is changed according to the relative locations of *pbest* and *qbest* . It is accelerated in the directions of these locations of greatest fitness according to the following equation [7]:

$$vn = w*vn+c1\text{rand}()*(gbest,n - xn) + c2\,\text{rand}()*(pbest,n - xn) \quad (1)$$

Here, vn is the velocity of the particle in the n-th dimension and xn is the particle coordinate in the n-th dimension, $c1$ and $c2$ are scaling factors that determine the relative "pull" of *p*best and *q*best (previous work has shown that a value of 2.0 is a good choice for both parameters [7]), and rand() is a random number uniformly distributed in interval (0,1). The parameter w is a number, called the "inertial weight", in the range [0,1], which specifies the weight by which the particle's current velocity depends on its previous velocity and how far the particle is from its personal best and global best positions. Numerical experiments have shown that the PSO algorithm converges faster if *w* is linearly damped with iterations starting at 0.9 and decreasing linearly to 0.4 at the last iteration.

4. Move the particle. Once the velocity has been determined, it is simple to move the particle to its next location. The new coordinate is computed for each of the dimensions according the following equation $xn = xn + vn$

5. Loop to step (2) until a criterion is met, usually a sufficiently good fitness or a maximum number of iterations.

For optimization of the HR, first it will be necessary to identify the parameters to be optimized. Then depending on their importance in the optimization, they shall be assigned a weighting value. This shall be followed by forming a cost function obtained by summing the weighted parameters. The next step is forming the particles. For this, one has to determine the components that are affecting the parameters. For each parameter being optimized, these components are to be identified individually. Then a vector of these parameters is to be formed as a particle. Different values of parameters shall give different particle. The optimization shall start with few such randomly generated particles and the process shall end after the objective has been met.

VI. Conclusion

In this paper we have discussed HR issues that can affect the transition to automation in a Steel Plant. In particular, we have considered the effects of uncertainties on various factors and disused at length how they give rise to risks and some traditional methods of analysing and minimizing the risks due to such uncertainties. Finally, we have proposed the use of PSO, a soft-computing method for use in optimization of HR components to regulate uncertainties.

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