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A DIKW Architecture for Cognitive Engineering

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Abstract

Though the word "cognitive" has a wide range of meanings we define cognitive engineering as learning from brain to bolster engineering solutions. However, giving an achievable framework to the process towards this has been a difficult task. In this work we take the classic data-information-knowledge-wisdom (DIKW) framework to set some achievable goals and sub-goals towards cognitive engineering. A layered framework like DIKW aligns nicely with the layered structure of pre-frontal cortex. And breaking the task into sub-tasks based on the layers also makes it easier to start developmental endeavours towards achieving the final goal of a brain-inspired system. ***machine learning, cognitive architecture, bio-inspired, Big-Data***

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Keywords:

1 Introduction

Brain has intrigued researchers since the beginning of scientific endeavours. Firstly, beginning of computers saw the advent of exciting developments which culminated to the development of the new discipline of artificial neural networks (ANN). ANNs have been through several generations of major developments, with the recent phase consisting of spiking neural networks based works [1]. Another parallel field of computational neuroscience has been the bio-inspired cognitive architectures (BICA) [2] a field which got major thrust in development. Cognitive architecture (CA) in general and BICA in particular also has a long history and the efforts have been devoted towards trying to emulate the functioning of brain. CAs like SOAR and ACT-R have been under development for many decades and have been applied in various studies [3, **?**]. A third direction in cognitive engineering has been the recent developments in communication and radar which are misleadingly termed cognitive communication and cognitive radar.

With the starting of few major big-science projects [4] to understand human brain, the focus on cognitive architecture has enhanced. The other innovation that has made phrases like cognitive and AI the buzz-words once more is the success obtained by deep learning [5]. Another reason creating an intense interest in brain inspired architecture and hardware is the emergence of big data and the hope that this might be solved using cognitive architectures [6]. The robotics community is also excited about the possibilities of cognitive robots [7].

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In spite of many very well written documents the author feels the lack of a single holistic model for cognitive engineering which is: intuitive to understand; shows action-items on how to implement; shows a long term vision and how that is connected to what can be achieved now; and not too abstract while not being restrictive (and thereby leaving scopes for disruptive innovations and discoveries).

In this work we endeavour to present a model that matches the requirements listed above. In doing so we chose the data-information-knowledge-wisdom (DIKW) model of representing human cognition. And build our proposed cognitive architecture layer by layer. We also present the action blocks that shows how each of the layers can actually be implemented.

Rest of the report is presented as follows. Section 2 presents our model. Section 3 expands the model with action/execution blocks. We end the report with the Conclusion section.

2 The DIKW Model of Cognition

From the seminal works by Fuster [8] to the success of the current generation of deep neural networks [9] evidences suggest that the cognitive abilities of human brain emerge out of a layered architecture of the prefrontal cortex. Having arbitrary layers will make it untraceable and confusing. Hence, we propose to have a layered architecture inspired by the data-information-knowledge-wisdom (DIKW) framework. The DIKW has its own set of merits and demerits as a model. For our purpose of cognitive engineering this appears to be the best available in the open literature.

Figure 1 shows the block level representation of the proposed model. There is a perception path (the left hand column) that shows the path in which signal from environment passes on to the higher levels. The action path (the right hand column) shows the way action signal passes on from the heights level to actuator level. Before explaining each of the blocks we shall put forward the two major novelties in our approach.

1. We have an action block associated with each of the signal processing blocks showing different levels of abstraction.

2. We follow robotics phrases to describe many of the blocks, viz. “plan”, “commands” etc. This is to give a physical interpretation of each block. It can be noted that this is by no means meant to limit the model for cognitive robotics domain only. With expanded meanings of the phrases the architecture can be applied to any generic cognitive engineering task.

We shall expound the different blocks of the architecture now. In doing show we shall approach it from top to bottom, i.e. from more abstract levels to less abstract ones.

Wisdom Level: Compared to the rest three Wisdom, in DIKW, is the one with hardly any proper definition. To take care of this lacuna we deal with this layer with the abstract phrase “wish” or “desire”. So the information that helps us to generate desire can be termed as belonging to this layer. In the data column this can be modelled by different emotions and from which may arise a “wish” to do something. This wish initiates the complete action column.

Knowledge Level: Knowledge is also very vaguely defined in the existing literature. We model knowledge as the ability to link disjoint bits of informations and labels. It can be pointed out here that this problem of linking disjoint bits of information is the focus of many recent efforts [10]. The action column equivalent of knowledge (if we use the explanation of knowledge we discussed just now) is “planning”. Planning needs a holistic view of the situation and the task and hence needs link between all disjoint bits of information. It can also be noted that planning

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