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COMPUTATIONAL MODEL FOR MENTAL FACTOR CLASSIFICATION

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Abstract

Artificial Wisdom is advancement of Artificial Intelligence where wisdom should be recognized with the intelligence. Wisdom can be realized by adding values in the positive decisions. This is resulted in to the overall behavior of human being. Behavior can be demonstrated with the help of simulating thought process. Thoughts are generated in the mind along with the mental state. Mental state also known as mental factor is responsible for arousal of different types of thoughts. Ancient Indian cannon Abhidhamm claimed 52 mental factors. These are categorized in three classes such as Ethically Variable Factor, Unwholesome Factor and Beautiful Factor. Proposed computational model of consciousness demonstrates the classification of the mental states. Dataset consists of 445 samples collected from various respondents by asking three questions. Preprocessing is performed by using the techniques of Natural language processing and non-axiomatic logic. Convolutional Neural Network Machine learning technique applied to classify the mental factors. Performance of the proposed system is measured by applying statistical measures such as Accuracy, Precision, Specificity, Recall and F1-Score. Accuracy for small and large database is obtained as 86.92% and 93.02% respectively.

Keywords:

Cognitive Science, Artificial Wisdom, Thought Generation, Consciousness, Mental Factors

1. INTRODUCTION

. Mental factors are considered very important while generating consciousness in the mind. This consciousness is nothing but the thinking capability oh human being at the particular instance of time. Hence thoughts are prime factor of consciousness. Thoughts are not generated without specific mental state. For example, at the moment someone is having happy mental state, and then the generated thoughts are happy in nature. This mental state is treated as mental factor. Mental factor and consciousness are concomitant. They co-exist. Modern science identified few mental factors but in Abhidhamma model in Ancient Indian literature consists of 52 mental factors. These mental factors broadly classified into three groups: Ethically Variable Factor, Unwholesome Factor and Beautiful Factor. This paper demonstrates the classification of these mental factors which are useful to identify the quality of thoughts and state of mind. Also, this model is useful to inculcate the values of good mental factors in Artificial Wisdom.

According to the article published in Cambridge University press in year 2020; Artificial Wisdom is the advancements of Artificial Intelligence because the term ‘intelligence’ in AI does not represent the current need of the modern society. [1] The term ‘Wisdom’ instead of Intelligence is associated with the modern society needs such as identifying the behavior along with the intelligence and inculcating the values and virtues which makes modern machines intelligent and wise also. Therefore, to serve the humanity better with technology, Artificial Wisdom is the need of future generations.

In 2020, [1] have conceptualized the idea of Artificial Wisdom. They examined the constructs of human intelligence and human wisdom in terms of their basic components, neurobiology, and relationship to aging, based on published empirical literature. Also, they reviewed the development of AI with respect to the model of human intelligence. Governing principles for Artificial Wisdom is identified by them. This paper covers the importance of Artificial Intelligence with it limitations and future need of new term as Artificial Wisdom. While constituting Artificial Wisdom, they pointed out the human behaviour, experiential learning and emotions which must be part of the Artificial Wisdom along with intelligence. Human behaviour is based on his quality of consciousness. Hence, while developing Artificial Wisdom researchers should be focused on the development of consciousness as like as humans in machines.

Paper is organized as follows: Section 2 explains related work. Methodology is described in Section 3. Section 4 discusses Experimental set up. Results and Discussion is elaborated in Section 5. It is followed by Conclusion and references.

2. RELATED WORK

The authors in [2] investigated a computational model of conscious and conscious strategy discovery and advocates a triangulation strategy. Triangulation strategy focuses on three approaches such as age-related changes, microgenetic studies of children’s gleaming, and computer simulations. Though it is computational model, it is not aiming towards emergence of consciousness, but moreover worked on human behavioural changes due to aging.

The authors in [3] discussed computational model for mental tasks classification in their research paper for improving brain computer interface application. Brain reading was taken using EEG. In this research different machine learning techniques for classification of mental tasks from Electroencephalograph (EEG) signals is investigated. Bayesian network, Neural Network, Bayesian quadratic, Fisher linear and Hidden Markov Model classifiers are applied on EEG datasets. The Bayesian network classifier is used for the first time in this work for classification of EEG signals which provides significant accuracy.

Starzyk and Dilip [4] Prasad invented computational model for machine consciousness based on theory of Mind process. Modelling was performed by integrating three subsystems (Sensory motor block, Episodic memory & Learning Block and Central Executive Block) which can generate consciousness in machine. Objective of this model was to create conscious in machine. In the same research paper, LIDA model and CODAM model was compared. Also, Axiomatic Theory of Aleksander is described. This theory is significant contribution to cognitive science. LIDA model by Baar is computational model of

consciousness based on Global Workspace Theory (GWT). Cognitive cycle was introduced by LIDA model which comprises understanding, consciousness and Action Selection Phase. CODAM model recognises importance of attention control, goals and emotions.

The authors in [5] investigated the thought formation by combination of emotions. It is emotion recognition model. They proposed computational model for emotions which was based on the consciousness theory depicted in Abhidhamma - Buddhist philosophical concepts. Authors declares that modelling emotions as a complex system is based on the hypothesis that mind state can be considered as an emergent phenomenon resulting from autonomous, interactive, elementary entities called emotions. Multi Agent Systems (MAS) technology has been used for the realization of model. Capabilities of the model are exposed through a virtual agent application who perceives, understands, uses and expresses emotions. Emotions are demonstrated through Game Play.

The authors in [6] introduced PACMAN computational model for identifying personality traits of individual using mental factors described in Abhidhamma model. They applied Abhidhamma literature of Buddhism to propose a theoretical model of an individual as a stochastic finite state machine. Facebook social media data is used which was accessed from my personality standard dataset to model a user's personality as an evolution of his/her mental states. The psycholinguistic tool namely Linguistic Inquiry and Word Count (LIWC) is used for feature generation. They present a new dataset PACMAN and machine learning module for analysis of mental states of a user from his/her social media data. Support Vector machine is used as classifier and Hamming Loss is used as measure to test the results. Accuracy is found to be 90%.

The authors in [7] from Stanford University investigated a novel computer simulation of the mind using Buddhist theories. Proposed model is composed of the mechanics of human consciousness and cognitive processes. Consciousness, mental states, sense-based and mind-based cognitive processes are designed and developed through this model. By utilizing timed events, individual queues for each of the five senses that are regulated by a central queue for the brain, feature and object memory, and a concurrent sense and mind architecture are implemented and demonstrated using tick-tack program. This research work is useful in modelling and mimicking human cognition.

The authors in [8] address the problem of the computational model of consciousness for artificial emotional agents by designing computer agents aimed at simulating "speech understanding" and irony. Also, he put forth minimal architecture which is able to mimic the effects of consciousness in computing systems. This model used a software agent which was programmed to operate with scripts (productions or inferences), to process incoming texts (or events) by extracting their semantic representations, and to select relevant reactions. Results in this model shown that software agent can simulate speech irony by replacing a direct aggressive behavior with a positive sarcastic utterance. This basic objective of this computational modelling is to understand speech and simulate irony. For getting results activation score is computed. This model is quite better to understand an emotion which is major part of consciousness.

In the research performed in [9] in 2017, stimulation of thoughts in mind is demonstrated by using *Z**-numbers. *Z**-numbers is a logical tool for facilitating expression of self, encase subjective and objective contemplation and self-reflection & self-conscious reactions. The purpose of their research is to identify fast and slow thinking, reactions and learning, and self-conscious decisions. Their research is performed on the observation of images and assumes sensory inputs. Emergence of thought is implemented but mental factors in which thought arouse does not address.

The authors in [10] emphasis that neurobiological realization can be possible with the computational model and algorithm using which one can understand the communication established in the process of consciousness in the human brain. Though it is theoretical model, it justified the consciousness process in broader sense. Model is prepared by considering the computation may be realized in the brain's neurobiology. Concepts of evolutionary fitness, thalamocortical feedback loop in the mammalian brain are practiced in the paper. This paper proposes an algorithm for inverting the unknown. This inversion theory is sensed as the feeling of consciousness. Computational model described in the paper elaborates communication idea in the conception.

3. METHODOLOGY

The proposed computational model is divided into three stages: understanding phase, consciousness phase and action selection phase. In first phase, model shows a picture to the user and user need to respond to the questions. Inputs from user is processed and sent to the second phase. In Second phase, different thoughts are generated and visualized graphically. Output of this phase sent to third phase where mental state of the user is identified for the generated thoughts. Mental state is shown as the final output of proposed model of consciousness.

Understanding Phase includes receiving and preprocessing of inputs from the user where techniques of Natural language Processing are used. After gathering samples from respondents, Natural language processing techniques are applied. Tokenization, Normalization, Stemming, Lemmatization, Stop Words, Parts-of-speech (POS) Tagging, Bag of Words and n-grams are adopted for Natural Language Processing. Preprocessed information is stored in memory processing unit. Output of the Understanding phase is generation of perception in the form of preprocessed data ready for Consciousness phase.

In Consciousness Phase, Non-axiomatic Logic is applied for the generation of thoughts. Thoughts are visualized using the diagraph. And details of generated thoughts are stored in the memory processing unit. Different words which are connected for generating thoughts are investigated and are determined. Connected words are combined to form different thoughts. Among those thoughts, only specific thought is registered. Hence, specific thought is generated as output of consciousness phase.

The last phase is Action Selection Phase where generated thoughts are classified in one of the three mental factors. Generated thought from the Consciousness phase is input to this phase along with mental state repository. Convolutional Neural Network is applied for classifying mental factors of identified thoughts. The Fig.1 shows the working of proposed model.

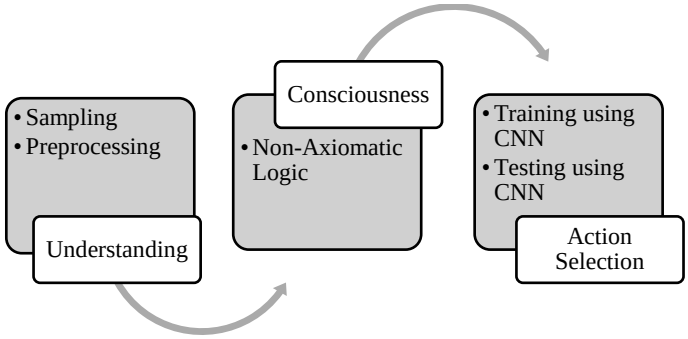

Fig.1. Proposed model

3.1 NON-AXIOMATIC LOGIC

NAL consists of formal language, a set of formal inference rules, and a semantic theory. NAL is attempted to capture the "laws of thought" or human thinking patterns conceptually. Axiomatic logic is suitable for an idealized situation whereas non-axiomatic logic is suitable for a realistic situation. Since all knowledge may be challenged by new evidence, there is no axiom in the system that has guaranteed truth.

NAL is the product of nine "layers" which are interconnected and are termed as NAL-1 to NAL-9. Each of them extends the sets of grammar and inference rules of the "lower" layers, so as to increase the expressive and inferential powers of the system, and consequently to make it more intelligent.

NAL levels are expanded layer by layer with the features of a previous layer including the grammar, inference rules and truth functions. All layers of NAL are classified into two sections: First four layers from NAL-1 to NAL-4 are considered as First-Order Inferences and remaining layers from NAL-5 to NAL-9 are considered as Higher-Order Inferences (NALs 5-8) [11].

3.2 CONVOLUTIONAL NEURAL NETWORK

Convolutional Neural Network (CNN) is one of the forms of ANN architecture. [12] CNNs are analogous to traditional ANNs which are comprised of neurons means interconnected nodes that self-optimize through learning. Each neuron receives an input and performs an operation. Score function known as weight is computed by the entire of the network right from the input vectors to the final output of the class score. In CNN, input layer is followed by more than one middle layer and at the end output layer exists. The last layer contains loss functions associated with the classes. Interconnected nodes are organized into three dimensions, the spatial dimensionality of the input (height and the width) and the depth.

4. EXPERIMENTAL SETUP

Researcher used 64-bit Microsoft Windows 10 Operating System, 64-bit MATLAB version.2019a Software for coding, Microsoft Office 2013 for preparation of documentation and presentation, Google chrome web browser, Google Search Engine, Google Forms and Google Sheets, Amazon kindle for and online access of web application NDL for web resources. Proposed system was applied for performing the experimental work. This work needs to execute with the state of art. Hence, to perform the task of experimentation different phases identified. Process of Abhidhamma model was implemented for generating consciousness. NLP used for preprocessing inputs. Non-Axiomatic Logic (NAL) used for generating structure or laws of consciousness generation. Classifiers were used for identifying types of mental factors. Training and testing were performed. Core algorithm describes overall functioning of the proposed system. Output of the proposed system is identified by mental factors. Algorithm for generating consciousness is given. below:

Algorithm 4.1: Core Algorithm of Mental Factor Classification

Input: Image *i* and three questions, database *DB*

Output: Mental Factor MF as Ethically Variable Factor (F), Unwholesome (U), Beautiful Factor (BF).

Step 1: Start

Step 2: Give input (image *i* and questions *Q*)

Step 3: Read input *i* text from answer of questions *Q* and store in database.

Step 4: Partition of database *DB* in training D_{tr} and testing D_{ts} data

Step 5: Apply Preprocessing (NLP)

Step 6: Apply Non-Axiomatic Logic (NAL) for feature learning with length of keywords, learning duration and number of layers

Step 7: Apply NAL (identifying and determining thought) for generating rules for consciousness/thought

Step 8: Apply CNN for classification of mental factors.

Step 9: Recognition of mental factor *MF*.

Step 10: Testing Samples

Step 11: End

5. RESULTS AND DISCUSSION

Since this type of research work is carried out for the first time, benchmark database is not available. Hence new database was articulated. Experimentation of the proposed computational model of consciousness was performed by collecting samples using Google Forms in simple English language sentences from people of different ages and professions to capture their inputs for certain images. 25 images are used for the research purpose. While applying natural language processing techniques, preprocessed input samples are taken into consideration. Responses from all respondents are segregated in terms of number of words. It has done by applying Tokenization, stop words, lemmatization and normalization. Tokenization picked out unique useful words from the responses recorded by the respondents. While processing the samples using Non-Axiomatic Logic, total tokenized words are taken into consideration for preparing the connection between the words and identifying the thoughts. Output of NAL constituted the identification of thoughts through the connection between numbers of words which are shown in diagraphs. These digraphs represent thoughts having specific word counts, edges and nodes. The Table.1 describes these figures out of which these diagraphs of thoughts are generated. As a whole, small database contains 243-word count while large database contains 1124 words. Both databases are having 45 edges while 34 and 35 nodes are present in small database and

large database respectively. NAL Table are showing the various different parameters and having size 45×7 in both databases. After applying Non-Axiomatic Logic, correlation between the generated thoughts is explored by using frequency and confidence digraph as shown in Fig.2 and Fig.3 respectively. The diagraphs show the bonding between the words which are in the form of thoughts. Frequency for thoughts represents how two words are frequently occurred in some thoughts while confidence represents strength of correlation between two words which are appearing in some thoughts. Thoughts are assembled in NAL and represented through the diagraphs. Mental factors which are also called mental states are identified for the thoughts. For the classification purpose, convolutional neural network is applied. six layers namely sequence input layer, word embedding layer, LSTM layer, fully connected layer, softmax layer and classification output layer are used.

Table.1. Non-Axiomatic Logic Processing

Database Name	Word Count	Edges	Nodes	NAL Table
Small	243	45	34	45x7
Large	1124	45	35	45x7

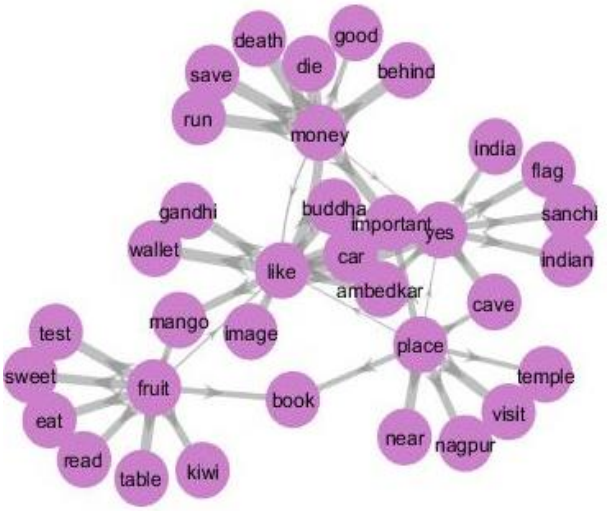

Fig.2. Digraph of Frequency for thoughts

Training and testing were performed on total 445 samples in the ratio of 80:20. Experimentation was performed on small and large datasets. As a result, thoughts were classified into one of the three mental factors. It indicates the mental health of the respondent. Mental factors are identified in three classes such as Ethically Variable Factor (EVF), Unwholesome Factor (UF) and Beautiful Factor (BF). Statistical measures such as Accuracy, Precision, Specificity, Recall and F1-Score are applied on both databases while getting mental factors.

Accuracy for small and large database is 86.92% and 93.02% respectively. Precision values are 84.55% and 90.07% for small and large database respectively. Specificity is 87.86% and 92.07% for small database and large database respectively. Values of Recall are 87.64% and 92.75% as well as F1-Score are 86.07% and 91.39% for small and large database respectively. Statistical values of mental factor classification are depicted in Fig.4.

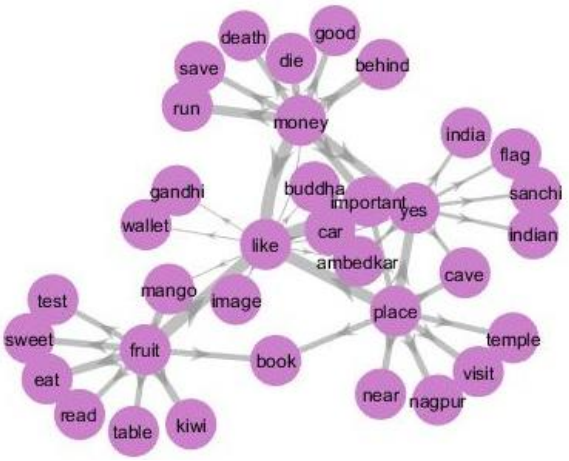

Fig.3. Digraph of Confidence for thoughts

Analysis of these statistical measures shows that Accuracy, Precision, Specificity, Recall and F1-Score are performing better for larger database (See Fig.4). Predicted Mental factors are shown with the help of probability function. Class 1 represents unwholesome class; class 2 represents ethically variable factor and class 3 represents beautiful factor. one predicted 'unwholesome' class is shown as output as in Fig.5.

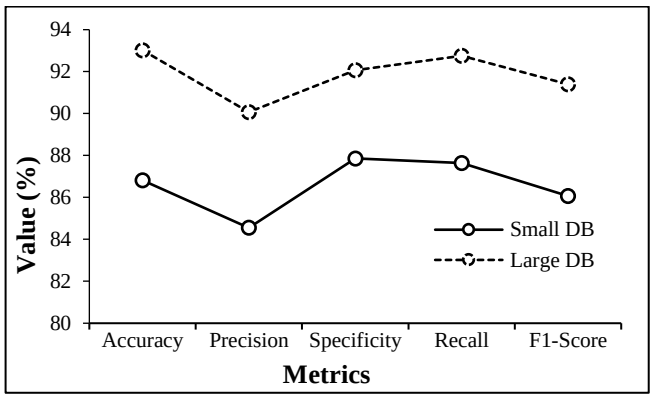

Fig.4. Results of Mental Factor Classification

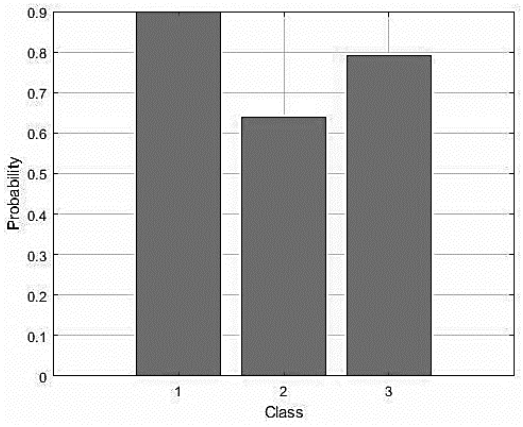

Fig.5. Unwholesome prediction

6. CONCLUSION

The computational model of consciousness is the innovative research where generation of thoughts and identifying mental

states of the human being was successfully demonstrated first time by using process of consciousness given in Abhidhamma model. This research is recognized as research under cognitive science and Artificial Wisdom. New dataset was articulated in absentia of benchmark dataset. 445 samples were applied. Preprocessing was performed using Natural Language Processing techniques. For thought generation, non-axiomatic logic was applied. The training and testing were performed by using Convolutional Neural Network. The proposed system demonstrated the process of thought generation with mental factors classification by obtaining highest accuracy of 93.02%. the proposed model also produced 90.07% precision, 92.07% specificity, 92.75% recall and 91.39% F1-Score for large database.

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