What is Automation?

When a single computerized or mechanical device or series of devices (machines) do something that may be normally done by a human they are considered to be automated. Since the 1950-1960's, the ability of machines to do things for or instead of humans has increased exponentially. Gordon Moore created Moore's law to describe this phenomenon in transistors <https://en.wikipedia.org/wiki/Moore%27s_law>. Moore's law states that technology will increase exponentially. While we had simple consumer machines in the 1950's such as toasters, now we have machines or computers for nearly everything.

For example, in a kitchen, computers and other machines make the whole experience of preparing food faster, more efficient, safer, reduces error, and reduces the amount of labor required. In the cases of large commercial kitchens, the robots make their product competitive with others. Humans like machines when they reduce the amount of effort a human must expend to accomplish a task. I would much rather type this manuscript on my computer than on a typewriter or by hand. I would much rather take an Uber to school every morning than drive or take the bus. All three of those (Uber, driving, taking the bus) incorporate different levels of automation.

Levels of Automation

Sheridan and Verplank (1978) along with other researchers proposed that we categorize automation by how much of the work is done by the machine or the human. This categorization is called a taxonomy. A typewriter would be a level 2 automation on the Sheridan and Verplank scale- the machine offers all of the choices. An Uber would be a level 5 automation. In level 5 automation; the human makes the request and the computer executes an action upon approval. See Figure 1 for an example of an automation taxonomy based on Sheridan and Verplank, (1978).

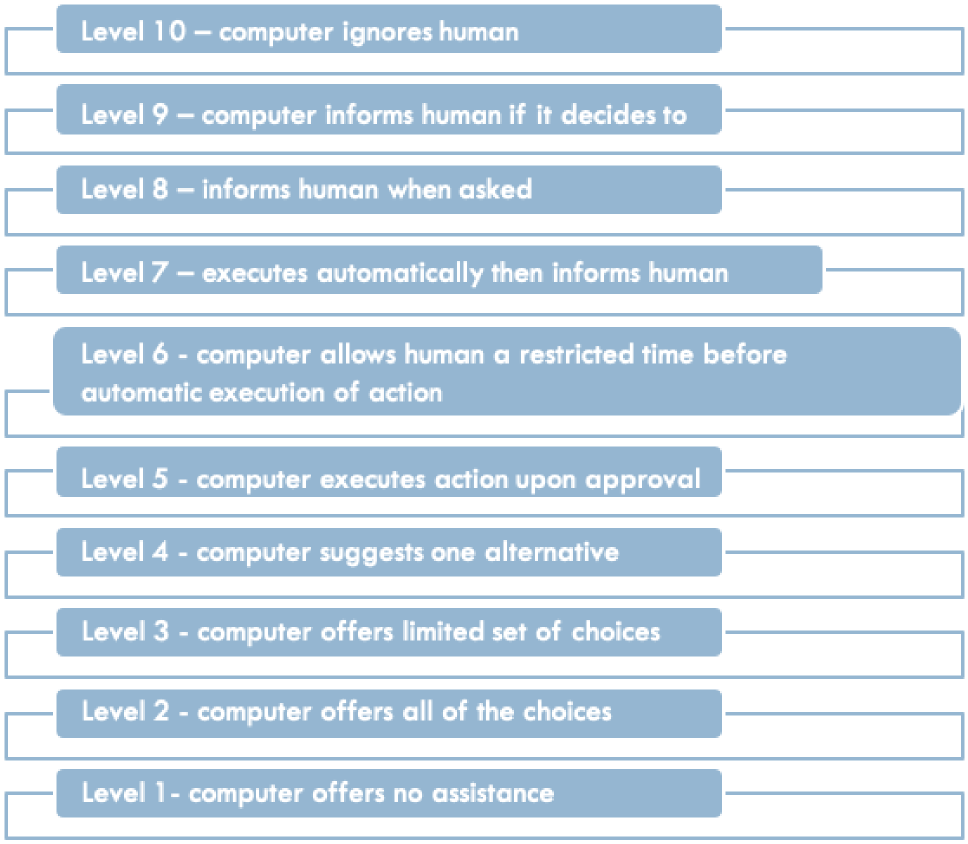

Figure 1. Levels of Automation as described in Sheridan and Verplank, 1978.

As the machine incorporates more and more automation, the human has less and less control overall. As the level increases the machine can act without human knowledge and without human consent. In some cases, this is beneficial to both such as an automatic braking system in a car or an automatic insulin pump for a diabetic patient. There are many times when human interference is detrimental.

In these cases, the machine makes decisions for the human. When the machine's decision does not align with the potential human decision then trouble begins. Such is the current discussion in the justice system. In trials where the judge uses a computer to help her/him to determine a sentence, the defendant may feel that she/he was unfairly sentenced. The computer program has an algorithm that rates a defendant on various criteria. Then, according to that rating, the computer predicts the probability that an individual would commit another crime. This probability influences the judge's decision on sentencing. A defendant with a high probability of committing another crime will likely receive a stricter sentence than a defendant with a low probability. An explanation is here <https://www.brookings.edu/blog/techtank/2019/03/21/algorithms-and-sentencing-what-does-due-process-require/>. The algorithm that controls the ratings can be adjusted based on the criteria, the cases that it learned from, and the bias that is introduced into the program.

OOTLUF

While the justice system sentencing programs offer a striking example of challenges with automation, in general, automation is beneficial as it does the dirty, dangerous, and dull work for which humans are illsuited. In most systems we can clearly state that as the automation level increases, several things happen on the human side. Humans will experience out of the loop unfamiliarity or OOTLUF. Let's take the example of driving and automated cars. As humans drive less, they will become unfamiliar with driving. Their driving skills will deteriorate. If they need to take the wheel, the OOTLUF will interfere and they will be less proficient. An example might be a manual transmission car. If you have learned to drive one, continued practice is necessary to be proficient. If you change to an automatic transmission, your manual transmission driving skills will deteriorate over time.

In addition to OOTLUF, situation awareness and trust increase as the amount of automation decreases or as systems are lower on the taxonomy. For example, you are perfectly aware of what a toaster is doing, how it is doing it, and when the toast will be ready to eat. This is perfect situation awareness, you know the past, present, and future situations and the contingencies and dependencies. Contingencies means that you know that if you smell bread burning, it is likely that small crumbs of bread became wedged into the heating coils and you must unplug the toaster to prevent a fire. Dependencies are such that the toaster must be plugged into the wall outlet to work. The machine is dependent on electricity. Remember that the toaster is on the lower levels of the taxonomy- about level two with trust and situation awareness at the maximum level.

Situation Awareness and Trust

As the levels increase, my situation awareness and trust change. When I call an Uber to come pick me up from work, I have a vague idea of how Uber contacts the drivers and decides who will pick me up. But, my situation awareness is restricted to what the interface reveals to me. On the interface on my cell phone, I can see the tiny cars driving around the map, but have no control over which car comes to get me and who the driver may be. This lack of control along with the lack of situation awareness contributes to my level of trust. If my previous experiences with Uber have been positive, I may trust the system to provide the best driver for me at that moment. If previous experiences had not been positive, I may feel frustrated over my lack of control and feel that the automated Uber algorithm will choose a driver at random. The more that the interface can reveal and communicate to me, the better my situation awareness and trust will be in the system/machine.

Overall, in a perfectly operating system that never fails, humans trust it to perform correctly about 67% of the time. In other words, about 33% of the time, I will expect that the Uber algorithm chooses a driver that is unsuitable for the task in that she/he won't know the way around town, will drive slowly, disobey traffic signals, or has an abrasive personality. System designers have a better understanding of how any system works because they have more complete mental models of how systems are designed and operate. So, someone with expertise in system design may have a different trust ratio.

Part of my loss in situation awareness and loss of trust in the system have to do with some of the challenges inherent in automating a process. Whenever you decrease human error by automating a process, you increase the probability of system error. For example, if each component in the system fails only 10% of the time, it is 90% reliable. To obtain the entire system's reliability, multiply each component's reliability. In a system with two components, each at 90% reliability, .9 x .9 = .81 or 81% reliability. Wickens, Hollands, Banbury and Parasuraman (2013) discuss this at length.

Measuring Situation Awareness and Trust.

In the situation awareness chapter, measures are discussed in detail. All of these measures are sufficient in determining how well the operator can predict what the system will do next and the current system state. For trust, there are several new measures, the Human Computer Trust Scale or HCTS (Jian, Bisantz, & Drury, 2000) and the Trust in Automated Systems Scale or TAS (Madsen & Gregor, 2000). Both have been validated extensively and are considered to be reliable measures of trust in a machine or computer system.

Overconfidence

Many systems rely on each other and this inference of trust and reliability will transfer from one perfectly reliable machine to other components that are not as reliable. For example, a new automated thermostat (i. e., NEST) runs the heating and cooling system. People may trust one system more than the other. The person who runs the heating system may trust the heating and cooling system even though it is a very old boiler system because it is predictable and has been reliable over the years. The person is overconfident in the system. When the new automated thermostat (NEST) returns a system malfunction error and the boiler doesn't heat the building, the person is more likely to ignore the new thermostat's report that the boiler is malfunctioning and look for the error in the new thermostat than look for the malfunction in the boiler.

Complacency

Let's say that the heating and cooling system has been working without error for several years. The person managing the system may neglect to perform the maintenance because the system is running so well. Or the person may ignore a minor error code that signals a possible future malfunction because of the positive history of the system. This happens with car owners and the engine warning light. Because the engine works fine and feel fine as the car drives, the car owner is more likely to ignore the light. If the car could give the owner a detailed warning, owners would be less complacent as their situation awareness and trust would increase.

Overconfidence and complacency issues are prevalent in aviation. There have been several incidents where airplane pilots till turn off the autopilot because she or he doesn't believe that the instrument panel is correct. When this happens, the pilot will take manual control of the plane only to discover that the instrument panel has not failed and he/she should have left the autopilot in control of the plane. At the time of publication of this chapter, the Boeing MAX 737s are still grounded because of automation issues. In this particular model, the Maneuvering Characteristics Augmentation System or MCAS system will override pilot manual control, reboot and misinterpret sensor data < https://en.wikipedia.org/wiki/Maneuvering_Characteristics_Augmentation_System>.

This phenomenon is not new, in 1997, a Master's student devoted a thesis to the issues of automation in planes. While this document is not widely read, it is very informative to those without a background in aviation. It can be found here <https://apps.dtic.mil/dtic/tr/fulltext/u2/a327119.pdf> .

It is easy to disparage automation because of these events. Increased automation does save lives as it prevents human error. Approximately 80% of aviation accidents can be attributed to human error according to Boeing <
https://www.boeing.com/commercial/aeromagazine/articles/qtr_2_07/article_03_2.html
>.

The current view on automation supports increased automation along with better cooperation with humans. It also recognizes the view that humans fail to value automation appropriately. Research is actively searching for ways to increase human compliance with automation as well as human acceptance of automated processes. Some of the most recent research has suggested that automated systems should behave more like humans to increase acceptance. This means making occasional errors as humans do, providing varied and consistent feedback, asking for permission, apologizing for errors, asking the human questions, and occasionally failing on purpose to help maintain human operator skills and situation awareness. Do you think that these recommendations are good or bad?

Adaptive Automation

When we think of automated systems, we often think of static automation. This is when the level of the automation is constant. For example, the toaster will always toast the bread at the designated setting. The toaster will not sense the environment and change the toaster settings on its own- it has static automation. Adaptive automation senses the environment and changes or adapts to it. The environment could be the physical environment or the human operator/passenger/user.

Automobile braking systems in new cars is an example. First, the braking system waits for the human operator to react. If the sensor determines that there is no longer enough time for the human operator to press the brake to avoid a crash, the automated braking system will engage and prevent the accident. Future adaptive automation in vehicles could sense when the driver is not paying attention through an eye-tracking system near the windshield. In either case, the adaptive automation senses something in the environment and this triggers a change in the automation.

Autonomy

Autonomy is the highest level of automation on any taxonomy. Autonomy occurs when the machine operates independently of any human control. Typically, when we think of robots, this is what we assume. The robot acts on predetermined or learned objectives and performs the tasks independently of humans. There are many concerns regarding this technology. These include system feedback and system state, the goals and directives of the system, and etiquette. Sometimes it's hard to think of a robot having etiquette, but if you think of the way that people interact, then it makes more sense. People know how and when to interrupt each other without being disruptive. There are stated rules between people to maintain civility. There are additional rules that govern communication between humans. These communication rules are the Gricean Maxims here <https://psychology.wikia.org/wiki/Gricean_maxims>. Increasingly, designers are incorporating etiquette, communication rules, and more transparency into autonomous systems in an effort to increase human acceptance < https://www.zdnet.com/article/robots-take-on-nursing-duties-at-japanese-hospitals/>.

Ultimately, as with automation, autonomous machines' greatest hurdle is human acceptance and trust. In order to increase trust, there should be excellent system feedback with the operator. Humans must understand what the system is doing at any given time. This helps with human situation awareness as they can step in at any point when the system falters. Treating the automation and the human as equal team members ensures that both give their full attention to the goal and help each other.

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