BUSINESS SUSTAINABILITY I

Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environments

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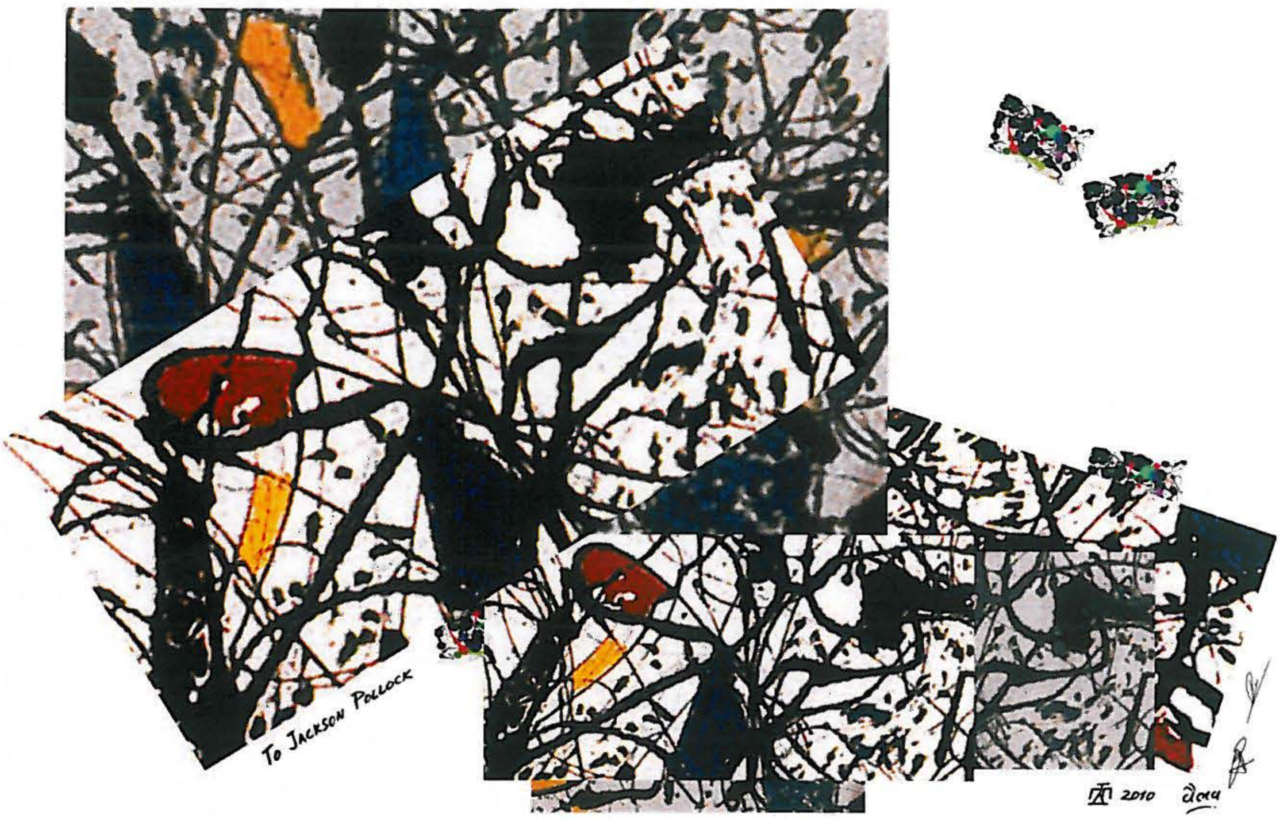

Chaos and Sustainability – the 2nd Order

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A DECENTRALIZED PREDICTIVE MAINTENANCE SYSTEM BASED ON DATA MINING CONCEPTS

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INTRODUCTION

In the last years we have assisted to several and deep changes in industrial manufacturing. Induced by the need of increasing efficiency, bigger flexibility, better quality and lower costs, it became more complex [1]. Enterprises had had the need to cope with market expectations, incorporating in their production philosophies new paradigms such as JIT- Just in time, MTO-Make to order, Mass Customization, agile manufacturing or Lean Manufacturing, that allow them to satisfy markets with a big diversity of products and also big quantities, becoming therefore more competitive. All this complexity has caused big pressure under enterprises maintenance systems. Maintenance mission is to make equipment and facilities available when requested. Maintenance function, seen as a non value aggregator one, became more and more requested to contribute to cost reduction, based on bigger and consistent equipment reliability. This perspective is stressed when enterprises existing equipment has an advanced service life. It is expected a profusion of breakdowns at those scenarios and consequently a smaller usability of equipment driving to less productivity.

From an economic perspective, maintenance function is seen to the enterprise as a cost [2]. In fact, experience shows that a major percentage of the overall costs of the business concerns with maintenance [3]. Considering this perspective, decreasing costs with equipment operationalization will increase maintenance productivity and consequently overall productivity [4].

BACKGROUND

Maintenance

Usually, manufacturing systems recognize high level costs due equipment breakdown. This type of events is directly connected with inspection costs, repair costs as well as costs associated with non production time or equipment non utilization. Thus, the quality of the maintenance that is performed affects directly the performance level of a specific business or activity. This global world where we live it is fertile in the existence of high expectations. The appearance of expensive normative constrains, dynamic changes in technological paradigms and, apparently, in strategic or functional reorganizations, will have deeply impact in maintenance teams and their activities.

Technologies used by maintenance function are in an open path of discovery of applications that will stop performance deterioration. Maintenance teams must decide which techniques are more suitable to each situation having in mind that a wise choice must increase the system efficiency as well as reducing global costs. An erroneous choice could be the source of new problems while the existent ones could became worse than they were before.

Breakdowns, usually, have more impact or visibility, because they may affect negatively the outputs of the system, security, environmental health, quality, client service, competiveness or unit costs. The severity or frequency that a breakdown deals with described consequences will dictate which breakdown management technique should be used. Maintenance policy must be effective in the utilization of resources (people, materials, reposition parts, tools, etc.). Maintenance costs are dependent not only of the maintenance team but also of equipment operators and/or designer.

An effective maintenance passes through i) integration of maintenance and process engineering functions at the phase of selection and application of machines and equipment; which must be extended to ii) pro-active actions on those machines and equipments that will necessarily passes by preventive and predictive maintenance and also by changes at the project [4]. Literature points out three generic types of maintenance [5]; [6]

1. Corrective maintenance, which consists in repair actions when some equipment or machine is broken-down. The equipment is in action until the moment that it fails. At that moment it will be repaired or changed. The main disadvantages of this approach included fluctuant and unpredictable production, high levels of non-conform products and scrap yard as well as high levels of maintenance due interventions motivated by catastrophic fails [7]

2. Preventive maintenance, characterized for periodic maintenance operations in order to avoid equipment fails or machinery breakdowns, bases its functionality in manufactures manuals and some heuristics [8].

3. Predictive maintenance uses some indicator values to "feel" when some breakdown is eminent. This type of maintenance intends to make interventions on machinery before malicious events may occur [9].

Data Mining

Nowadays the databases are associated with all the activity areas, resulting in an accumulation of large amounts of data. However, the existence of large quantities of data by itself does not imply the possession of knowledge; this existence is just the first step in obtaining information and knowledge. After data processing the results lead to knowledge that can be used in monitoring, analysis and process prediction [10]. The path which starts with the existence of data to obtain knowledge passes through intermediate steps such as obtaining information or facts, or by the establishment of rules or values.

Data mining is defined to be the exploration and analysis, by automatic or semiautomatic means, of large quantities of data stored either in databases, data warehouses, or other information repositories to discover interesting knowledge including meaningful patterns and rules [11]. In general, the Data Mining term is the process of analyzing data from different perspectives, categorizing them and summarizing identified relations in order to return useful and usable information. Technically it can be seen as the process to find or identify correlations or patterns among dozens of camps in large relational databases [12], which can also be data warehouses or other information repositories [13].The most used techniques in Data Mining are:

1. Artificial Neural Networks: Consisting in a non linear predictive model that learns through training; their structure is similar to a biological neural network;

2. Decision trees: Structures in the shape of a tree representing sets of decisions. These decisions create rules for classification of data sets. The specific methods of the decision trees include Classification Trees and Regression (CART Classification and Regression Trees) and Chi Square Interactive and Automatic Detection (CHAID Automatic Interaction Detection Chi Square);

3. Genetic algorithms: Optimization technique that uses processes such as genetic combination, mutation and natural selection, based on the evolution concept;

4. Neighbourhood closer Method: Technique based on the classification of each record of all data on a class combination of k records that resembles more a history of a data deposit. It is sometimes called technique of k closest neighbours;

5. Induction Rule: extracts if-then rules from data based on statistical significance.

SYSTEM FUNCTIONALITY

In literature there are some approaches that use data mining concepts to improve manufacturing activities (14). It isn't so common to find approaches that use it to improve the capacity of predicting behaviours based on historical data. In fact, if the case is the possibility of a distributed collaboration of independent enterprises sharing data between them, even if they are competitors, the examples are even reduced.

We have found some examples which work on historical failure data and provide suggestions for an appropriate preventive maintenance schedule [14]. At the same work exist other references to the utilization of data mining techniques, including decision trees, rough sets, regression, and neural networks to predict component failure based on the data collected from the sensors of an aircraft. Other references to neural networks utilization for prediction effects in maintenance scope are present at [15], or references of equipment maintenance using optimized support vector machine existent at [16]

Data bases utilization with statistics is a tool well established in engineering scope. Maintenance activity, as well as other issues, have been influenced and evolved based on information and communication (ICT) developments. Technology evolution has lead to an increasing number of data flowing from all the processes of the organization such as product and process design, material planning and control, assembly, scheduling, maintenance, recycling, etc [14]. On their activity of reactive, preventive and predictive maintenance enterprises produce huge amounts of information that are stored to build historic profiles that can be helpful in future interventions. Data storage is usually made in a local perspective either in electronic or paper support. Nevertheless, it is known that the integration of those tools not always is effectively achieved.

Usually, enterprises do not share data produced from their maintenance interventions. This investigation intends to create an organizational architecture that makes the integration of data produced in factories on their activities of reactive, predictive and preventive maintenance. The main idea is to develop a decentralized predictive maintenance system based on data mining concepts similar to those that support virtual enterprises functionality.

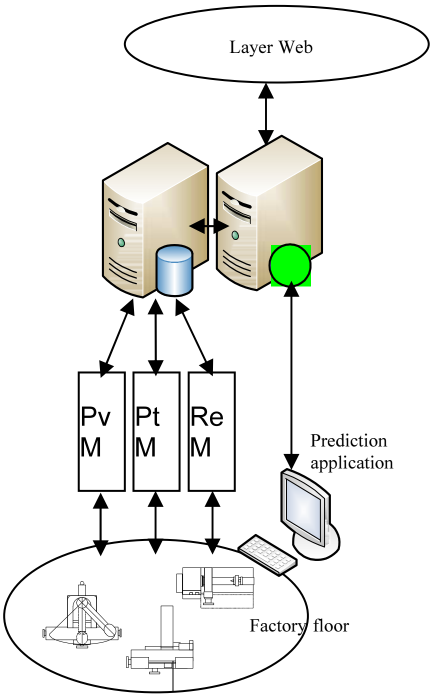

Fig. 1. al activity of maintenance

Data will flow from a local perspective to a higher layer that will integrate local data (see figure 1). Over that layer, data mining tools will operate to achieve and use implicit and hidden knowledge to generate predictive behaviour patterns. The possibility of an inevitable and eminent equipment failure will be reported to local layers through a prediction system unit existent in each node of the network. Data concerning the maintenance process used material, consequences of a non intervention and scenarios generation will be available in a decision support system base.

The main significant difference proposed by this system concerns to the possibility of using maintenance data originated from similar machines working in different factories dispersed through the globe. This particularity will allow the existence of higher amount of data and also data that reflects different natures and utilization of similar machines in different environments (see figure 2).

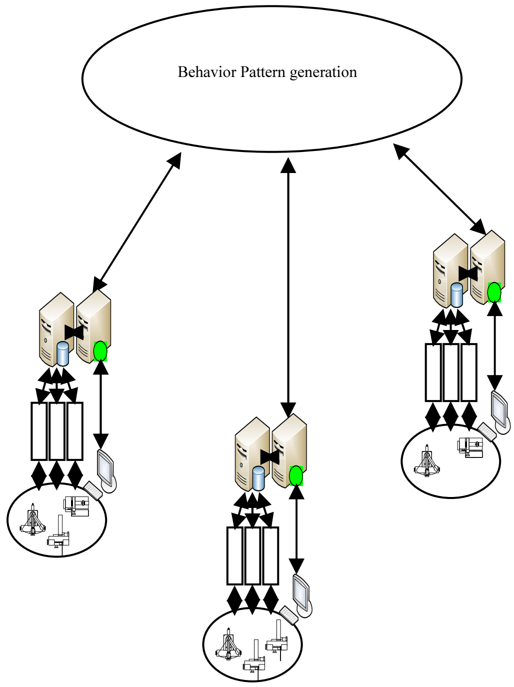

Fig. 2. Interaction of individual units

In a local perspective, data on the factory floor will be collected through maintenance operators using a formalized internal registry. Data will pass from a local layer to the prediction layer using a XML application. This application, designated by extractor, will be responsible for the integration in a common database (DB) data from external DB. The extractor will be a generic one, must be able of working with any DB schema or document type. Consequently, its development will force the existence of an appropriated specification language that allows describing the sources structure, the structure of the central DB and the transference schema.

Next the overall functionality will be explained deeply recurring to IDEF0 method. IDEF0 method is used to specify function models, representing high-level activities of a process and its decomposition in lower hierarchical sub activities or processes. IDEF0 models portrait a view of the process in terms of Inputs, Controls over the process, Outputs, and Mechanisms acting on the process, named ICOM's. IDEF0 Function Modeling is designed to model decisions, actions, and activities of an organization or system. IDEF0 model notation uses functions and activities abstracted from temporal sequence. The diagrams in this notation show activation (of functions, processes), not flow. More information may be found at [17].

activity will try to infer knowledge from formatted data. It is expected that data mining activity will perceive relations that allow a better understand of machinery behaviour and lead expert systems to predict events that may damage equipment or at least to perform a behaviour pattern to a better understand of equipment functionality.

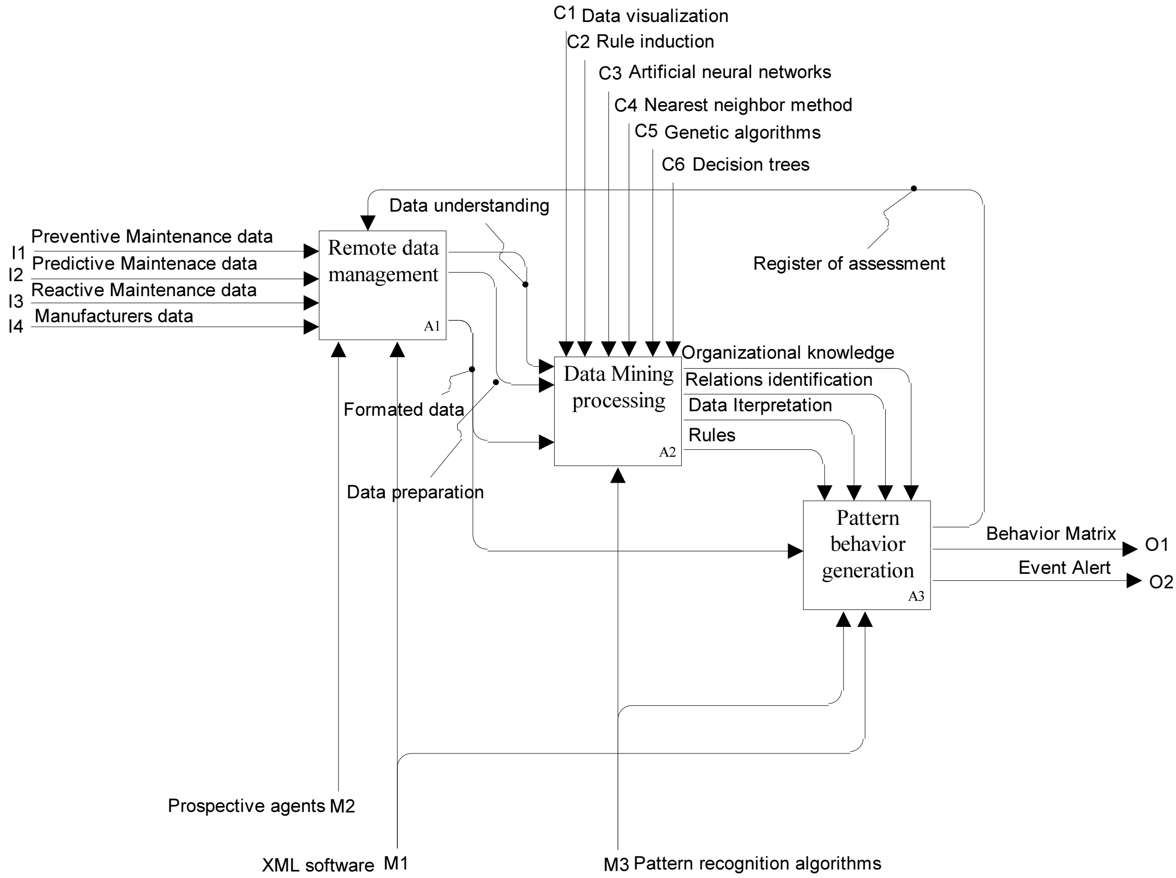

Fig. 3. Overall functionality using IDEF0 Format

When data concerning maintenance arrives from different sites will be treated at “Remote data management”, A1 activity. This activity uses as mechanism prospective agents that are responsible for gathering data from remote systems and XML applications to make transparent data collected in the private databases of each participant and usable by data mining algorithms. Remote data management will be responsible for producing data understanding, formatted data and data preparation. Those three types of data will be used by “Data Mining processing” activity as inputs. This A2 activity will be controlled by five control arrows: Data visualization, rule induction, artificial neural networks, nearest neighbor method, genetic algorithms and decision trees. Data mining activity will be responsible for producing organizational knowledge, relations identification, data interpretation and definition of rules. In fact those are some of the five steps of data mining knowledge discovery process. This

The referred outputs will be control inputs for pattern behaviour generation. This A3 activity will send to local partner’s information concerning the eminence of events that may damage machines and thus allowing maintenance teams to act before breakdowns happen. With this system it is expected a higher accuracy in predicting the occurrence of equipment breakdowns. We believe that more amounts of data produced on diverse environments, combined with machine manufactures information and also with registries of assessments will increase levels of reliability based on machinery maintenance activity.

CONCLUSIONS

Equipment maintenance prediction is an important and widely studied topic since it has a significant impact on equipment maintenance prediction and reliability. The existent huge amount of data from maintenance actions are not fully used for increase the efficiency of maintenance prediction. Data mining seems to be the step forward that will change the actual state.

The proposed system will help enterprises to collect, extract and create knowledge in a way that enterprises will predict with more accuracy the moment to realize maintenance actions and thus improve the productivity of manufacturing process. The innovative point of this system is the capability of collecting and treats data dispersed in different facilities that result from maintenance interventions in different environments. The contribution of machinery manufacturers it is also an important contribution.

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BUSINESS SUSTAINABILITY I

Management, Technology and Learning
for Individuals, Organisations and Society in Turbulent Environments

FOREWORD

This book presents the collection of fifty two papers which were presented on the First International Conference on BUSINESS SUSTAINABILITY '08 - Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environments, held in Ofir, Portugal, from 25th to 27th of June, 2008. The main motive of the meeting was the growing awareness of the importance of the sustainability issue. This importance had emerged from the growing uncertainty of the market behaviour that leads to the characterization of the market, i.e. environment, as turbulent. Actually, the characterization of the environment as uncertain and turbulent reflects the fact that the traditional technocratic and/or socio-technical approaches cannot effectively and efficiently lead with the present situation. In other words, the rise of the sustainability issue means the quest for new instruments to deal with uncertainty and/or turbulence.

The sustainability issue has a complex nature and solutions are sought in a wide range of domains and instruments to achieve and manage it. The domains range from environmental sustainability (referring to natural environment) through organisational and business sustainability towards social sustainability. Concerning the instruments for sustainability, they range from traditional engineering and management methodologies towards "soft" instruments such as knowledge, learning, creativity. The papers in this book address virtually whole sustainability problems space in a greater or lesser extent. However, although the uncertainty and/or turbulence, or in other words the dynamic properties, come from coupling of management, technology, learning, individuals, organisations and society, meaning that everything is at the same time effect and cause, we wanted to put the emphasis on business with the intention to address primarily the companies and their businesses.

From this reason, the main title of the book is "Business Sustainability" but with the approach of coupling Management, Technology and Learning for individuals, organisations and society in Turbulent Environments.

Concerning the First International Conference on BUSINESS SUSTAINABILITY, its particularity was that it had served primarily as a learning environment in which the papers published in this book were the ground for further individual and collective growth in understanding and perception of sustainability and capacity for building new instruments for business sustainability. In that respect, the methodology of the conference work was basically dialogical, meaning promoting dialog on the

papers, but also including formal paper presentations. In this way, the conference presented a rich space for satisfying different authors' and participants' needs. Additionally, promoting the widest space for satisfying different authors' and participants' needs. Additionally, promoting the widest and global learning environment and participativeness, the Conference Organisation provided the broadcasting over Internet of the Conference sessions, dialogical and formal presentations, for all authors' and participants' institutions, as an innovative Conference feature. In these terms, this book could also be understood as a complementary instrument to the Conference authors' and participants', but also to the wider readerships' interested in the sustainability issues.

The book brought together 97 authors from 10 countries, namely from Australia, Finland, France, Germany, Ireland, Portugal, Russia, Serbia, Sweden and United Kingdom. The authors "ranged" from senior and renowned scientists to young researchers providing a rich and learning environment.

At the end, the editors hope and would like that this book will be useful, meeting the expectation of the authors and wider readership and serving for enhancing the individual and collective learning, and to incentive further scientific development and creation of new papers.

Also, the editors would use this opportunity to announce the intention to continue with new editions of the conference and subsequent editions of accompanying books on the subject of BUSINESS SUSTAINABILITY, the second of which is planned for year 2011

Guimarães, 01-May-2010

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