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State of The Art-Intense Review on Artificial Intelligence Systems Application in Process Planning and Manufacturing

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ABSTRACT

Artificial Intelligence (AI) systems applications are widespread due to its domain independent characteristics. In this work, an attempt has been made for review on AI applications in Computer Aided Process Planning (CAPP) and manufacturing. Primarily, uniqueness of present review work addressed by analysis of existing review articles. The review work comprise of three main elements; 1. Feature based design, a primary input for a CAPP system, 2. Expert System (ES) usefulness in Process Planning (PP) and manufacturing and 3. Evolutionary approach applications. The review begins with an overview and the use of AI systems in decision making. Research works exemplified for the past three and half decades (1981–2016) are analyzed in terms of feature based modeling, Standards for Exchange of Product Model data approach, ES in PP, scheduling, manufacturing and miscellaneous applications. Role of Evolutionary Techniques (ET) in intelligent system development, execution of PP activities and manufacturing are described. A statistical analysis on existing review articles, number of publications, domain specific articles and percentage contribution of each area are carried out. Finally, research gaps are identified and the possible future research directions are presented.

1. Introduction

Artificial Intelligence (AI) deals with computer program that possess own decision making capability to solve a problem of interest. AI concerned with creation of computational system that imitates the intelligent behavior of expertise. John McCarthy invented AI in 1956, explored a machine that could reason, problem solving and selfimprovement like human being. It possesses the key characteristics such as adaptive control, better handling and reusability of stored knowledge. According to the sophistication, AI system can perform action such as perception, interpretation, reasoning, learning, communication and decision making similar to human being to arrive solution for the given problem. From the inception, various development have been done on AI system, which broaden its application such as pattern recognition, automation, computer vision, virtual reality, diagnosis, image processing, nonlinear control, robotics, automated reasoning, data mining, process planning, intelligent agent and control, manufacturing, etc.

Process Planning (PP) using computer automates the procedure of preparing a sequence of operations involved in manufacturing a product. Computer Aided Process Planning (CAPP) plays vital role in integrating Computer Aided Design (CAD) and Computer aided Manufacturing (CAM), Steudel and Harold (1984). Scope of CAPP in a manufacturing cycle is shown in Fig. 1. Traditional approaches involve the use of experts in solving PP related problem. The domain experts use their knowledge and skill in order to determine the processing steps required for manufacturing using design specification and available resources. Problems associated with conventional PP include; expert's dependency, time consuming and inconsistent in nature. To overcome the bottleneck with traditional approach, Niebel extrapolated the use of computers in decision making for PP in 1965. Over the period, various research works exemplified related to PP system development, Alting and Zhang (1989). CAPP generally divided into variant and generative approaches. Variant technique based on part similarity with in a part family using Group Technology (GT) perception, it follows the mechanism that equivalent part necessitate related plan.

It requires expert to categorize a part, feature information input, recover comparable plan and makes essential alteration. In intelligent or generative type, process plan developed in accordance with geometry information, decision logic and algorithms. It synthesize process plan for a new product, based on part shape, material and other variables that affect the manufacturing decision. Geometry description is the prime input to the system. It provides quick advice to the designers and closely joined with the product-modeling activities. AI techniques include Knowledge Based System (KBS) and Evolutionary Approaches (EA) are the foremost development in Intelligent Process Planning (IPP).

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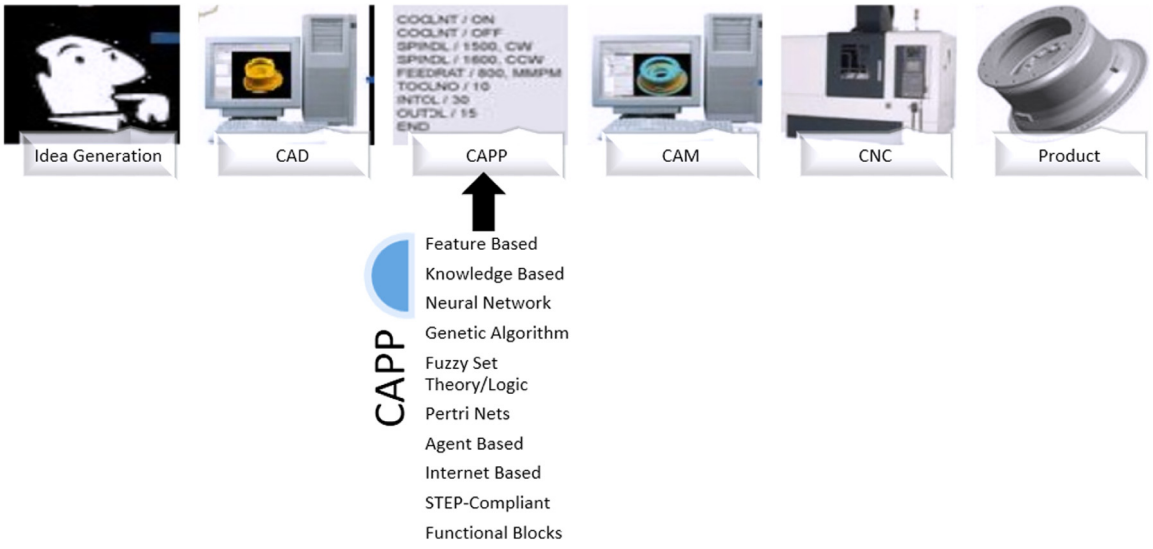

Fig. 1. CAPP applications in manufacturing Cycle, (Yusof and Latif, 2014).

In this work, an attempt has been made to perform state of the art intense review on AI techniques applications in CAPP and manufacturing. Since AI applications are wide spread, ES and EA are considered in this paper. The review objective is to provide intense knowledge to the researcher from the origin to latest trend of research work exemplified in the field of process planning and manufacturing. Research work carried out for the past three and half decades (1981–2016) considered. Major part of the work devoted to CAPP and certain manufacturing application also presented.

2. Previous review work

Knowledge Based System (KBS) or Expert system (ES) utilizes human knowledge to provide solutions to manufacturing problems that require human intelligence. ES fashioned to bear the information available with experts and provide the knowledge to solve manufacturing problems, (Tripathi, 2011). Since the inception of CAPP, various review works were exemplified related to CAPP system and review on ES in decision making for manufacturing planning and for a range of domain applications are shown in Table 1. Weill et al. (1982) performed a review in order to provide knowledge on CAPP system. Review process classified into two components such as description of areas of computer utilization with typical examples and review on existing CAPP system and their characteristics. Austin (1984) performed an intense review on various research themes in AI planning, characteristics and addressed their research development. Steudel and Harold (1984) discussed the use of computers in planning for the production of discrete product. Growth of CAPP in terms of past, present research trend and future developments are discussed in detail. Major focus on generative type CAPP system. Finally, future research direction is presented. Nau and Chang (1985) incorporated ES approach for generative PP. Eversheim and Schulz (1985) carried out a survey on CAPP system, addressed the current state of art and presented possible future research direction.

Van't Erve and Kals (1986) developed generative CAPP system "XPLANE", to perform CAD and linking, jigs and fixtures selection, Numerical Control (NC) program creation, tool supervision and capacity development. It automatically generates machining operation, tools and their sequence selection. Gupta and Ghosh (1989) carried out a review on ES applications related to PP and manufacturing. The key focus on problem definition, implementation scheme and special features and enduring efforts for design and development of ES for manufacturing viz. PP and possible future research directions are presented.

CAPP performs vital role in developing Computer Integrated Manufacturing (CIM) system. Alting and Zhang (1989) carried out an intense survey and forecasted future trends of CAPP. Various techniques include GT, AI techniques and programming languages are taken into the consideration for the implementation of CAPP system. A total of 14 renowned CAPP systems based on variant and generative approaches are discussed. Possible future research trends include interfacing, integration, data base system, workstation and software relocation strategy are presented. Gupta (1990) performed review on ES for Automated Process Planning (APP). Need for ES technique, important features and limitations were addressed in relevance with part design input, representation of knowledge base, control policy and suggestions were made for possible future direction. Shah et al. (1991) performed intense survey on various methods for APP and NC programming. Different aspects of CAPP include part definition, reasoning and search techniques, traditional and Al-based methods and various PP languages were presented. NC programming techniques are categorized into cell decomposition, volume decomposition, sectioning and geometric reasoning. Simulation and verification of NC program was carried out and their characteristics also presented.

CAPP has received a strong research attention from practitioners and researchers. One of the key benefits include reduced throughput time and improved quality. Marri et al. (1998) carried out a review with the focus on insight into design and realization of CAPP system. The review between 1989–1996 related to different PP systems are discussed and future research direction in different aspects of PP are presented. Tu et al. (2000) proposed a CAPP frame work for virtual production corporation. The problems involved in customized products, product development, network, part and production data, capturing of opportunities and response to customer's demands, customer influence, partners selection and synthesis are addressed. Ahmad et al. (2001) performed a summary of current development of research work on CAPP. It includes design by solid modeling, Object Oriented Programming (OOP), database, ES and AI. Recent research areas include Feature extraction; AI techniques like Genetic Algorithm (GA), Artificial Neural Networks (ANNs) and Fuzzy Logic (FL) are discussed.

Liao (2003) performed analysis on Knowledge Management (KM) technologies and its applications. KM classified into categories include KM framework, KBSs, data mining, information technology, AI/ESs, database and modeling together for across domains. Future research directions are presented in terms of development towards expert orientation, suggestion for different social studies methodologies to implement KM technology and their integration. Duflou et al. (2005) performed review on research connected with PP for sheet metal bending operation, its proposed methodology is shown in Fig. 2. APP