Automation of Engineering Documentation

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Dylan House

Spring, 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Bryn E. Seabrook, Department of Engineering and Society

Introduction

What would a future look like in the engineering field where daily small tasks like documentation are automized? Engineers spend a sizable amount of their time creating documents and reports that could potentially be automated. Estimates suggest that engineers spend 32% of their time doing "non-value added work" such as *How Are Engineers Spending Their Time?*, n.d.). In addition, around five hours per week are spent generating drawing documentation per engineer(*(26) Engineering Team Spending Too Much Time on "Other" Documents? You're Not Alone... | LinkedIn*, n.d.). Clearly there is an established need for greater automation in order to improve workplace efficiency. It is necessary to properly assess the usefulness of automating these repeated tasks. The purpose of this research paper is to address: what would automation look like in engineering documentation and design? In addition, potential security risks of automation, the impact on relationships with customers, and potential automation errors are included in this investigation. The framework of sociotechnical systems theory helps discuss the integration of automation into engineering documentation.

Methods

To discuss the implementation of automation into engineering documentation, this paper utilizes different methods for the discussion. First, there is brief history of different types of automation in engineering documentation. Next, an overview of how Artificial Intelligence (AI) works is discussed. The sociotechnical systems theory, the framework for the science and technology analysis, is then introduced. For the results and discussion of this paper, an outline of different documentation is provided, and case studies are brought forth to highlight the pros and cons of AI along with its implementation into engineering. Throughout the results and discussion section the sociotechnical systems design approach evaluates the answers to the research questions.

A little bit of history

Just like any business, engineering firms look for ways to maximize their time to increase their profit. There have been many different efficiency tactics employed by engineering firms, but the focus of this paper is solely on automation. Automation itself comes in many forms, it can look like a water wheel that generates electricity, a steam engine train to transport goods faster or even an industrial controller that regulates systems autonomously (*Timeline History of Automation - How Automation Was Evolving*, 2022). In the context of engineering design and documentation, the history of automation narrows. In automating engineering documentation there have been many software programs introduced that have made engineers' jobs easier.

One type of software automation, Computer Aided Design (CAD), has seen many improvements which have significantly reduced the time for creating schematics and drawings. Originally, engineering designs were on paper and multiple sketches and perspectives were needed to convey the designs accurately. Automation and improvements of this software has come in waves which have significantly helped lower the time required for drawing and simultaneously allowed for more complex drawings. In 1957 PRONTO, the first numerical control programming system was made, sparking what is known as CAD today. In 1963

Sketchpad was the first system to use a graphical interface which allowed users to use light pen on a display allowing properties to be constrained in drawings. A little over ten years later the first 3d modeling software, CATIA, was released significantly improving the CAD experience. Since then, there has been an exponential increase in technology that has allowed 3d drawings to be transferred and combined, simulations to be run, and even the ability to scan objects and automatically make a model of them (Beck, 2017). The question now is, what is the next advancement for CAD and other engineering documentation methods?

One potential next step in automation is AI. Document scanning and interpretation is currently a technology that AI is capable of so applying to engineering documentation is promising. AI document processing uses machine learning and other methods to extract data from documents and identify and comprehend the meaning and context. Machine learning relies on large sets of data to train the AI on how to function and recognize things (*AI Document Processing Explained*, 2023). One example of machine learning is instead of coding every scenario of what a chair looks like and is, you can instead give the AI tons of images of chairs and let it figure out its own interpretation of what a chair is. The need of large data sets to train the AI becomes apparent as for the AI to be effective there must be good data sets that it is trained on. The need for a large data set highlights the need for AI to be connected to some type of server to function and continue to improve with new data sets.

Socio-technical systems design

At its core the Socio-technical systems design (STSD) methods are a way to incorporate human, social, technical, and organizational factors into the design of a system. This framework allows scholars to better understand the way human, social, and organizational factors affect technological systems usage. The main principle of this framework is that design should consider technical and social factors that influence the usage of technological systems. This approach is important because while the technology in the system may work, if not incorporated into the organizations system well, then the technology will be a failure. Baxter and Sommerville discuss the main characteristics of open socio-technical systems. The characteristics are that systems should have interdependent parts, systems should pursue goals and adapt to external environments, systems goals have more than one means of being achieved. They go on to say these systems should have an internal environment where there are separate but interdependent technical and social subsystems. Lastly, systems performance relies on a joint optimization of the technical and social systems (Baxter & Sommerville, 201, pp.4-17).

In the establishment of a proper STSD the end user must be involved in the design process. Different approaches for integrating the end users were described by Baxter and Sommerville. Participatory design covers a wide range of methods which typically involve the user integrating into the system designers from the beginning of the design. A contrasting design approach is empathic design and contextual design where the developer is put into the work of the users during the system development process. These approaches allow for an understanding of the users work structure which allows the technology to conform to these structures. Most STSD approaches have been centered around a specific market which has led to little significant attempts at integrating these approaches to a more general method of STSD (Baxter & Sommerville, 201, pp.4-17). Some concerns of this method are that there must be suitable users available to interact with the development team and these users must have similar requirements to the broader organizational requirements.

Results and Discussion

In the current state of AI, there is too much risk involved in letting the algorithm fully automate the documentation process of engineering. In the past couple of years there have been many errors with AI that have led to serious consequences, with engineering AI mistakes could have serious ramifications. Partial automation of engineering documents using AI is possible if there is a format established by the users of how the AI should help in their work. More importantly the users should not rely on AI fully and should double check or even triple check the work of the program.

To start discussing the potential use of artificial intelligence in engineering, it would be useful to investigate fields that similarly have high documentation requirements. In this case, a good place to look is the medical field. Medical professionals spend a disproportionate amount of time having to create documents about patients. These forms, such as notes about patients and clinical encounters have importance to the future and current treatment of the patients, so it is critical that they have as little errors as possible. One study done by the National Health Service of England aimed to figure out to what extent automation could be used in the medical field. The study started by observing the typical day of a general practitioner (GP) to understand what were the roles that the automation would need to fill. The general practitioners made notes in the patients' medical records that varied in size based on what the patient is being seen for, the prior relationship between the patient and the provider and the experience of the provider. The documentation work also consisted of referencing codes from the British National Formulary, looking up information online, studying lab work, revising previously written text, and calling specialists for advice. The work had to have been completed promptly too with little delay after the patient had left (Willis & Jarrahi, 2019, pp. 202-204).

Most of that noting work could be replaced with a speech to text algorithm that fills out the information automatically. However, doing this would lose some of the intimacy of the relationship between the patient and the GP. The study found that the GP's often would look back at notes from patients while considering potential treatments, the decision about the patients' treatment was specialized to the patient. If a doctor had not written down their notes but rather had an AI take them, it is possible the doctor would not have been able to recall the case at a later point. To add on to the problems with this voice to text algorithm the study found additional issues. This was the first finding: while the documentation could be automated with an algorithm that takes voice and converts it to speech (voice to text), there is so many personal preferences and different formats in the medical field that need to be accounted for. Additionally, the text to speech algorithm when implemented gave too much information that wasn't needed and proved to be cumbersome to sort through. So, the takeaway is if the algorithm can be trained for the needs and the specific formatting required by the job it would be a good time saver. Lastly the paper mentions that the current state of AI is not capable of incorporating the required intricacies of the field. While there is an outlined potential use for the automation, the technology is not there yet.

The analysis from the medical field is also applicable to the engineering field. If the documentation were to be automated it would have to be robust and be able to adapt to the specific needs of the engineering firm and not create too much information. One major part about the study was the conclusion that at the time of the paper's writing, AI was not up to par with what is required in the medical field. However, it has been five years since writing and AI has gained many new capabilities and much more "intelligence." While it is possible that AI could not fill an equivalent role for the engineering field, it is useful to investigate because one day the technology will be at the required level.

In the engineering field there are many types of documentation. Some types of documentation are technical drawings such as plans for a product or structure, engineering reports, product specifications, protocols and procedures for testing, user manuals, test reports, and change orders and revisions. A lot of this documentation is paperwork that the engineer must complete frequently, and it takes up a good portion of their time. As discussed earlier in the medical field it was seen useful to automate repeated tasks that take up large amounts of time so the same principle can be applied to the engineering field. With an estimated 23.1 percent of engineers' time being spent creating documentation, there is a huge opportunity so save so much time for the engineers to work more research or design (Crabtree et al., n.d., P. 1).

To talk about more specific needs for engineering, multiple engineering document types are analyzed here. To start is an engineering laboratory report on "Hypersonic Wind-Tunnel Measurements of the Boundary-Layer Pressure Fluctuations." The report starts by explaining the importance of the project, explaining that during reentry into the atmosphere fluctuating pressures can cause vibrations of internal components that can lead to structural failure. The report explains research done in this topic by other firms and facilities and gives the general findings of their research, it goes on to explain their partners and give schematics and performance metrics of their corresponding facilities. Next the report has many diagrams and descriptions of the testing device they are using in their facility along with how they will be acquiring the data. The rest of the report discusses their testing results and provides many diagrams and findings with the differing conditions used (Casper et al., 2009).

Automating such a document would present many challenges. A large part of the report consisted of explaining the testing procedures, discussing the testing setup, displaying, and describing schematics, and referencing past work. This portion of the work, especially the procedure, is individualized to this specific scenario and is not something AI could pull from a data base to automatically write for the researchers. The individualization would limit the potential of AI on this laboratory report to a few scenarios. One way AI could be used would be for the researcher to explain the procedure and then the AI program would take the steps the researcher said then elaborate on them using online sources or simply write what the researcher stated. After the AI would write out the procedure the researcher would have to proofread the resulting text for correctness so it is arguable how much time would be saved if significant edits would have to be made. The diagrams and schematics would have to be made at one point by someone, so unless it is already in a database the researcher would have to make that portion of the report as well. The AI could be used to compile all the information given and write a report based on the given information and added information through the cloud. This approach would save the most time for the author, however once again it would have to be checked over by the author for accuracy and grammar. Correctly applying an AI into this researcher's job could help create reports faster, it would need to be applied in a way the researcher would find helpful. Correct application follows one of the ideas in the sociotechnical systems theory that there should be a joint optimization of the technical and social systems. While the AI might have many capabilities, if it does not conform to the technical and social standards set by the engineering laboratory then the AI would not be deemed as useful.

Diving into another document type is a crane design handbook by Whiting Corporation. The purpose of this crane design handbook is to cover the capacity of cranes, the operational practices that are acceptable and to discuss the many advancements in cranes. The handbooks' intended audience is "efficiency and maintenance men" as the handbook is primarily to keep all relevant people informed of almost everything of previous crane models and current crane models so the audience can make informed decisions. Inside the handbook an overview of the many types of cranes and models is given along with their operational speeds, dimensions, and load capacities. To convey this information, descriptions and diagrams of many crane models were present along with tables documenting exact dimensions for the crane based on boom length and configuration. The handbook goes on to describe the design process with equations relating dimensions and loads. For much of the handbook is tables along with text explaining the tables and what each dimension, or speed, or load does to affect the cranes' structure or performance (Greiner, 1967, PP. 2-190).

Once again, like the laboratory report, this handbook would be challenging to fully automate. Sections of the handbook like the history of cranes and previous models can be pulled from data sources and compiled onto the document without much intervention from human authors. Other sections such as the heavy description sections could be potentially automated as well, however, it would have to conform to the standards set by this company and touch on all the information they are trying to convey. Conveying all that specific information could be a challenge for the AI unless there were extensive examples from this company that were fed into the AI so it could understand what the company needs. If the AI were to be trained on all the company documents, it could potentially understand the needs of the company and write a similar document to an engineer. As of right now the diagrams and dimensions would be something that the AI would not create organically, but rather pull from the engineering companies data base and format onto the handbook. Successful understanding of the companies needs by the AI would be an optimized program as it would have incorporated the needs and structure of the company socially. Under the sociotechnical systems theory this understanding by the AI would be a good integration into the company system.

Downsides of Automation

Making sure engineering documentation is correct is extremely importance on many levels for the safety of the public, if automation were to record a number wrong it could lead to a bad design choice and if not corrected it could lead to failure in real life. A failure in real life could be anything from a simple warping that shouldn't happen, to something like a bridge collapse. Another point of issue would be if the specific policies the engineering firm wants the AI to follow are broken by the AI. An example of this can be seen with Air Canada's chatbot that managed to get the company into a lawsuit. Air Canada was sued after their chatbot lied to a customer about a policy which did not exist. The error led to a customer being misinformed about being able to get a refund on tickets when air Canada had no such policy (Cecco, 2024). This chatbot scenario shows that even the simple task of reading off a list of policies can be too much for the current state of AI. This chatbot scenario highlights a perfect example of a small error that led to a large financial disaster. Such an error could potentially happen to an automation bot that an engineering firm employes, especially with the much more demanding tasks an engineering firm would ask of the AI.

A large part of the engineering field is independent companies that are not associated with government work; however, a large part of the field is also government contracting companies and the government bases themselves. Many of the projects being worked on by the government and its contractors are classified and have information that we cannot allow other countries to get their hands on. To handle classified digital information the Department of Defense (DOD) mandates you only use classified networks to transmit information and use an information system that's has been specifically authorized to process classified information (Handling classified information, 2023, P.2). A downside of AI is it needs a server to run on (manuelam, 2024). And with a classified environment there is a need for a classified server to handle the information. The need for a classified server means the DOD would have to create their own server that is private from the public. Earlier it was mentioned AI needs tons of data to operate correctly, so the DOD would have to feed extensive data into their classified server which would be a huge undertaking.

Future researchers looking into automation into the engineering field should investigate the trade from the initial investment of training the AI to a company's specific needs and the time that would be saved by using automation. Because while AI automation is great and there is a very promising field for it, in the engineering field the AI's work would have to be checked and this would take time. Even calculations from trusted sources are checked in the engineering field using different methods. At the end of the day saving time in the engineering field is good, but saving too much time and potentially missing a detail could lead to horrific things.

In conclusion, automation from AI can be a very useful tool for engineers. Currently there is limited uses for AI due to its current capabilities and the nature of engineering documentation being based off things that might not yet be in the AI's data base. In the future as AI's capabilities increase, there is a promising opportunity to save time for engineers as long as the technology sticks to the social structure of the engineering firm and the engineering field as a whole. It should be noted also that with the nature of how many mistakes AI is making any work made by

AI in an important field like engineering the work should be reviewed heavily. As with any new technology there is excitement at the possibilities but there should be a systematic release of this technology into the work field with each step having multiple checks to ensure the accuracy of the software and the safety of the public. To answer the original questions in a more concise way is hard, but in short yes, AI can save time for engineers if implemented correctly.

References

(26) Engineering team spending too much time on "other" documents? You're not alone... | LinkedIn. (n.d.). Retrieved February 13, 2024, from https://www.linkedin.com/pulse/engineering-team-spending-too-much-time-other-documents-blaine-watson/

AI document processing explained. (2023, August 23). Nanonets Intelligent Automation, and Business Process AI Blog. https://nanonets.com/blog/ai-document-processing/

Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, *23*(1), 4–17. https://doi.org/10.1016/j.intcom.2010.07.003

Beck, A. (2017, September 26). *60 Years of CAD Infographic: The History of CAD since 1957*. CADENAS PARTsolutions. https://partsolutions.com/60-years-of-cad-infographic-the-history-of-cad-since-1957/

Casper, K., Beresh, S., Henfling, J., Spillers, R., Pruett, B., & Schneider, S. (2009, June 22). Hypersonic Wind-Tunnel Measurements of Boundary-Layer Pressure Fluctuations. *39th AIAA Fluid Dynamics Conference*. 39th AIAA Fluid Dynamics Conference, San Antonio, Texas. https://doi.org/10.2514/6.2009-4054

Cecco, L. (2024, February 16). Air Canada ordered to pay customer who was misled by airline's chatbot. *The Guardian*. https://www.theguardian.com/world/2024/feb/16/air-canada-chatbot-lawsuit

Crabtree, R. A., Baid, N. K., & Fox, M. S. (n.d.). *Where Design Engineers Spend/Waste Their Time*.

Greiner, H.G. Whiting Corporation. (1967). Crane Handbook. Whiting Corporation. Chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cranebuzz.com/IndustryStandards/Whiting%20Crane%20Handbook.pdf.

Handling Classified Information. (2023, March). *CDSE Pulse, volume 4(issue 3), P. 2. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cdse.edu/Portals/124/Documents/publications/pulse/CDSE_Pulse_March2023.pdf*

How Are Engineers Spending Their Time? (n.d.). Engineering.Com. Retrieved February 13, 2024, from https://www.engineering.com/story/how-are-engineers-spending-their-time

Manuelam. (2024, February 27). AI server: What you need to know. *BHOOST - ENG*. https://www.bhoost.com/blog/ai-server-what-you-need-to-know/

Timeline History of Automation—How Automation Was Evolving. (2022, April 26). Progressive Automations. https://www.progressiveautomations.com/blogs/news/the-evolution-of-automation

Willis, M., & Jarrahi, M. H. (2019). Automating Documentation: A Critical Perspective into the Role of Artificial Intelligence in Clinical Documentation. In N. G. Taylor, C. Christian-Lamb, M. H. Martin, & B. Nardi (Eds.), *Information in Contemporary Society* (pp. 200–209). Springer International Publishing. https://doi.org/10.1007/978-3-030-15742-5_19