Artificial Intelligence and Commonsense

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Abstract. The use and development of artificial intelligence (AI) capabilities in a company's production environment is critical to improving assembly process times and product quality. Manufacturing processes are complex and require highly skilled operators to build quality products. Production processes and engineering designs are even more complex and new methods must be employed to address these complexities. AI technologies hold promise to address these complexities using 'commonsense' knowledge (CSK) tools. Implementing and using CSK capabilities has accelerated the growth of AI applications in industry. The development of AI capabilities has been a slow and painstaking process in its attempt to fully mimic the capabilities of humans. However, there is much work to be done to duplicate human process capabilities in an AI system. As new technologies are developed and made available to the design and development engineers, the acceleration and growth of AI capable systems will grow exponentially.

Keywords: artificial intelligence, commonsense knowledge, complexity, engineering designs, product quality

1 Introduction

The design and development of AI capabilities has been a formidable task for over a half century. AI developers face the challenges related to the digital capture of human-based CSK [4]. Some of the early researchers in AI include John McCarthy, Marvin Minsky, Nathan Rochester, Alan Turing, Arthur Samuel, and Claude Shannon. They had a daunting task which continues today of determining how to utilize the existing technologies of their day to create AI capabilities by using computational logic to capture and classify normal human CSK reasoning [11]. Because computational technology capabilities have expanded greatly since the 1950s, the development of AI and machine learning technologies (expert systems) have continuously improved [7]. One of the initial expert systems, an early form of AI, was the MYCIN system, used in the medical profession. The MYCIN system is a program consisting of many patient symptom questions used to best advise

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physicians diagnosing and treating blood diseases [2]. Companies and academia across the world are investing significant capital funds to make breakthroughs in AI capabilities in the quest to have machines perform most or all tasks that humans do today. One of the key foundational requirements in the design of an AI expert system is the use of 'CSK' elements. This research study will investigate these elements associated with AI systems.

2 Defining CSK

Implementing AI capability requires the development of an 'expert system'. An expert system utilizing CSK knowledge data, requires the use of mathematical-based probability and inference theories, applied to random processes and samplings in AI and machine learning systems [3]. An expert system must be able to perform processes such as [8]: perception, interpretation, reasoning, learning, communication and decision-making in order to arrive at a solution for the given problem. The design of an expert system is the combination of stored human expert knowledge and intelligent database content where knowledge is used to solve problems, but this expert system design lacks the ability to address unknown or undefined situations [2, 12].

The design of an AI system improves upon the use of stored information and the use of CSK knowledge to address new and undefined situations, conditions, or problems [12]. John McCarthy proposed that if a technology is to be defined as AI, it must demonstrate an ability to perform CSK reasoning, the use of mathematical logic, and the use of inference logic applied to its assemblage of knowledge resources [11]. An AI system uses CSK knowledge, stored information, and deductive capabilities to solve problems and develop new knowledge that would typically require significant human capital investment to achieve [8].

3 CSK in AI Applications

The progress in developing effective AI applications has been slow. The availability of new computational, visual, audio, and sensor technologies has greatly accelerated the abilities to develop many new types of AI capabilities. However, the significant scientific and engineering challenge relates to the intricate workings of the human brain. There are many functions and capabilities of the human brain that are still unknown, but research continues to discover and expand the knowledge base of these functions. There are several approaches taken to classify and document events when translating human mental and physical abilities into digital data. One approach taken, as noted by McCarthy, is the construction of mathematical models. The other approach was analysis of pattern recognition, used by Minsky. Both of these approaches fit into the realm of developing a large repository of CSK elements which will enable computational devices and machines to function independent of human intervention.

The development of AI capabilities is dependent on the analysis and understanding of CSK knowledge within the context of an expert system. CSK knowledge "can be viewed as a collection of simple facts about people and everyday life, such as 'Things fall down, not up', and 'People eat breakfast in the morning'" [9]. Reasoning of CSK knowledge in AI systems is critically dependent on the use, understanding, and context of natural language, digital visual image interpretation, and robotic action/reaction to unanticipated situations [1, 3, 4, 5]. The formidable task in the development of an effective AI system is the central problem related to the computational analysis, understanding, and reaction to the accumulated expert system data and the accumulated CSK [9].

In order to make AI applications more effective and useful, the application developers must construct a significant data file of CSK knowledge content. With the AI design "many tasks that humans can do, humans cannot yet make computers do" [10]. There has been substantial progress made in four areas related to CSK reasoning/knowledge in AI [3, 4]:

- Reasoning about taxonomic categories – collection of categories and individuals and the relations between them. The interrelations include: a dog is a mammal, which is an animal – one is a subset of the other. This is a simple taxonomic structure which is used in AI programs. Besides subsets, other elements would include: instance, disjoints, properties, transitivity, and inheritance. An example would include web mining searches to collect CSK knowledge from web documents.
- Reasoning about logic – the strategies used as a theoretical framework to encode CSK knowledge can be expressed symbolically and reasoning can be characterized. The components of logic are: syntax and symbols, mathematical semantic characterization, and a CSK inferential sequence of axioms.
- Reasoning about time – temporal reasoning representing knowledge and automating reasoning about times, durations, and time intervals is a largely solved problem. One difficulty relates to natural language interpretation, which is complex and context dependent.
- Reasoning about actions and change – events are atomic (one event occurs at a time), every change is a result of an event, events are deterministic, single actor, and perfect knowledge. The domains that satisfy these constraints, the problem of representation and important forms of reasoning such as prediction and planning, are largely understood.
- Reasoning about space and sign calculus – CSK spatial reasoning includes visual cues, robotic manipulations, physical and biological reasoning, and folk psychology and sociology. There are two forms of sign calculus used in CSK reasoning processes. Situation calculus uses a branching model of time to characterize planning with alternative possible actions. Whereas, event calculus,

uses narrative interpretation - events are treated as atomic where the order of the events is known.

The implementation of CSK knowledge capabilities into AI systems is critical to the further development and improvement of process controls. The implementation of CSK processes “represents the base level of context that one can assume by default, exclusive of specialized domain knowledge and user-personalized details” [9]. One of the most difficult tasks in AI development is the issue of ambiguity. The configuration of a large set of CSK knowledge data must consider the “disambiguation in a number of natural language and speech interfaces” [9].

4 Proposed Enhanced Form of Educational Technology

The incorporation of CSK capabilities into AI applications in industrial processes and instructional designs can enhance the overall manufacturing capabilities. The integration of AI and augmented reality (AR) technologies in training and industrial applications can enhance overall productivity processes and product quality. These technologies are enhancements that are slowly being implemented in many industries. AI and AR enhanced processes can be used in instructional training as well as in the production environment.

Technologies such as iPhones, iPads, and smart glasses use AR application capabilities to enhance an operator’s skills when performing process tasks. These technologies enable the user to complete process tasks without being dependent on external resources. The CSK enhanced AI/AR technologies are used to develop what is being termed the new digital factory or Industry 4.0 [6]. The design of this type of AI/AR technology would digitally integrate all aspects of a manufacturing task requirements into one expert system [6, 8]. All of the drawings, procedures, planning, checklists, and process final acceptance would be integrated into one software application. As the operator works through a process task, whether on the production floor or in a training environment, the AI/AR expert system would be utilized to complete the operations of a given task.

The AI/AR interactions would include process checks to ensure the operator is completing the manufacturing process steps in the correct order and continuously check the ongoing assembly process to assure that all of the task steps are completed before the operator moves on to the next operation. Throughout the task process, the AI/AR capable system can check and measure the overall process performance and make suggested process improvements to address process times and product quality issues.

The AI/AR expert system would include the virtual display of the process drawings, procedures, planning, checklists, and final acceptance for the operator. The operator would use the built-in features of the application to display all of the required documentation necessary to complete the process task(s). An additional feature is that in conjunction with the AI/AR application capability, the production parts will have virtual overlays that guide the operator through the complete assembly process. The integrated design of the AI/AR expert system in a production assembly process can be simulated in the classroom to train the operator in the complete end-to-end process. The benefit of the AI/AR production design is that the application is used to enhance the learning environment during the initial operator training as well as the actual production task process. The overall benefit of the AI/AR expert system is that the instructional content of the application is the same as the actual production content so as to maximize training and task effectiveness and efficiency.

5 Added CSK Features

One of the key CSK features that can be added to an AI/AR expert system is the ability to capture all of the process steps used to complete an assembly process. Research studies at MIT have implemented AI capabilities that include [9]: predictive typing, speech recognition, natural language understanding, end-user programming, activity recognition from sensor data, interface to other networks, online helps, and live video conferencing capabilities. All of these capabilities are available and used currently, to some degree, throughout industry.

With the mix of generational workers in industry today, companies are faced with many of its employees at or close to retirement age. A big concern is how the company can capture the CSK and operational knowledge of its older workers before they retire. Many of the company's production processes are done by older employee operators that have performed these tasks many times. These operators have developed a skill base that is not formally documented. Implementing CSK measures in the design of the AI system will enable the successful knowledge capture of these older workers as they perform their daily tasks. The AI/AR system can capture and compare the engineering, manufacturing, and planning requirements to the way the operators perform their process steps. The AI system can decipher the differences between the two and formulate suggested process changes and improvements to enhance build times and product quality. Once the knowledge of the older operators has been captured and validated in the AI system, the instructional designers can revise the instructional content and the design engineers can revise and update the engineering and manufacturing process requirements. The capabilities of an integrated AI/AR expert system can minimize the learning curve of new operators by having a well-defined instructional design as well as maintaining up-to-date engineering process requirements used by the operators on the production floor. Without capturing and integrating the CSK skills of the older operators into the AI/AR application, the new operators are more susceptible to making mistakes and producing poor quality products while they are learning these new skills.

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