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# Adoption of Artificial Intelligence in Operations Management: A Design-Oriented Review

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Abstract: This is a review conducted in relation to the application of artificial intelligence in operations management particularly in the design aspects between the years 2010 - 2021. The purpose of this paper is to provide a survey of the usage of artificial intelligence methods in operations management aimed at presenting the themes, trends, direction of research and its practical impacts. Artificial Intelligence is playing a major role in the fourth industrial revolution, and a lot of evolution in various operations management and engineering scope. Artificial Intelligence techniques are widely used by operations managers to solve a whole range of intractable problems. This study provides a forum for rapid evaluation of the works describing the theoretical and practical application of artificial intelligence methods in operations management. The study reports some novel aspects of artificial intelligence used for real-world operations/engineering applications towards solving problems, increased productivity, reducing costs and improved customer satisfaction.

Keywords. Artificial Intelligence, Operations Management, Review, Survey

## 1. Introduction and Methodology

Organisations are becoming more competitive due to new regulations, global challenges, and focus on net zero energy. The adoption of Artificial Intelligence (AI) has helped organizations to deal with these challenges by providing solutions to uncertainties and achieving optimized results through reduced costs, speed, agility, efficiency, and flexibility. There have been an increased number of studies and publications for the adoption of AI in operations management. That is indicated by the annual increase in relevant publications in the recent decade. With over one hundred and twenty thousand (120,000) articles published between years 2010-2021 and over seventeen thousand (17,000) in operations management, that has associated complexity of understanding what else needs to be addressed. Other known issues linked with the use of repetitive publications, lack of substantial useful information hence not making significant contribution to knowledge are noted and avoided in this study.

The design and methodology adopted is like authors of previous surveys. To seek for literal replication of the review process and to build on the wealth of knowledge of authors, their

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experience(s) and expertise; the same areas of operations management on previous surveys (Kobbacy et al., 2011) was used which includes process planning and control, quality, maintenance and fault diagnosis and areas of design and scheduling. The areas from the previous survey have been maintained to represent the categories that will be researched.

- Case-based reasoning (CBR).
- Genetic algorithms (GAs).
- Neural Networks (NN).
- Knowledge-based Systems (KBS).
- ➢ Fuzzy logic (FL); and
- Data Mining (DM).

Due to core links with AI and page limitations; FL, GA, KBS and NN in the design aspects of AI only are presented in this paper. The Science Direct database was used to search for references using only the keywords that have been categorised in this paper. Review articles and research articles were identified while unrelated papers were removed. Further filtering was conducted to eliminate other forms of irrelevant papers to avoid double counting the same paper, however in most cases the title, abstract and conclusion sections were clear indicators to categorize the papers. This paper is arranged in four parts namely, introduction and methodology, survey and categories giving insights into the papers published in each section, the results presenting the quantitative data in this paper, and the conclusion.

## 2. Survey and Categories

### 2.1 Design

## 2.1.1 FL in Design

FL is employed in controllers for example, Youssef et al., (2018) reveal how to use FL for maximum power point tracking (MPPT) in photovoltaic systems, enabling it to function with different irradiance and temperature conditions. The proposed MPPT controller provides high flexibility and re-configurability, low cost of implementation and power usage. Costo Branco and Dente (2010) design and evaluate a fuzzy logic pressure controller for the braking system on an Airbus to achieve pressure control with high fit for hydraulic load fluctuations. Tzafestas et al., (2010) proposed the design of a FL in the control of autonomous non-holonomic mobile robots to discover a fuzzy path tracking algorithm. Cheng et al., (2010) investigated the design of a variable-voltage DC source using a fuzzy logic controller to handle load changes and input voltage fluctuations.

Furthermore, there are uses of FL in hybrid sectors; Tahmasebi and Hezarkhani (2012) adopted fuzzy logic in grade estimations which is useful in mine projects to overcome challenges due to difficulties of mineral ore deposits structural complications. Anifowose and Abdulraheem (2011) demonstrate functional networks, fuzzy logic driven and support vector machines to predict oil and gas reservoir attributes. Menghal and Laxmi (2016) discussed the control of an induction motor drive using fuzzy logic knowledge which was developed using MATLAB/Simulink to clarify the usefulness of PI and fuzzy control and to present an improved control performance of FLs algorithm over conventional PI controllers. Garcia-Diaz et al., (2013) argue for the use of FL models in software development effort estimation as an alternative to linear regression methods. The authors argued further by comparing two types of FL systems: Mamdani and Takagi-Sugeno and proving the outcome from the results of Takagi-Sugeno FL system to be more accurate than the other FL system as well as the linear regression model. Mehbodniya et al., (2013) established an innovative multi-criteria vertical handoff algorithm for heterogeneous wireless networks that achieves seamless mobility with maximal end-users' satisfaction using Fuzzy VIKOR (FVIKOR).

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# 2.1.2 GAs in Design

Genetic algorithm is a process of natural selection used to generate high quality optimized solutions to problems by depending on selection, crossover and/or mutation. Pan (2010) used Canonic Signed Digit (CSD) coded GA to develop chromosomes by decreasing the time emaciated by trials and errors in the evolution process and to increase the training speed. An efficient hybrid code for the filter coefficients is suggested to enhance the precision of the coefficient of finite impulse response digital filter (FIR). Nagarajan et al., (2016) proposed the retrieval of any kind of medical image such as breast cancer, brain tumor, lung cancer, and thyroid cancer adopted to decrease the existing system dimensionality problems. The experiment proved that the GA directed image retrieval system chooses optimal subset of feature to recognize the right set of images using a machine learning based feature selection method. Luan et al., (2019) used the hybridization algorithm of GA and ant colony optimization (ACO) to provide a decision support tool that helps in solving the challenges associated with multicriteria decision making of supplier association. The unified algorithm has shown improved quality and efficiency with a methodological contribution to the optimization of algorithm research. Lee (2018) conducted a review of the applications of GA in operations management (OM) over a ten-year period ranging from year 2007 to 2017. The study encouraged the use of heuristic search methods for improved OM decisions as against non-deterministic polynomial hard problems algorithms.

### 2.1.3 NN in Design

Neural networks fundamentally reflect the behavior of the human brain, which allows computers to recognize patterns and solve problems.

Kamrunnahar and Urquidi-Macdonald (2010) utilized supervised neural network (NN) method as a data mining tool to forecast corrosion behavior of metal alloys. The NN model learned the basic laws that outline the alloy's composition and environment to the corrosion rate. Both DC and AC corrosion experiments were conducted with existing corrosion data on corrosion allowable and corrosion resistive alloys. The data mining outcomes recognized the categorization and prioritization of certain parameters for example, pH, temperature, time of exposure, electrolyte composition, metal composition to establish the synergetic impact of the parameters and variables on electrochemical potentials and corrosion rates. Chen (2011) employed a Takagi–Sugeno (T–S) fuzzy model and parallel-distributed compensation (PDC) plan to design a nonlinear fuzzy controller for the stability of nonlinear systems. The neural-network model is used to submerge the modelling error challenges associated with nonlinear systems. The control problem is now presented as a linear matrix inequality (LMI) difficulty and a simulation is provided to explore the practicability of the proposed fuzzy controller design method.

Hassan et al., (2013) presented a review of major studies adopting the ANN method to solve major problems related to power system control due to the constraint of conventional control theory, modern control theory, and adaptive control theory. It was discovered that fast-acting, accurate controllers based on ANN technique are the preferred choice to shun system collapse, sustain system transient stability, damp oscillations, stabilize voltage, and to provide high-quality service to consumers. Though, all NN has some benefits and disadvantages, it was proposed that the recurrent neural network (RNN) is appropriate for monitoring and control. And, power systems should be taken as a supplementary tool, rather than a substitute for conventional or other AI based power system methods. In transiting from power system monitoring to forecasting stream flow, Sahoo et al., (2019) established the application of NN in simulating river flow for forecasting the development of water resources. Traditional radial basis function network (RBFN) and RNN were utilized for model development and RNN model provides optimized performance as against RBFN. For RNN,

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Tan-sig, Log-sig, Purelin transfer function are adopted for evaluating model performance, and Tan-sig provides best value of model performance among them.

#### 2.1.4 KBS in Design

Publications on knowledge-based systems are quite few and dispersed, Naranje and Kumar (2014) established that KBS is used for the design of deep drawing die for axisymmetric parts yielding an interactive user-friendly, flexible, and economic implementation system. Mayr et al., (2018) shows that KBS are mostly relevant for supporting the planning of electric drives production systems, but ML-based methods are principally for optimizing single production processes. Khan et al., (2021) developed an integrated KBS useful for the transformation of traditional supply chain to digital supply chain. In year 2012, Rocca discussed knowledge-based engineering (KBE) as a budding technology with great potential for engineering design applications and its distinctiveness based on programming method to portray its validity in capturing and reusing engineering knowledge to automate large portions of the design process. Bing et al., (2017) provides a language-independent framework to implement slot-filling assignments by searching the web with accurate inquiries and originating lightweight extraction patterns. Hence, a pseudo-testing approach is adopted to approve the patterns derived from various sentences and highly encouraging outcomes are achieved.

## 3.0 Results

This section compares the results obtained from the present review (2010-2021) to the review conducted in a previous paper (2005-2009). The number of papers released on average annually have increased by 37%. Figure 1, 2, and 3 gives a visual comparison of the surveys over the durations, 2010-2021, 1995-2004, and 2005-2009 respectively.

The previous survey displays trends for design and scheduling which showed an increase in the use of GA. *Based on the graphs in Figure 1 and Figure 2, scheduling and design have a huge interest in GAs as an AI method used in OM in both review durations*. In the review between 2005-2009, Two hundred and ten (210) publications are for design and three hundred and nine (309) for scheduling, that shows the highest number of papers published for any of the categories over that period. About twenty to thirty-five (20-35) papers have been published for NN for design during that period. The second highest use of AI in OM is NN as statistics show that a total of three hundred and eighty-six (386) papers have been published which is over a half of the number of GAs published.



Figure 1: Charts representing the number of publications of AI in OM from 2010-2021.



Figure 2: Charts representing the number of publications of AI in OM from 1995-2004.



Figure 3: Scatter plots of publications of AI in OM during years 2010-2021 and 2005-2009.

The use of NN within process planning and control seem to control more than 70% of all publications in the process planning category in comparison to the review conducted between 2010-2021, GA and NN have remained to be areas of great interest with GA having a total of four thousand five hundred and fifty-four (4554) papers published and NN with two thousand, two hundred and thirty-two (2232) publications. *This shows increased interest for the use of GA and NN in OM over the course of eleven years (2010-2021)*. Many operations managers understand the impact of GA research on evolving designs due to their flexibility and potential for optimizing tasks. *Both surveys discovered a decline in the use of KBS as most of its benefits have been studied and it is no longer considered innovative, because newer and more advanced systems have been developed*.

In the 2010-2021 survey, Figure 1 shows an exponential increase of the hybrid models, while in the 2005-2009 survey, the use of GA increased exponentially for Design and Scheduling. Whereas quality, maintenance and fault diagnosis, process planning and control, display the adoption of NN as the dominating factor while other methods are fluctuating. *However, considering the time frames, both surveys reveal an increased interest in the adoption of hybrid artificial intelligence methods in operations management.* 

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#### 4.0 Conclusion

This study has shown that the interest in KBS has declined drastically over the periods considered. In contrast, the interest in hybrid AI aspects have seen a surge in the adoption of AI in OM as evidenced by the total papers published annually. With more companies adopting AI within the supply chain, it is increasingly more attractive to find the most effective solution to provide a compelling solution to their users. Design is the most appealing and logical solution to research for hybrid AI methods. Considering the future, research has shown that hybrid is still a major research focus with thirty-six per cent (36%) of the total publications referencing



hybrid systems. In year 2022, as shown in figure 4, a total of four thousand, three hundred and nineteen (4319) papers have been published within operations management. A key statistic to consider is data mining which has gained interest with a further twenty-five per cent (25%) papers related to that. KBS has almost 0 paper in that year, and it is believed that the trajectory will stay the same as most of the research in this field has been conducted thoroughly with no new innovations.

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