Journal of Information Engineering and Applications
ISSN 2224-5782 (print) ISSN 2225-0506 (online)
Vol 2, No.9, 2012

Synthesizing and Reviewing Research Trends in Automation

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Abstract

The objective of this paper is to develop a thorough understanding of the evolution of automation techniques throughout its time span. To achieve this, a literature review followed by classification schemes and simple Meta analysis have been presented in this paper. The literature review was based on journals collected for the study. A total of 234 articles were selected for the study. The study yielded 37 variables which formed the basis of classification schemes. The first classification scheme was conceptual while the second was functional. The entire study was grouped into these classification schemes. The classification schemes were the foundations for performing simple Meta analysis. The analysis was done under three categories, according to classification schemes, according to year of publication and according to journals. The results show various trends of automation throughout the years. In the end, the results are discussed in detail and future areas of research are identified.

Keywords: Automation techniques, Classification schemes, Meta analysis, Primary dimensions

1. Introduction

Automation as a concept did not have a strong foothold in the industrial sector until after the industrial revolution in the 19th century. With automation, came the revolution of industries, manufacturing sector in particular. Developed with the introduction of concepts of neural networks and genetic algorithms, automation has gained immense popularity and has become an indispensable part of many organizations.

Throughout time, automation has changed its focus considerably from increasing productivity to improving quality of the product and most recently providing customer satisfaction. These goals have been successfully achieved through various tools of automation. These include not only machine but highly intelligent systems such as neural networks, distributed control systems, programmable logic controllers and robotics. Although automation has impacted the industrial sector as a whole, there are various dimensions that have surfaced which specifically illustrate the contributions of automation. These fields include technology, economics, organization and process oriented. Automation has played a major role in refining the technologies used in the industries today. It further gives scope for development of new technologies which are user friendly as well as more productive. The economic sector has been the most influenced field. Despite of various concerns about the initial cost of investment it can be safely said that automation has taken the world economy to a higher level. Labor force has been an important parameter in any organization. Man-machine relationship is quite complex and has posed trouble in successful implementation of automation. Not only this, automation has increased manifold the process parameters such as quality, volume of production and adaptability etc.

Despite its immense benefits there are certain challenges which hamper its implementation process. Common belief is that by replacing man with machines, jobs are eliminated causing a considerable disinterest in adopting automation techniques for the industries. Another issue hampering the progress of automation in the industries is the risk factor associated with high cost of investment, especially in developing countries.

The purpose of this paper is to study and analyze the contributions and effects of automation throughout time. The trends and developments in automation techniques are studied and they have been classified according to different schemes. This paper has been divided into five sections. Firstly, we introduce the term automation. Research methodology adopted for conducting our study has been explained in the next section. Thirdly, we classify various constituents of automation according to different schemes developed. Next, a simple Meta analysis is performed and

the result has been presented. Finally conclusions are derived from the study and the scope for further study can be suggested.

2. Research Methodology

The research methodology adopted to conduct the study revolves around the technique of Meta analysis. To apply this tool, data was collected related to automation techniques which were the focus of the study. A literature survey was conducted to explore the field of automation throughout its time span. The survey yielded 350 articles that were helpful in determining the constituents of automation. Next, an in depth study of these research articles was done to search for exploratory variables which defined the constituents of automation. In total, 83 variables were extracted from the literature. These variables were refined and checked for redundancy and 37 variables surfaced clearly. These variables were used to construct the information framework. These variables were grouped under four primary dimensions which described the nature of contribution made by them in the field of automation.

This information framework formed the basis of our classification schemes used in the study. The classification schemes are both conceptual and functional in nature. The research papers were classified under time span and the areas of contribution. Having completed the classification of the literature, Meta analysis was performed. It is an important tool for systematic review that provides with the benefits of generalizing the study while also surfacing the variations and deviations in the field of research. Next, the results are displayed in form of tables and bar graphs. Further, conclusions have been drawn from the study conducted and scope of further study has been identified.

It should be noted that while conducting the literature survey, only research articles which were relevant to the field of study were included as opposed to all the research papers of the journals considered. Further, only those journals which had a high impact factor were included in the study. Although the study cannot be claimed exhaustive, it can be concluded that the study forms a basis for thorough understanding of the field of study.

3. Classification Schemes:

On the basis of extensive literature review carried out on the concept of automation and its techniques, two classification schemes were developed, under which the articles reviewed were categorized. The first classification scheme is a conceptual and the second is a functional.

The first classification scheme in Figure 1 focuses on the time span of developments in automation. The numerous developments and modifications that have taken place in the field of automation are identified and categorized in this classification scheme. The 37 variables that were used to develop the information framework were clustered into four different categories according to the purpose or field of implementation in relation to automation. These categories included technological parameters, economical parameters, organizational parameters and process oriented parameters. The first category includes all the technical modifications taken place in the field of automation since its inception and the parameters that govern these changes. The technological changes vary from computer aided process controls to recent developments like artificial intelligence including tools such as neural networks and fuzzy logics. Further, concepts of flexibility and adaptability are also deep seated in the technological aspects of automation. The second category includes the parameters that influence the cost and cost effectiveness of implementing automation. The third category deals with the human involvement and their relationship with the machines. All parameters that affect the man machine interface are discussed under this category. The fourth category deals with the process governing parameters in automation that includes functionality, safety, machine life and many more. Each category is further sub divided into perceptions of each variable associated with the respective category. The whole scheme has been sorted into two broad time spans- early developments that included developments before the year 2005 and recent developments included the years from 2005 to 2012. The changes developed in the two time spans show remarkable differences. For instance, early developments show a great deal of emphasis on the economic aspects of automation than in the latter years which focus mainly on the cognitive aspects of automation. Also, recently more emphasis is laid on improving man machine relationship.

The second classification scheme in Figure 2 views automation from a commercial point of view. Here, the variables along with their primary dimensions are categorized according to the functions performed by them in the industries

they are applied in. A thorough examination of the Indian industries was done to enlist all the industries of India providing both products and services to the masses. A total of 27 fields were enlisted. These were categorized into three main categories- industrial sector, office automation and cognitive automation. The industrial sector involves manufacturing, textile and other industries which utilize automation mainly on the shop floor and provides products to the consumers. The automation mainly focuses on mechanization and cost effectiveness. The industries included in office automation include banks, media, retailing and telecommunication. They provide services to the customer. Thus accuracy and speed are the governing factors which are reflected in the variables associated with this category. The cognitive automation includes sectors such as software, education and hospital where highest level of automation is required. Artificial intelligence plays an important role in these sectors. The ability of machines to think like humans and take decisions is a key factor in this type of automation.

4. A Simple Meta Analysis

The analysis was based on the classification scheme developed, the year of publication of articles and the contributions of journals selected for the study.

4.1 Distribution of articles by classification scheme

According to the first classification scheme, the frequency distribution is shown in the table 4.1. It can be seen that there are equal number of article in both time spans although the time span for recent developments is quite less as compared to early developments. This shows that recently the field of automation has captured the interest of more and more researchers. The wide areas of research available in this field that have emerged recently can also be considered a contributing factor. It is also noticed that the technological parameters have most contribution amongst all dimensions of automation. These are followed by process governing parameters. Economic dimensions have the least contribution amongst all dimensions.

4.2 Distribution of articles according to year of publication

This distribution has been shown in the Figure 3. To create the distribution, a class interval of two years is selected. The distribution clearly shows that up to 1990 there was not enough research being done in the field of automation. With advancement in technologies in the last eight years (since 2004), automation emerged as a frontrunner in revolutionizing the manufacturing sector. Since then vast amount of research has been done in this field which has opened new areas for researchers to explore.

4.3 Distribution of articles Journal wise

In our literature review a total of 234 articles were collected from 99 journals. This distribution was created to identify the contribution of each journal in the area of our research in terms of number of related articles published in the journal. As is clear from the table the journal "Assembly Automation" has the highest contribution. It is also observed that journals related to manufacturing and robotics have the highest contribution. This trend is expected since automation is predominant in shop floors and is closely linked with robotics and computer aided manufacturing. Fields such as management and energy have the least contribution. The distribution of articles according to Journals is shown in table 4.2.

5. Conclusion and Scope for further study

From the study it is observed that most of the research work in the field of automation was done after the year 2004. This may be attributed to the fact that by then, both the need and the means were sufficient enough to boost the research in this field. Immediate spurt in the number of articles published in recent years shows that automation is a widely sort after field of research. Also, discussing the dimensions of automation that were identified in the literature review, it is clear that the technological dimensions are predominant over the other primary dimensions. This is due to the fact that technological advancements have been the driving force behind the evolution of automation

techniques.

There were many unexplored areas such as lack of mathematical model that were surfaced during the study as well as during Meta analysis. These are opportunities for the future researchers to work upon. Finally, the review cannot be claimed exhaustive but is sufficient to provide a clear understanding of the automation concept and techniques. It provides a foundation for further research in this field. This analysis can be used as a reference to determine the areas that still need exploring and further study.

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Note

Readers can contact the corresponding author to get complete reference list.

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Table 4.1 Distribution of articles according to Classification Scheme

	Primary Dimensions	*Secondary Dimensions*	*No.of articles*	*Percentage (%)*
Early Developments (Before 2005)	**Technical Aspects**	R & D	3	10.5
		Computer Aided production Control	8	
		Flexibility	8	
		Adaptability	3	
		Technological Trends	11	
		Complexity	1	
		Innovation	1	
		Product Variety	2	
	Economical Aspects	Size of Firm	3	6.5
		Cost & Capital Effectiveness	15	
		Growth of Industry	1	
		Ability to meet Demand	3	
		Return of Investment	1	
	Organizational Aspects	Human Training & Interface	17	13
		Managerial Aspects	15	
		Decision Supports	3	
		Working Environment	2	
		Risk Analysis	3	
		Communication	2	
		Environmental Compatibility	4	
	Process Governing Aspects	Functionality	14	13
		Product Life Cycle Management	3	
		Operator Error	1	
		Quality Standards	6	
		Feasibility	3	
		Machine Life	1	
		System reconfiguration capability	1	
		Safety	3	
		Software	7	
		Reliability	1	
		Sustainability	1	
		Robustness	3	
		Scope Of Customization	1	
		Volume of Product	2	
Recent Developments (After 2005)	**Technical Aspects**	R & D	18	0.5
	Economical Aspects	Computer Aided production Control	29	27.5
		Flexibility	3	
		Adaptability	7	
		Technological Trends	32	
		Complexity	3	
		Innovation	2	
		Cost & Capital Effectiveness	2	
	Organizational Aspects	Human Training & Interface	12	16
		Managerial Aspects	18	
		Decision Supports	7	
		Communication	16	
		Environmental Compatibility	1	
		Uncertainty	1	
		Competence	3	
	Process Governing Aspects	Functionality	9	13
		Quality Standards	6	
		Machine Life	2	
		System reconfiguration capability	6	
		Safety	3	
		Software	19	
		Volume of Product	1	

Table 4.2 Distribution of articles Journal Wise

S.NO	NAME OF JOURNAL	CONTRIBUTION OF EACH JOURNAL
1.	CIRP Annals-Manufacturing Technology	11
2.	Computers in Industry	14
3.	Thermal Engineering	4
4.	Instruments and Experimental Techniques	1
5.	Russian Engineering Research	2
6.	Journal of Intelligent and Robotic Systems	1
7.	Management Science	2
8.	The Academy of Management Journal	1
9.	Review of Educational Research	1
10.	Automatica	7
11.	Interfaces	1
12.	ISA Transactions	3
13.	Small Business Economics	1
14.	Journal of Manufacturing Systems	1
15.	Management International Review	1
16.	Technovation	5
17.	Computational Cybernetics and Simulation	1
18.	Technological Forecasting and Social Change	1
19.	Philosophical Transactions of the Royal Society	1
20.	Control Engineering Practice	2
21.	Assembly Automation	27
22.	Journal of Engineering Manufacture	2
23.	Annual Review in Control	2
24.	Displays	1
25.	J. Eng. Technol. Manage	1
26.	Information and Management	1
27.	Journal hazardous materials	1
28.	Biological Psychology	1
29.	Annals of the American academy of political and social science	1
30.	Automation in construction	2
31.	Laboratory automation and information management	1
32.	Annual reviews in control	2
33.	Control eng. Practice	1
34.	International journal of industrial ergonomics	1
35.	Information & management	1
36.	Energy	1
37.	Robotics and Computer-Integrated Manufacturing	17
38.	Journal of Process Control	5
39.	Ergonomics	10
40.	HVAC&R Research	1
41.	International Journal of Computer Integrated Manufacturing	2
42.	Theoretical Issues in Ergonomics Science	9
43.	SISSA	1
44.	Int J AdvManufTechnol	6
45.	ComputMech	1
46.	Journal of Computer and Systems Sciences International	1
47.	Journal of Machinery Manufacture and Reliability	2
48.	Int J Interact Des Manuf	1
49.	J Pharm Innov	1
50.	Automation and Remote Control	1
51.	ApplGeomat	2
52.	Russian Aeronautics	2
53.	Inorganic Materials	1
54.	Prod. Eng. Res. Devel	2
55.	Coke and Chemistry	1
56.	KSCE Journal of Civil Engineering	1
57.	Computers in Human Services	1
58.	Int. J. Human-Computer Studies	2
59.	International Journal of Production Research	3
60.	Military Psychology	1
61.	Cogn Tech Work	4
62.	The Journal of General Psychology	1
63.	The International Journal of Aviation Psychology	3
64.	Int. J.ProductionEconomics	3
65.	Journal of Marketing Channels	1
66.	J. Cent. South Univ. Technol.	1
67.	Information Systems Management	1
68.	EDPACS	1
69.	*IEEE* Transactions on Automation Science and Engineering	1
70.	IEEE Robotics & Automation Magazine	2
71.	Journal of Management Information Systems	2
72.	Analytical Letters	1
73.	Spectroscopy Letters	1
74.	The European Journal of Development Research	1
75.	Journal of Manufacturing Technology Management	2
76.	Industrial Robot: An International Journal	5
77.	Information Management & Computer Security	1
78.	BMC Bioinformatics	1
79.	Mamm Genome	1
80.	Int J Softw Tools Technol Transfer	1
81.	Int J Flex ManufSyst	1
82.	International Journal of Automation and Computing	1
83.	Russian Agricultural Sciences	1
84.	Journal of Computer Science And Technology	1
85.	MicrosystTechnol	1
86.	Automation of Production	1
87.	Atomic Energy	1
88.	PersUbiquitComput	1
89.	Metallurgist	1
90.	Journal of Structural and Functional Genomics	1
91.	InfSyst Front	1
92.	Journal of Civil Engineering and Management	1
93.	Applied Measurement in Education	1
94.	Mechanics Based Design of Structures and Machines	1
95.	Industrial Management & Data Systems	1
96.	Journal of Interlibrary Loan ,Document Delivery & Electronic Reserve	1
97.	ISSN 0258-0543	1
98.	1070-9932/09/$25.00©2009 IEEE	1
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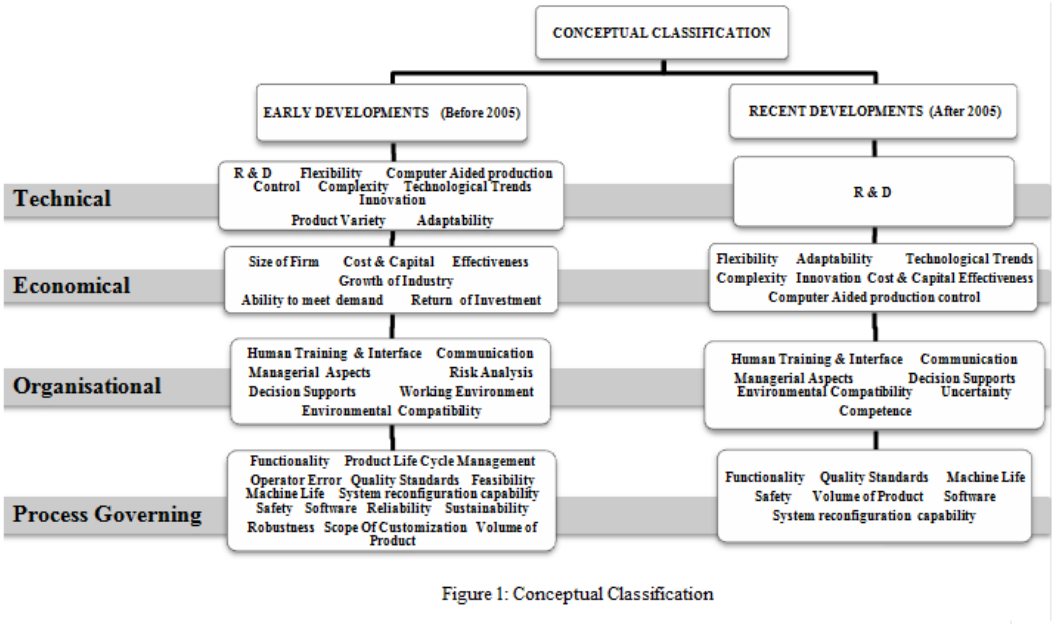

Figure 1: Conceptual Classification

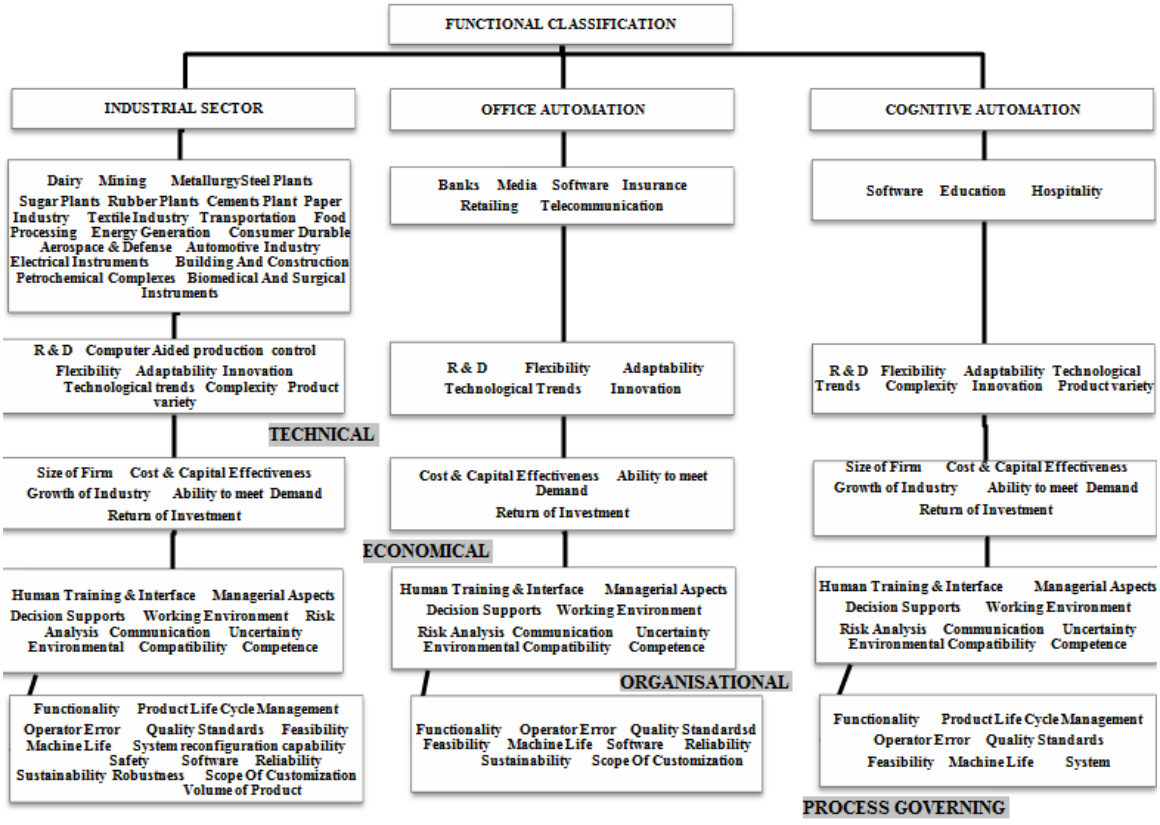

Figure 2: Functional Classification

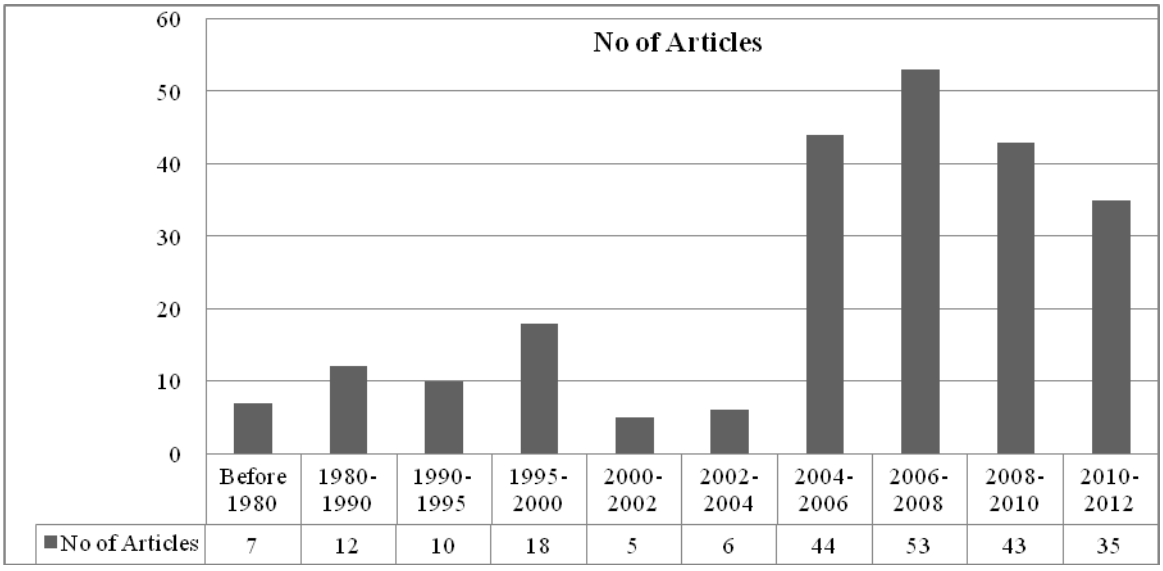

Figure 3: Shows the distribution according to year of publication

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