Supervisory control

Business

This project has involved the exploration and investigation of a supervisory control.

By way of system design and implementation, I have demonstrated that supervision is an effective model for building Tele-operation systems. Supervision can serve as the basis for the design, providing clear principles upon which it can construct user interfaces and robot controllers. Through evaluation, I have provided evidence that the supervisory control method helps to coordinate robot action, facilitates adjustable autonomy, and enables human compensate for an inadequate autonomy. In short, I have illustrated that supervisory control: Enables joint problem solving. As the robot can execute some aspects of planning on its own, the operator does not have to bear all the planning responsibilities.

Supervisory control preserves the best aspects of both the direct and autonomous control by the use of the human perception and cognition but does not require situation-critical or time critical response. In other words, Tele-operation can be improved by inverting the conventional approach so that the human works for the robot. Supervisory control facilitates a mutually beneficial relationship between robot and human. With the supervisory control, the robot can request the human for assistance to help compensate for limitations or inadequacies in perception, planning, and cognition. Since the robot informs the human when help is required, the human does not need to monitor the robot on a continuous basis.

This produces better results than those that could be obtained from either the robot or the human independently. Minimize the operator effect on system operations. By minimizing the need for the continuous human involvement using the supervisory control system, it is possible to match operator's and robot's roles. This enables a robot to have more freedom during execution. If the operator is unavailable, inattentive or makes an error, the robot can still function effectively.

Because we can adapt a human-robot communication, based on the human's availability, knowledge and expertise, supervisory control facilitates the support of a wide range of operators. Specifically, it allows building systems, which are user adaptive. This facilitates the configuration of system parameters and interface customization to match the user's capabilities and resources appropriately. Although this does not guarantee that all users will be able to perform a specific task with equal results, it does provide a mechanism for improving each user's utilization of the system. Robot is a mechanical device capable of performing programmed tasks that appear to possess intelligence.

However, this is limited to the scope of the controlling program for the intended task. In cases where it encounters situations that it cannot process, it fails to operate. Science fiction has popularized the notion that robots possess human-like intelligence. However, when a robot encounters situations beyond its cognitive and processing abilities, it requires the intervention of a human controller. In situations where a robot senses an obstacle on its path, its program should guide it to respond appropriately. Thus, it can stop for a while and choose an alternative path.

Nevertheless, if the size or shape encountered is beyond the original scope, for example, a shadow of another object, the robot may become stranded or take undesirable steps. In such cases, the human intervention can override the processing limitations of the robot and proceed on its task. Channels of communication like sending the image of the obstacle to the human controller can facilitate the accomplishment of this cause. Similar situation can arise for a robot designed to detect intruders or motion in a building to prevent unauthorized entry. Here, sensors depend on the changes in the vision or sound patterns.

However, robot can have problems in accurately detecting the intrusion where the stimulus it receives lies on the border of the valid and invalid input threshold to trigger the alarm. This may result in false alarm or worse, the robot may fail to raise the alarm even if the situation calls for such an action. Nevertheless, the presence of the robot's channels of communication with humans such as camera images facilitates easier detection of the nature of intrusion and act accordingly. There is no doubt that robots can efficiently make decisions by themselves if they are in environments where there are no random inputs such as in assembly lines. The algorithm provides unambiguous solutions, which make robots appropriate for fast automation jobs. However, in situations where unstructured decision-making is involved, and there is a need for the use of common sense, human intervention is necessary (Clarke 1994).

In tasks associated with high-level perceptual recognition, object recognition and situation assessment, the performance of robots remains unsatisfactory (Mailgram et al. 1993). Thissuggests that, with the help of the human intervention, robots’ performance can considerably improve as the human expertise eliminates the limitation of perception and cognition. To achieve this cause, robots would need to function not as passive tools, but as active partners with their operators. Therefore, robots must be able to act on their own in unambiguous situations with more freedom to act, but refer to human help when necessary.

A robot ceases to be autonomous if its every command originates from the human operator. The “ Human as a controller” model engages humans to receive the information and processes it to generate the control command that the system will execute. Although the “ Robot as a tool” demonstrates the robotic actions’ limitation, the “ Human controller” also has challenges in the Tele-operation mode. The first problem in the “ Human as a controller” model arises from the imperfect human-machine communication, which affects the performance. Poor interfaces prevent the operator from closely engaging in the task, thus limiting the ability to act directly.

Moreover, the risk of noise or delayed transmission affects the communication quality. The situation worsens if the robot and the controller are widely separated. (Sheridan 1993). Another problem in this model is the value attached to the human resource, which limits the robotic system to the responsiveness of the operator. This considerably obstructs the purpose of automation.

Despite the fact that the robot has a better performance in terms of accuracy and repeatability, it is restricted to the limited capabilities of the human operator. Tele-operations clearly illustrate this scenario. Problems the system encounters are the operator limitations based on their skills and knowledge, and sensor-motor response limitations, which include reaction time, decision delays and cognitive and perceptual errors such as misclassification. (Ferrel 1967; Sanders 1993; Sheridan 1992). As there are numerous challenges associated with the models of the “ Robot as a tool” and “ Human as a controller”, a better model is envisaged that eliminates the limitations of both of these systems.

The “ Supervisory Control” model allows both human and robot participation and facilitates the human-robot Interaction. In this model, human and robot interact by performing the complementary tasks, thus succeed in achieving common goals. Although robot acts autonomously, human can guide the robot in situations where it is unable to make a decision. For example, if robot is stalled because its algorithm cannot attain the shortest route in case of an obstruction, a human operator can lead the robot quickly from such an impasse. In other operating matters, robot has the freedom to execute its functions, which best suite a task.

Robot will not stop operating even if the operator is unavailable or distracted. Thus, the Tele-operation renders the system more adaptable and flexible offering higher levels of autonomy and utilizes optimum capabilities of human and robot. This marks a radical departure from the conventional Tele-operation or from the “ Robot as a tool” model. Supervisory control facilitates natural and balanced human-robot interactions. Robots benefit from overcoming the limitation in perception and cognition instead of only the command generation.

The Supervisory control has the obvious advantage of better coordination between robot and human in working together. The tasks in which the joint operation is critical, as in human-robot explorations, the practicality of the model is quite evident. In areas where total automation is considerably difficult to achieve, it is acceptable to exploit human capabilities. The supervisory control utilizes the effective human-robot interface, and thus, is superior to the fully autonomous or direct control models. In a clear departure from the traditional models, it enables the human-robot interaction operate like the more effective human-human interaction. The supervisory control also makes Tele-operation more flexible.

The robot acts and functions as a partner instead of solely following a continuous stream of instructions. It can work regardless of the partial control exerted by humans. The important characteristics of Supervisory control are: It enables Human to be part of the robot resources It offers an effective framework for collaborative coordination It is marked by an efficient adaptive mechanism Let us examine these characteristics in detail. Supervisory control makes human act as one of the robot resources. Some researchers (Rosenblatt 1995) have studied the use of the human as part of a robotic system as an element or a module.

However, these approaches define the role of human as that of providing control input to the system. The Supervisory control expands the human involvement beyond this narrow role envisage. Robot can request for the human assistance when undertaking perceptions or decision taking, which are in contrast with the model where human assumes the role of providing inputs. This leads to several important outcomes. First, robot is no longer limited to pursue a strategy limited by its algorithm, but can seek alternate solutions from a human controller.

Thus, the supervisory control enhances robot's operating horizons no longer limited to the program's design. If robot is unable to decide on how to proceed, a novice can use Tele-operations to guide it. Secondly, robot can take on an " equal' role during Tele-operations. It has autonomy in all situations where it can act, and only seeks the human assistance when it is stuck. Furthermore, this is beneficial to a human because he or she does not require being " in a loop" all the time. Moreover, the operation becomes independent of time-critical response from the supervisor.

Even if the human resource is unavailable for some time, the system can continue functioning. Supervisory control can adapt to the requirements of differing situations. Although robot seeks human assistance when necessary, it can also work in situations where humans fail to respond immediately to particular cases. It allows a fine trading off and the controls' sharing to achieve the required results. Specifically, in a situation where robot is not functioning appropriately, it has the opportunity to hand over the decision-making role to the human for that specific situation. In other words, supervised control enables the dynamic allocation of roles to robot or human throughout the task performance.

This project is an investigation of supervisory control. The aim is to illustrate that a Tele-robot is more capable than a Tele-operator as it performs considerable tasks. In the following chapters, an establishment of what is needed to design, build, and operate a supervisory control system was made. In particular, project's objective is to identify the fundamental issues presented by the approach and techniques required to implement such a system. Then, through demonstrations, evidence is provided to support the claim that " combination operation between human and robot is an effective model for building and operating Tele-operation systems".

A supervisory control system refers to this combination. The outlining of the structure of the report is in the following chapters below, which discusses requirements to design and build a Supervisory control system. Chapter 2 reviews technical literature on the functions of the various robotic control systems and the methodology based on the factors for developing supervisory control system. The description of the vehicle Tele-operation concerns its characteristics and systems models conventionally deployed. The chapter concludes with the examination of the key design issues that require attendance.

Chapter 3 elucidates the development of the general design principles, reviews the design approach, and then, describes the system architecture needed to create the Supervisory control for this project. Chapters 4 and 5 describe the individual components specifications required and the implementation details of the system architecture developed in Chapter 4. In Chapter 6, the application of the system in vehicle Tele-operation is examined, which presents the results of the system testing with an analysis of the impact of Supervisory control in vehicle Tele-operation applications. Chapter 7 discusses the strengths and weaknesses of Supervisory control, indicates the directions for future research, and summarizes the contribution of various research works to Supervisory control. Appendix A describes the toolkit (Arduino Mini POP Bot) developed during the course of this project, appendix B describes the User Interface and appendix C presents the planning details from a project management perspective. Before tackling the actual work needed to complete the project and fulfill the project aims, it has been vitally important to have some idea regarding the undertaking of the work and supervising my project.

I created a Work Breakdown Structure (WBSs) by outlining the main objectives. I was able to represent the project in a diagrammatical form by creating a Gantt Chart. This provided a clear insight into various activities regarding their duration and milestones. The planning techniques mentioned above allowed me to monitor the project closely for the project research's, development of the system, regular supervisor meetings, monthly progress, first, second and final digital submissions.