Scientific Journal of Impact Factor (SJIF): 3.134
E-ISSN (O): 2348-4470
P-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 12,December -2015

HUMAN AND MACHINE INTELLIGENCE: ADAPTIVE AUTOMATION

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***Abstract** - Adaptive automation is a form of automation that is flexible or dynamic in nature. In adaptive systems, decisions regarding the initiation, cessation, and type of automation are shared between the human operator and machine intelligence unlike more traditional forms of automation, adaptive automation can adjust its method of operation based on changing situational demands. The motivation for AA includes previous demonstrations of reduced operator cognitive load, increased operator situation awareness, and improved task performance as compared to static automation or manual control. Design parameters for AA include what functions to automate, how functions are shared between human and machine, when automation is invoked, and who maintains authority over dynamic function allocations (DFAs).*

***Keywords –** Dynamic Function Allocations (DFAs), Function allocation, Automation invocation, Adaptivity*

I. INTRODUCTION

Adaptive automation refers to systems in which both the user and the system can initiate changes in the level of automation. The first adaptive automation systems were implemented in associate systems based on models of operator behavior and workload. Automated machines and systems are intended and designed to reduce task demands and workload. Further, they allow individuals to increase their span of operation or control, perform functions that are beyond their normal abilities, maintain performance for longer periods of time, and perform fewer mundane activities. Automation can also help reduce human error and increase safety. The irony behind automation arises from a growing body of research demonstrating that automated systems often increase workload and create unsafeworking conditions.

Research on human interaction with automation has shown that it does not always make the job easier. Instead, it changes the nature of work. More specifically, automation changes the way activities are distributed or carried out and can therefore introduce new and different types of problems. Automation can also lead to different types of errors because operator goals may be incongruent with the goals of systems and subsystems. In systems where subcomponents are tightly coupled, problems may propagate more quickly and be more difficult to isolate. In addition, highly automated systems leave fewer activities for individuals to perform. Consequently, the operator becomes a more passive monitor instead of an active participant. This shift from performing tasks to monitoring automated systems can actually inhibit one’s ability to detect critical signals or warning conditions. Further, an operator’s manual skills can begin to deteriorate in the presence of long periods of automation.

Given the problems associated with automation noted above, we have to employ alternative methods for implementing automated systems. Adaptive automation is one such method that has been proposed to address some of the shortcomings of traditional automation. In adaptive automation, the level of automation or the number of systems operating under automation can be modified in real time. In addition, changes in the state of automation can be initiated by eitherthe human or the system. Consequently, adaptive automation enables the level or modes of automation to be tied more closely to operator needs at any given moment.

Adaptive automation systems can be described as either adaptable or adaptive. One dimension of this concerns the underlying source of flexibility in the system, i.e., whether the information displayed or the functions themselves are flexible. A second dimension addresses how the changes are invoked. In adaptable systems, changes among presentation modes or in the allocation of functions are initiated by the user. By contrast, in adaptive systems both the user and the system can initiate changes in the state of the system.

II. ADAPTIVE STRATEGIES

There are several strategies by which adaptive automation can be implemented.

- One set of strategies addresses system functionality. For instance, entire tasks can be allocated to either the system or the operator, or a specific task can be partitioned so that the system and operator each share responsibility for unique portions of the task.

- A second set of strategies concerns the triggering mechanism for shifting among modes or levels of automation.
- A third approach uses models of operator performance or workload to drive the adaptive logic.

III. DESIGN ASPECTS OF ADAPTIVE AUTOMATION

Human-computer interactions can be described in terms of the Level of Automation (LOA), originated by Sheridan and Verplank (1978).

Scale of levels of automation:

1. The computer offers no assistance; human must do it all.
2. The computer offers a complete set of action alternatives, and
3. Narrows the selection down to a few, or
4. Suggests one, and
5. executes that suggestion if the human approves,
6. allows the human a restricted time to veto before automatic execution,
7. Executes automatically, then necessarily informs humans, or
8. Informs him after execution only if he asks, or
9. Informs him after execution if it, the computer, decides to.
10. The computer decides everything and acts autonomously, ignoring the human.

Human-computer interactions can be distinguished into the following four classes of functions:

(1) Information acquisition,
(2) Information analysis,
(3) Decision selection,
(4) Action implementation.

There can be various design alternatives regarding to what extent each of the four functions may be automated. In other words, an appropriate LOA must be chosen for each function. The automated forms of functions (1)-(4) are called, respectively, acquisition automation, analysis automation, decision automation, and action automation.

- Acquisition Automation

When the LOA is set at the lowest, human must him/herself collect every piece of information at all instances. An example of the automated system information acquisition may be radar for automobiles or aircraft, or sonar for ships. Sometimes these systems simply collect information and display it on the screen. When the computer involves more, certain types of acquired information may be highlighted to attract a human's attention. Filtering is another important capability for acquisition automation.

- Analysis Automation

If the LOA is set at some moderate level, the computer may be able to give humans some information by processing available raw data. One example of such information is the prediction of the future state of a system.

- Decision Automation

It is often useful to distinguish situation-diagnostic decisions and action selection decisions.

- Action Automation

There are many examples of automation for action implementation. A photocopy machine, is a good example for illustrating that various LOAs can be chosen in a single machine. Suppose someone needs to quickly make copies of 10 pages for five people. He or she must decide which mode to use: automatic sorting without automatic stapling, automatic sorting with automatic stapling, or manual mode to make five copies of each sheet. In the last case, he or she must sort and staple sheets manually. The time required for giving necessary directives to the machine through a touch sensitive panel differs, as does the time needed to finish the task. Once a mode has been chosen, operation starts at one of three different levels of automation.

3.1 Design of Adaptive automation:

A design of adaptive automation systems involves the following steps.

3.1.1 Function Allocation

Suppose we are to design a system with specific missions or goals. We first have to identify functions that are needed to accomplish the goals. We then come to the stage of function allocation. Function allocation refers to the design decisions that determine which functions are to be performed by humans and which are to be performed by machines. Various strategies for function allocation are defined below.

Strategies for Function Allocation:

A. Traditional Strategies for Function Allocation

Rouse (1991) classified traditional function allocation strategies into three types.

1. Comparison Allocation:

The strategies of this type compare relative capabilities of humans versus machines for each function, and they allocate the function to the most capable agent (either human or machine). The most famous MABA-MABA (what “men are better at” and what “machines are better at”) list.

Here is the MABA-MABA List

Humans appear to surpass present-day machines with respect to the following:

- Ability to detect small amounts of visual or acoustic energy.
- Ability to perceive patterns of light or sound.
- Ability to improvise and use flexible procedures.
- Ability to store very large amounts of information for long periods and
- Torecall relevant facts at the appropriate time.
- Ability to reason inductively.
- Ability to exercise judgment.

Present-day machines appear to surpass humans with respect to the following:

- Ability to respond quickly to control signals and to apply great forces
- Smoothlyand precisely.
- Ability to perform repetitive, routine tasks.
- Ability to store information briefly and then to erase it completely.
- Ability to reason deductively, including computational ability.
- Ability to handle highly complex operations, i.e., to do many different
- Things at once.

2. Leftover Allocation:

The strategies of this type allocate to machines every function that can be automated. Human operators are assigned the leftover functions to which no automation technologies are available

3. Economic allocation:

The strategies of this type try to find an allocation that ensures economic efficiency. Even when some technology is available to automate a function, if the costs of automating the function are higher than that of hiring a human operator, then the function is assigned to the operator.

B. Non Traditional Strategy for Function Allocation

- Sharing Control or Trading Control:

Sharing of control means that the human and the computer work together simultaneously to achieve a single function.

Trading of control means that either the human or the computer is responsible for a function, and an active agent changes alternately from time to time. For trading of control to be implemented, it is necessary to decide when the control must be handed over and to which agent. It is also important who makes the decision.

3.1.2 Automation Invocation:

In adaptive automation, functions can be shared or traded between humans and machines in response to changes in situations or human performance. There are three classes of automation invocation strategies:

- Critical-event strategies

  Automation invocation strategies of this class change function allocations when specific events (called critical events) occur in the human-machine system.

- Measurement Based Strategies:

  Adaptive automation works as follows under a measurement-based measurement strategy: First the task is defined and structured and subtasks are allocated to either an automated subsystem or to the operator. Next, the operator’s effort is compared with the task difficulty so as to assign a criterion for adaptivity. The criterion can be expressed as a measure of mental workload, a measure of primary task performance, or a combination of both. Once the criterion is defined, the adaptive system trades task components in order to improve future measurement of the criterion. In the workload-based measurement method, adaptivity can be achieved through three main procedures: by adjusting allocation of subtasks between operators and automation; by adjusting the structure of the task; and by refining the task. Psycho physiological measures, such as pupillary dilatation and heart rate, may be used for adjusting function allocation. The psycho physiological measures may be recorded continuously and thus be useful, unlike most behavioral measures, in measuring mental activities of human operators placed in supervisory roles that require few overt responses.

- Modelling based Strategies
  The decision authority issue is related to the selection of appropriate LOAs. When the LOA is positioned at level 5 or lower, the human operator is maintained as the final authority. The human-centered automation principle is violated when the LOA may be positioned at level 6 or higher.

3.2 Advantages:

- One major motivation for introducing adaptive automation is to regulate operator workload, where an operator can control a process during periods of moderate workload, and hand off control of particular tasks when workload either rises above, or falls below, some optimal level.

- Adaptive Automation is a potential solution to the problems associated with human automation interaction, regardless of the complexity of the application domain.

- Adaptive Automation aims at optimizing the cooperation and at efficiently allocating labor between an automated system and its human users and it can be considered as an alternative method used to implement automation in a system, whose purpose is to bridge the gaps of traditional automation.

3.3 Future Scope

Adaptive automation is also beginning to find its way into commercial and more common technologies. Some examples include adaptive cruise control found on several high-end automobiles and “smart homes” that control electrical and heating systems to conform to user preferences.

IV CONCLUSION

The development of adaptive automation represents a qualitative leap in the evolution of technology.

The challenges facing designers of adaptive systems are significant. Current methods in system analysis, design, and evaluation fall short of what is needed to create systems that have the authority and autonomy to swap tasks and information with their users. These systems require developers to be knowledgeable about task sharing, methods for communicating goals and intentions, and even assessment of operator states of mind.

Most of the adaptive automation systems that have been developed address life critical activities where the key concerns surround the safety of the operator, the system itself, and recipients of the system’s services. However, the technology has also been applied in other contexts where the consequences of human error are less severe.

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