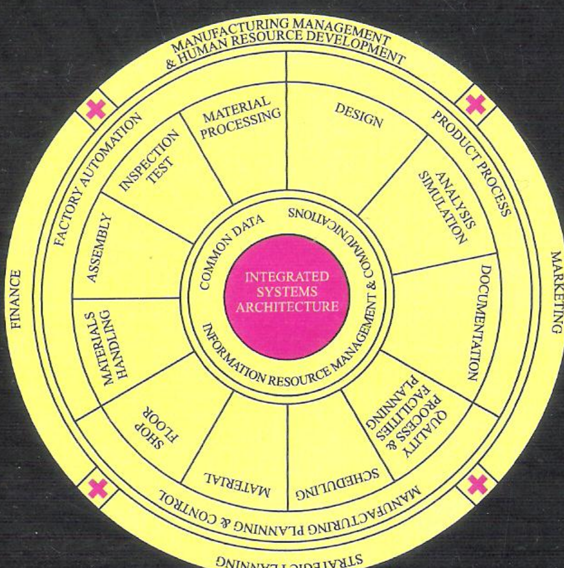
ADVANCES IN COMPUTER INTEGRATED MANUFACTURING - II

Proceedings of National Conference on
Advances in Computer Integrated Manufacturing - II
March 16-17, 2012



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IMPLICATIONS OF AUTOMATION

Is "Automated Adaptiveness" in Manufacturing Always an Appropriate Option?

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Abstract- **Automation is the use of controlled systems such as computers to control industrial machinery and process, replacing human operators. The term „automation" translates to „self-dictating" in ancient Greek. It refers to any process or function which is self-driven and reduces, then eventually eliminates the need for human intervention.**

In the present scenario, the art of automation is no longer confined to manufacturing industries but has seeped into every aspect of our daily living. Modern automation equals computers performing tasks which were previously performed by humans. Ever since their first appearance during world-war II decoding of secret messages, computers have "significantly exceeded human mental dexterity in their ability to remember and process information." This is the computer age and "microprocessors are now in millions of appliances and devices." Computers are built into ATM machines, microwave-ovens, automobile ignition systems, medical instruments, cash registers, cell phones and also not leaving apart, industrial equipment in the manufacturing factories replacing humans.

Through widespread use of robots, an automobile manufacturer improved its global competitiveness and economic success. Much of the savings resulted from reducing its workforce from 138,000 to 72,000. There was a human cost of displaced workers, however, and displaced employees had a difficult time finding new jobs. Was the automation decision defensible on ethical grounds? What steps can a firm take to be a responsible and ethical employer when cutbacks are necessary?

Keywords: - Automation; Automated Adaptiveness.

I. INRODUCTION

Understanding the impact of ethical and social dimensions in automated systems is a topic that is receiving increasing attention both in academia and practice. Designers of Decision Support Systems (DSS's) equipped with computer and microprocessor interfaces have a variety of additional ethical responsibilities beyond those of designers who only deal with the physical and mechanical world. When a human element is introduced in a fully automated decision control system, entirely new layers of social and ethical issues emerge but are not always recognised as such. This paper discusses those accountability issues that result from introducing un-adaptive automation and highlight areas that interface designers should take into consideration.

If a DSS is faulty or fails to take into account a critical social impact factor, the results will not only be expensive in terms of later redesigns and lost productivity, but possibly also the loss of life. Unfortunately, history is replete with examples of how failures to adequately understand decision support problems inherent in complex sociotechnical domains can lead to catastrophe. For example, in 1988, the USS *Vincennes*, a U.S. Navy warship accidentally shot down a commercial passenger Iranian airliner due to a poorly designed weapons control computer interface, killing all aboard. The accident investigation revealed nothing was wrong with the system software or hardware, but that the accident was caused by inadequate and overly complex display of information to the controllers (van den Hoven, 1994).

Automation can indeed make a system highly efficient but ineffective, especially if knowledge needed for a correct decision is not available in a predetermined algorithm. Thus higher, more ―efficient‖ levels of automation are not always the best selection for an effective DSS. Also a fully automated system can lead to an extent of unemployment and decrement in wages in the regions of less educated population again leading to social and economic upheavals. Displacement of jobs is also one of the impacts of automation. Substitution of human labour and skill with computing machinery sways economic stability (increased productivity, focus shift of highest paying jobs, unemployment) educational policies (vocational training, new skills set), government rules and regulations (safety issues i.e. result of automated systems malfunction), cultural environment (theme of entertainment mediums like books and films). Thus change is inevitable and the impact of automation on our lives is undeniable. The purpose of this paper is to examine the current trends and consequences of automated systems so that we can better prepare ourselves for an automated future. After all, as Ray Kurzweil puts it, ―We still have the power to shape our future technology, and our future lives.‖

II. PROMINENT VIEWS ABOUT AUTOMATION

At the establishment level, most researchers agreed that the impact of any new technology depends upon the nature of the technology, and so they identify and study a specific technology. Being able to study a specific technological change is one of the strengths of case studies as opposed to national studies, where technology is often only vaguely defined (e.g., computers). Here we refer to three studies that focus on the importance of shifts in automation technology that have changed the nature of work, increased skill requirements, and opened new output possibilities for companies.

Zuboff (1988) shows how digital technology has dramatically changed work by automating routine tasks and allowing some workers to perform new kinds of work in both manufacturing and service companies. She argues that although technology automates routine tasks, its true potential lies in its ability to —informate|| work and organizations by making key information more widely and easily accessible, by generating new information, and by revealing previously hidden relationships. The use of this information transforms the experience of work, requires developing workers' potential for learning, and opens new possibilities for the organization. Application of the technology dramatically changes the way work is done and organizations function, and the transition is often traumatic for both the workers and organization.

Levy and Murnane (1996) and Murnane, Levy, and Autor (1999) reach a similar conclusion about the way new computer technology has changed work. They argue that job tasks include routine or rule-based problem-solving operations, which can easily be done by a computer, and exceptions or model-based problem-solving, which cannot be done economically by a computer. The use of computers results in the exceptions shaping the demand for labour both in terms of quantity and skills. In their case study of accountants at a large urban bank, computerization eliminated the routine parts of the job (e.g., data entry and transfer, computation) and left the more difficult exceptions (e.g., data rework, valuation, and analysis). Although computerization increased the demand for skilled labour in the redesigned job, the bank chose to provide in-house training rather than increase the wages and skill requirements for new hires. Computerization also required upgrading the skills of the first-line managers and allowed the development of increasingly complex products. They also studied the how the lower-skilled jobs in check processing were redesigned with the introduction of image processing technology. The outcomes for these jobs were more complex, in those instances of both increases and decreases in skill and pay occurred. The transformation required a structured training program and worker buy-in to be successful.

Barley and Orr (1997) study technicians and the —technization of work||, or the emergence of work that is comparatively complex, analytic, and abstract, because it makes use of tools that generate symbolic representations of physical phenomena. Sometimes technization of work does not change what an occupation is called, and technicians may appear to be doing what they have always done, even though the work is done in dramatically different ways. Managers often do not understand and may undervalue the work of technicians.

III. DISADVANTAGES OF FULLY AUTOMATED SYSTEMS

According to Opperman (1994) there is a line of distinction between —adaptable|| and —adaptive|| systems. In the both the cases, flexibility exists within the system to adapt to the changing circumstances, but his distinction is centred on who is in charge of this flexibility. According to him, an Adaptable system is one in which the flexible control of information, system performance and automation resides in the hand of a human (user); he/she must be able to explicitly command, generally at runtime, the changes which occur. In an Adaptive system, by contrast, the flexibility in information or automation behaviour is controlled by the system. Also in the majority of cases, the phrases —adaptive system||, —adaptive user interface|| and —adaptive automation|| are used to imply in the Opperman's sense of when a machine system is responsible for flexibility in information and performance subsystems replacing the role of humans.

The increased role of automation in systems has enhanced many aspects of system operations, but it has also led to unique antecedents to errors which have led to incidents and accidents. The major issue with any automated system is the low amount of human interception and intervention in the technological aspects of the automated systems. This lack of understanding the need for a human-centred interface design was faced in the form of critics by the military in the 2004 war with Iraq when the U.S. Army's Patriot missile system engaged in fratricide, shooting down a British Tornado and an American F/A-18, killing three pilots. Some other issues related to fully automated systems area as discussed below in the under the following heads:

A. Reducing operator's situation and system awareness.

Automation can be seen to have a direct impact on the situation awareness of the human in-charge which may occur due to some of the below stated possible reasons:

- Assumption of a passive role instead of an active role in controlling the system by the operator.
- Changes in the amount of care taken for monitoring the system i.e., certain operators may continue to rely on automation even when it malfunctions and may not monitor it effectively.
- Changes in the quality or form of feedback provided to the human operator (Endsley & Kiris)

Each of these factors can decrease the situation and system awareness of the operator and can create out-of-the-loop performance problems. The demands for higher levels of situation awareness can also be challenged by the nature of complexity of the automated system during on-going system operations.

B. Increased Opacity.

When systems is faced by a sudden break-down and begin to perform non-regular and abrupt operations, the operators inability to know the reasons for such actions of the system limits the extent of diagnosis of the system and may also delay the much required restoring responds. Thus, the problem associated with the system is difficult to find out which increases the opacity in the issue. Increased nature of complexity of the system may again be stated here to be responsible for such a problem.

C. Over-Reliance and Trust on the automated system.

We all have heard a very famous saying —Trust is very difficult to win, but very easy to break.|| The same thing also applies on to the automated systems. For example, mistrust on an automated burglar alarm may prove to be very costly and also on the other hand it may cause a lot of nuisance due to excessive faulty and misleading alarms due to many other reasons. Thus, over-trust on the system may also be absurd. Over-reliance on automation may also hinder certain tasks but it‘s not worthy as such because humans are not very good at monitoring automation states for occasional breakdowns if their attention is occupied with other manual tasks.

D. Skill and Performance Degradation.

Automation as defined in the opening lines of this text is nothing but the use of controlled systems in manufacturing and other processes, replacing human operators. The tasks which were earlier performed by humans were now performed via machines and the skills in the humans which made them capable to do those tasks start degrading and in a certain period of time the confidence of the person in performing those tasks also finishes. Also, intermediate levels of human involvement in tasks can produce better overall performance of the machine + human system than either full manual or fully automated levels, especially when the human and automaton roles are well structured and when carried out in a more sophisticated manner. Thus, a fully automated system also contributes to the performance degradation of the system.

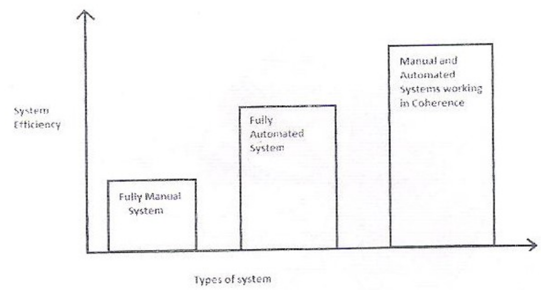

Figure 1. *Efficiency comparison of different types of system.*

So, this property of the system could be taken as a precautionary measure to reduce the impact of automation in our live i.e., to try to make machines work out with human operators

E. "Un-employment" – leading to social and ethical issues.

Some who correctly anticipate that technological change may produce short-run employment-adjustment problems overstate those problems. They also often fail to mention that the short-run unemployment that occurs is primarily the result of artificial imperfections--a lack of competition--in certain labour and product markets. The amount of short-run unemployment created by advancing technology, as well as the amount of howling (or lobbying), is directly related to the degree of artificiality in the particular labour markets affected. It will be argued below that the workers harmed by technological advancement are those who have been receiving wages in excess of the amount they would receive in a fully competitive labour market. In other words, they have been receiving economic rent. It will be further argued that those workers remain unemployed when displaced by technology because they seek to regain their former employment or seek employment in another industry that pays excessive wages. In other words, they are unemployed because they are rent seekers. Finally, the effects of slow and rapid technological change will be discussed. The rate of change can serve as a basis for reasoned debate of some of the legitimate social concerns facing our society as a result of technological advancement, given the institutional imperfections already existing in the labour market.

Although automation in technology doesn‘t bring about a mass unemployment but its consequences can be restricted to a certain region of work. Like, introduction of automation can be worth stating the reason for unemployment where there is concentration of factories performing metal work which cannot be neglected. So unemployment is also an issue associated with changes in the automated technologies especially on the basis of education standards of the people.

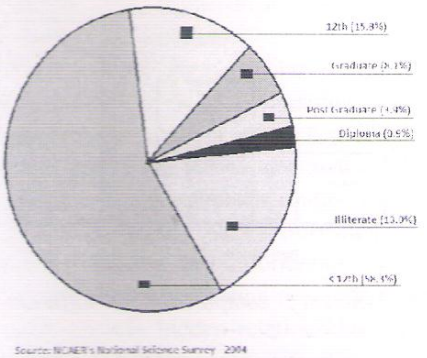

Figure 2. *Distribution of unemployed by levels of education.*

So, with regards to our country India, it is implied from the above figure that if there is a revolution in any manufacturing industry and the configuration of its tasks is been changed to automatic instead of manual than it would certainly have to cut off its man-force. Then the most effected people from this will constitute of the most less educated people. Depending on the company's policy the situation can be avoided from getting worse in the region by selecting a bunch of people and training them to perform the automated tasks or else in the tasks associated with the use of manual systems.

Public attitude towards science and technology related issues
(All India, percentage) Year: 2003-04

Characteristic	People should live a simpler life without much technology			Computers and factory automation will create more jobs than they will eliminate		
	Agree	Disagree	do not know	Agree	Disagree	do not know
			LOCATION			
Rural	[illegible]	[illegible]	33.4	[illegible]	[illegible]	[illegible]
Urban	47.2	28.0	23.8	27.8	19.8	32.4
			SEX			
Male	46.3	28.3	23.8	33.6	12.7	33.6
Female	45.1	21.8	31.6	26.8	14.5	48.7
			AGE GROUPS (YEARS)			
18-30	44.1	26.3	27.6	[illegible]	20.0	37.3
31-45	44.3	25.4	30.2	38.9	17.2	43.9
Over 45	42.3	27.6	33.1	25.3	16.9	47.8
			FORMAL EDUCATION			
Illiterate	29.2	15.8	54.4	11.7	20.2	68.1
Upto 12th	45.3	28.1	25.4	32.5	30.0	37.5
Graduate degree	59.1	35.9	3.3	53.6	35.2	11.2
Post graduate degree	63.2	32.7	3.5	49.2	44.3	6.5
Other degrees	59.1	28.5	13.0	30.2	9.2	10.7
			FORMAL OCCUPATION			
Professionals	56.7	34.7	3.6	50.3	16.7	13.0
Administrative workers	57.7	27.6	14.7	55.0	16.5	18.4
Clerical workers	53.2	28.5	13.3	49.3	12.6	18.1
Service workers	43.1	30.8	25.7	39.1	17.8	33.1
Production workers	49.1	25.7	25.2	51.1	20.0	34.3
Others	43.5	28.5	22.1	36.2	[illegible]	[illegible]

Source: NCAER's National Science Survey - 2004

Figure 3. *Public Attitude in India.*

The above data clearly indicates that people in India, mainly those who are referred to as the future of our country, also believe that automation of industries won't lead to any major unemployment issues. Again views of percentage of people vary as per their education background. But still majority of professionals, administrative, clerical, service, productive workers do believe that automated technology will infact create more employment instead of unemployment.

IV. RECOMMENDED MEASURES

A. Automation Design Considerations.

The designers of the Decision Support Systems (DSS's) or any other automated system should always try to limit the amount of automation in any task, thereby laying stress on adaptive automation. The designers should be familiar with the fact that increasing the extent of automation would lead to increase in nature of complexity and thereby making it difficult for the human operators to adapt the system and interpret its results correctly.
If the levels of automation and the complexity of the tasks to be performed were taken on to the complimentary axes, then adaptive automation, which is certainly recommended, is nothing but a line which makes equal angle with both the axes.

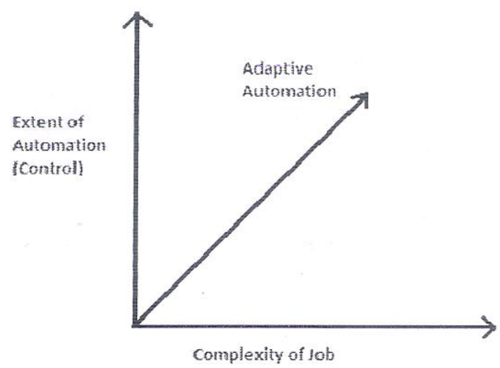

Figure 4. *Adaptive Automation.*

It can be inferred from the above figure that due to increase in complexity of the task the level of automation also needs to be increased. But this has to be done via the route of _adaptive automation.'

B. Limiting the Rate of Technological Development.

In general, people expect to receive increasing benefits from ever-greater output as the rate of technological development speeds up. At low rates of technological advancement, perhaps 2 or 3 per cent a year, there may be other social benefits in addition to increased physical output. For example, young persons can find new challenges and opportunities that are not available in a no-growth or very slow growth situation. Further, at low rates of change, the rent-seeking elements of society are in less conflict. Rent seeking is easier because only a relatively small number of people are required to retrench at a given time and because the rents can be paid out of the expanding economic pie. Also, social attitudes tend to be more optimistic and cooperative when the economy is advancing. At low rates of technological advancement, almost all perceptions are positive and advancement is everywhere hailed as valuable.

However, many fear that at some significant rate of technological change, perhaps 20 or 30 per cent, both individuals and institutions will be unable to adapt rapidly or avoid high social-adjustment costs. If the rate of technological change is very high, perhaps the social dis-utilities it creates may reduce the appeal of the added output benefits.

In a nutshell, the argument that the prospect of extremely rapid technological change can lower expected social utilities for much of society is based on two concerns: first, that technology will breed unemployment and social disruption; and second, that the fear of rapid technological change may be used to justify government intervention, making the social allocation of resources less efficient.

C. Increasing Human Role.

Another way to reduce the negative effects of automation is to implement schemes that keeps the human actively involved in the decision making loop while simultaneously reducing the load associated with doing everything manually. This can be accomplished by determining the level of automation that minimizes negative impact on operator's situation awareness. By implementing functions at a lower level of automation, leaving the operator involved in decision making process, situation awareness remaining at a higher level, it is still possible to assume and get manual control as and when needed.

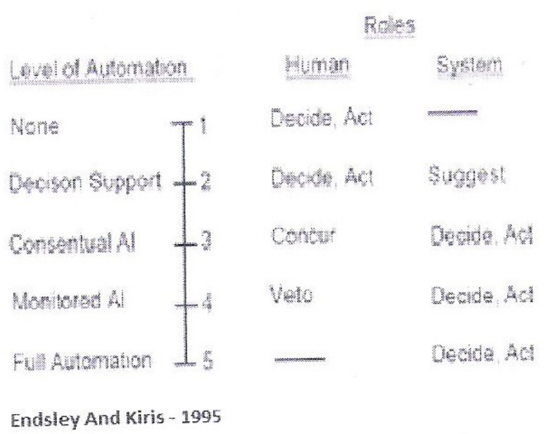

Figure 5. *Levels of Control and Automation.*

Thus, even though full automation of a task may be technically possible, it may not be desired if the performance of the joint human – machine system is to be optimized. Intermediate levels of automation may be preferable for certain tasks, in order to keep human operator's situation awareness at a higher level and allow them to perform critical functions. *Figure 1.* Also shows the advantage of higher levels of human role in an automated system which increases the overall performance of the system.

D. Giving more Control over the System.

By allowing users more control over how much automation to use when, they will be in a better position to manage their mental workload and keep it balanced. If users can make good judgments (or simply better judgments than adaptive automation) about how much automation to use when to best compliment their workload, skills and capabilities, then we would expect more nearly optimized mix of human and automation performance and the avoidance of performance degradation effects associated with full automation.

Leaving the user in charge of when and how to use automation is likely to enhance the user's sense of remaining in charge of automation performance, not only leading to a greater degree of acceptance, but also to a sense of being primarily responsible for overall task performance—in turn leading to greater attention and concern for the situation and all aspects of system performance. Infact giving more control to the human operator over an automated system will surely increase his own confidence of doing the job which would definitely prevent skill degradation of the operator to a certain extent.

E. Changes in Social Structure

Automation is not deniable in present rapid changing world of technology and advancement. If humans need to stand and face this situation they have to make themselves prepared to do so. Changes in the methodology of teaching in the schools itself would be worthy enough to be mentioned. But this is only for the new generation coming ahead. Human resources training and management is another important factor in this regard. Workers should be updated on a regular basis with the latest trends in technologies in automation. This would help in making the future of the company and the country a brighter one.

V. CONCLUSION AND IMPLICATONS

The successful implementation of an automation system is a complex issue. The traditional form of automation which places human in the role of monitoring has been shown to impact the system and situation awareness and thus their ability to effectively perform the function. As a result, many automated systems have been sub-optimized, with less frequent, but major errors attributed to a failure of the human component. Some other issues associated with the use of automated systems are increased opacity, mistrust on automated systems, skill and performance degradation and also —unemployment|| sometimes in certain regions of work. New approaches to automation design that seeks to alter the role of human in an automated system provide a great deal of promise in surmounting these problems.

The most appropriate way to face such issues lies in an integrated approach of _Adaptive Systems' rather than a _Adaptable' one. In short, after years of attempting to design truly adaptive systems, in Opperman's sense, we are sceptical about their utility in high complexity and high criticality domains. Instead, we opt for a more nearly adaptable approach that leaves the decision about when and what kind of automation to be used in the hands of a human operator/supervisor. And the most important result which comes out of this is that neither the automated systems nor the human resources are individually capable to give high performance to any task. Rather to optimize the performance of the system both the automated system and human operators should work in mutual coherence. Automation is inevitable. However, the depths to which we accept it is up to us. Currently we use computers to automate our tasks. But will there be a time when computers will be automated sufficiently to think and do the tasks. Does the future of automation hold computers thinking and not just doing without human intervention?

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