A Review on Role of Case Based Reasoning in Industrial Application Development

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Abstract

The aim of this paper is to provide the outlined conceptual structure of the Case-Based Reasoning (CBR) with its involvement in various industrial arenas. CBR though, being a recent automated reasoning technique, gaining popularity with its successful implementation in the real world problem solutions. This paper focuses on the basic concept of Case Based Reasoning with its general framework and a brief overview of the existing CBR based application systems is presented along with its advancements and its role in different industrial applications. The last application discussed here, describes a development methodology for implementing CBR systems in material engineering with a specific implementation in Plasma Ion Nitriding System for surface hardening of steel. The paper concludes with a research scheme for Case Based Reasoning.

Introduction

Over last few years, a progressive approach and research efforts have shown promising results of different soft computing techniques in various engineering and manufacturing industrial arenas. Among them Case Based Reasoning being an automated and Knowledge-Based reasoning technique has been proved to be competent of providing good optimal solutions for the problem of predicting values through the already existing set of data and experimented specifics.

Here, section two presents the basic concept and steps of Case Based Reasoning. Section three recapitulates influential CBR applications currently in usage and proposed in industries with the introduction of a new system to be used for manufacturing industries concerned with material engineering.

CBR Concept

In Case Based Reasoning (CBR), new problems are solved through the set of solutions obtained from the old problems. A basic cycle is traced to follow the CBR mechanism, involving 4 steps, also known as 4 REs:

- Retrieve the most similar case or cases
- Reuse the case/cases to solve the problem
- Revise or adapt the proposed solution if needed
- Retain the new solution as a new case

Here, a new problem is matched against cases in the case base and one or more cases that are similar to the problem case are retrieved. A solution obtained by the matched cases is then reused and tested in real life. The solution is revised until a best fit solution is not obtained. The resultant solution is to be kept or retained as a new case in the case set.

The Case Based Reasoning cycle till now, rarely occurs without human involvement. In most cases, Case Based Reasoning tools act principally as a case retrieval and reuse system. Case adaptation and revision is looked by the administrator. But this could not be said as the drawback of the CBR, instead the role and involvement of human being could be seen as the decision support.

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An Overview of Few CBR Industrial Applications

This sub-section describes few existing commercial industrial applications in brief and introduces SPIN system, a new mechanism for the steel hardening unit, i.e. for the Plasma Ion Nitriding System.

Clavier

The first commercial CBR application was the CLAVIER, developed at Lockheed, which is an aerospace company of US. Modern aircraft contain a variety of elements that are made up from composite materials. These materials require curing in large autoclaves. Lockheed, produces many such parts. Here, every part has its own heating characteristics and must be cured correctly. If curing is not correct the part will have to be discarded. Regrettably, the autoclave's heating characteristics were not fully understood i.e., there was no standard or model that operators can follow. This was difficult, as many parts are to be fired together in a single large autoclave and the parts after interaction with each other, alter the heating and cooling characteristics of the autoclave. To solve this problem of finding heating parameters, operators of Lockheed's autoclaves started relying upon designs and drawings of previous winning parts layouts to inform how to layout the autoclave. However, this was complicated by the fact that layouts were never identical because parts were required at different times and the design of the component materials was constantly changing. Consequently operators had to select a successful layout they thought closely matched and adapt it to the current situation. This closely resembled the CBR pattern and became the basis of the CLAVIER system. CLAVIER finds solution through a set of previous autoclave layouts, where every layout is defined in terms of parts and their relative positions on a table, tables with their relative positions in the autoclave and production statistics like start and finish times, temperature and pressure. CLAVIER finds substitutes for parts in a layout that do not match, and it suggests new layouts to the operators of the system. Currently, this system consists of around 150 successful layouts and its performance has improved by 90%, i.e. solutions are sure to be obtained with an excellent rate of success.

ERCP

Groupe Legrand is a top industry for the production of low - voltage electrical equipments. A major part of these equipments are of plastic. The research center of the company developed the ERCP i.e. a system meant for the Rapid cost Estimation for Plastic Parts Production. This system helps the technician to find the cost of tooling investments and the wholesale price of the final finished product. The data is collected as the case bases for the prediction which involves the detailed features of around 600 tools configuration. Each case comprises over 40 pieces of data which included the photos and computer aided designed drafts of the tools. This domain set was developed with the help of pricing and production experts. This system facilitates the communication and the real and expert knowledge transfer between the pricing and the production sectors. This system helps pricing experts to estimate the cost of a part in three days instead of three weeks thus the total cost of work required by the experts is reduced by 30% time. This application is an effective mechanism for the cost estimation of other materials in the manufacturing industry.

FREYA

Odense Steel Shipyard Ltd. is one of the top industries in design & building of big commercial ships in Denmark. This industry has a record performance in production by the use of giant robots for welding purpose with the fourteen meters per hour rate of speed of welding. Thus the reduction in the down-time of the robots was very critical for the industry. Finally a fault diagnosis system i.e. a robot station was developed for multi-robot gantry system. In this station, twelve robot gantries were placed seventeen meters above the shop floor. These robots were programmed offline with the station schedule governed by a shop floor control system. Here the robots were supervised by 4 operators and 1 maintenance technician. The system FREYA was developed with the help of maintenance specialists, operators, experts from parallel application center and the editor of the multimedia authoring tool. With FREYA, the shop floor control system operator gets the awareness about the malfunctioning of any robot. In FREYA around five hundred cases were created stating the possible faults, breakdown or malfunctioning for the purpose of diagnosis. These cases involve the collection of relevant documents, CAD designs, pictures, electronic drawings and video clips. The general framework of the Freya is a good and optimal implementation for similar robot stations and for giant machines like cutting machines and cranes too.

SPIN

Plasma Nitriding System is an industrial surface hardening system for metals. The basis of this system is the Plasma Nitriding process, also known as Ion Nitriding or Plasma Ion Nitriding (PIN) System. In Plasma Ion Nitriding process, nitrogen is introduced onto the surface of steel while maintaining a specific temperature range of around 5000 to 5700C° in the heating system of the PIN unit. In vacuum, high-voltage electrical energy is supplied in this heating system to form plasma, which results the acceleration of the nitrogen ions to infringe on the steel material, thus help in attaining the required hardness of the material. Here, few process parameters are required to be identified before the hardening process, which is not easy to find, especially in case of new type of steel material, Thus our proposed Soft PIN i.e. SPIN system which is under development is expected to meet out this problem. This model is based on the case base reasoning mechanism where the already existing set of information are acting as cases and helping in finding the process parameter values for the new cases. The complete model is to be discussed in the consequent papers.

Conclusion

The review of the CBR Applications shows that all the works on the implementation of Soft Computing to materials engineering have reported excellent, good, positive or at least encouraging results. The lack of negative results might be due to the simplification of materials engineering problems to manageable and predictable situations. Till today application of other soft computing techniques has been applied and successful model formulation and their implementation has been notified in a variety of Material engineering procedures, but the Case Based Reasoning has also now gripped its position in the field of commercial industrial applications. All the evidences and results also indicates that there is a range of promising future directions for the solution of other similar kind of industrial and commercial problems.

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