A Computational Approach to Understand The Human Thought Process

1st Jitesh Dundas
Independent Scientist,
Cumming, Georgia 30041, USA
jiteshdundas@protonmail.com
0000-0003-0637-1788

2nd Maurice Ling
School of Applied Science,
Tamasek Polytecnic Singapore
Singapore
mauriceling@acm.org

2023 3rd International Conference on Electronic and Electrical Engineering and Intelligent System (ICE3IS) | 979-8-3503-2776-2/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICE3IS59323.2023.10335478

***Abstract*— The aim of this paper is to understand the human mind functions such that we can simulate them into a computational model for making cognitive systems more intelligent. We then present this model with formulae using a top-down approach. We propose that the human thought process, which is the fundamental unit for the human mind and all the different emotions coming from it, can be implemented as a mathematical formula to a reasonable extent. Furthermore, we argue that our model has the ability to derive mind functions such as dreams and thinking. The model utilizes a top-down approach for understanding the factors involved in the thought process while explaining the factors involved. The authors are intending to make continuous improvements in the formulae as more scientific advances happen in the understanding of the human cognitive functions.**

Keywords*— *human thoughts, cognitive systems, formulae, neuro-modeling, top-down approach, computational intelligence, machine learning, neurons.

I. INTRODUCTION

The human thought process has not been understood to an extent [1] such that it can be utilized for a wider audience and in worldwide applications. At present, there exist very few computational frameworks [2][3][4] which can simulate the human thought process right now. Thus, in this paper, we present our own model and explain the rationale behind doing it. We also argue that our computational mode of scientific investigation of the human thought process has been employed and widely used by several recent scientific studies [4][5]. Crosby [6] argues that by understanding and decoding the cognitive processes of animals, the bottom up approach helps in building models for more evolved cognitive processes which exist in human beings. Vandekerckhove [7] throws light on how a bottom up approach to understanding the emotional regulation due to the white matter integrity in cognitive networks. As these scientific studies have been successful in clearing our understanding of the cognitive mechanism s[7][8][10], we argue that our research work, which uses a similar top down based approach towards understanding the human thought process, also provides a persuasive argument for understanding the thought process [9].

Understanding the cognitive side of the human brain using a purely computational and mathematical approach helps in establishing a clear research direction as explained by Milkowski [10]. Milkowski [10] also explains why computationalism helps to recast cognition in a mechanistic way. This helps in reviewing the information processing that happens in cognition. This also helps in finding hidden patterns at the deeper level of the different abilities which are present in the human mind [9]. We argue that this approach, which has worked well in understanding certain cognitive functions like the mental dictionary[10], can also be used for understanding the human thought process. We also argue that this approach also helps to establish and validate models which are easier and quicker to experiment and find new patterns as they emerge [10].

The past studies in the computational approach have focused more on specific aspects of the human mind which relate to the abilities. For e.g. Atiya et. al [11] propose a mathematical model to explain the decision uncertainty and the ability to make the right choice in a given decision. Meniel et al [11] presents a hierarchical inference based model where the impact of confidence is shown in the learning process of humans. Walsh et. al [12] presents a review of predictive processing based models which depend on information from the outside environment for making inferences in the human mind.

Also, the past studies have focused deeper on a specific factor or an aspect of the human thinking process. Due to this deeper insight based work, there is a void created for understanding the overall thought process in the bottom up approach. The above studies also do not present a model which shows how the overall thinking process is affected when certain factors are modified beyond a certain point. However, this current research work is based on the cumulative impact of these factors and how they can impact the thought process. Our paper uses the top down approach due to which our model can explain how each of the aspects of the human mind like dreams, intuition and decision making are able to work using the same neural circuits. Our work also helps in understanding how the above studies are indeed helping in understanding the overall thought process and how their functioning leads to different outcomes such as dreams, intuitions, etc. Our model also presents how different thought processes can co-exist and that they can form a chain of different thoughts, which form a continuity and the support the feedback based models as by several cognitive studies [13][14][15].

We further argue that the past scientific studies have focused on understanding the features of the human brain like the neuron cells to develop AI advances like the neural networks[16]. As a result of these successful approaches, significant advances [17][18][19][20] have been made towards understanding the human brain. As a consequence of these advances, we now know that there are certain sections of the human brain [9][10] which are responsible for corresponding changes to the way in which we behave. We also, know that there are still certain changes in the brain patterns which cause a change in the way we get certain behavior aspects [21][22] like being happy, being sad, dreaming [23], etc. However, we do not have a clear understanding of the human mind and the different aspects which give us the above discussed abilities. This is because we still do not understand the human thought process to the extent where we can computationally develop models to imitate it completely. Hu et al [24] mentioned in their work introduced the concept of thought cloning. In this imitation framework, the authors argue that thoughts cloning along with the behaviour cloning improves the performance of reinforcement learning(RL) agents. In another paper, Wei (et al) [25] present the concept of chain of thoughts as a series of reasoning steps can improve the performance on a range of tasks. Furthermore, Dehaene [26] et al, argue that humans possess multiple languages of thought, which help it in processing different types of data. Danaila [27] explores the process of cogitation and how the neurons are interconnected in a dense network. Such interconnected networks help with the transfer of information from the originating brain to other supportive destination devices. Chen, et al [28] introduces the concept of Program of Thought(PoT) for large language models which, combined with self-consistency decoding, consistently produces a 12% performance gain over Chain of Thought(CoT) in their experiments. Piatti et al [29] present a model framework called 'CT-Cube' which can analyze and execute algorithm based thought processes. Also, it does consider the social nature of the thought processes which can effect solving of the Cross-Array tasks(CAT).

We argue in this study that the approach used by the past studies cited above as well as supported by other scientific work [30][31] will help us in gaining a better understanding to the extent of developing a computational model to imitate the human thought process. Also, the past work is not yet complete and considers only some of the types of factors which influence the human thinking process.

II. Methods and Explanation

A. Background

In this paper, we present our answers to the following questions:-

a) Is it possible to computationally interpret the thought process? b) Is there a reasonable computational model which can be developed from it?

We present arguments to computationally prove that the above are indeed possible. We further believe that this study also provides a deeper understanding of the human thought process which can which can highlight the different factors affecting it.

B. Assumptions and Limitations

In this paper, we have considered the following factors which affect this model:

1. The number of attributes or factors which affect this mathematical framework are going to change as we make more progress in understanding and deriving some of the mind functions such as dreams, creativity, intuition, etc.

2. This current mathematical framework is still abstract and defined at a high level which makes the results approximate in nature. As more work get accomplished in this research study, we will be able to provide more reasonably accurate results.

3. We assume that the human thought process always has at least one active thought. We also assume that it is not possible for the human mind to be considered functioning normally without it.

C. Factors Involved

Let us say that a small child does not have any past experience of walking down a stair. After observing that others can do it and that other people are also able to do it, the child starts trying on its own. In short, it starts using the past experiences of observing these people. Now, these experiences give the child the ability to simulate the actions as given here: "How did that person climb up the stairs?" . In short, this is coinciding with the principles of reinforcement learning[31]. Again, this experience alone does not justify the thought process. It also involved the health of the brain or the underlying infrastructure which holds the thought making process. Since it is networks of neuron cells in the human brain[32] which cause the thoughts to form different logical processes like decision making, intuition, dreaming, etc, we can say that the overall physical and tangible well being is also an important factor in this process. If a person is having a predisposition or a brain related disease which impacts the thinking process, then there is a strong inclination of extreme prejudices or thoughts to occur. In short, the rationale thinking process is affected by the physical well being in human beings. This factor of well being is being capture by this paper in the below formulae based calculations.

Another factor that we propose here is the emotional inclination which is the inner drive or the intention to achieve a certain goal or to run away from it. Each human has a certain predisposition based on past thoughts (which we call as experiences in this paper). This inclination which comes from the past thoughts has an impact on how the human being takes their decision [33][34][35][36][37][38]. Dr. Kahneman's work [33][34][35][36][37][38]on human psychology and decision making shows how we humans think and take rationale decisions. Clearly, the motivation to achieve or to avoid a certain outcome is of paramount interest in moving the thoughts in a specific direction. Which kind of activity occurs and how we reach a specific goal, when given two different options, is also another area where the motivation factor becomes important. Stronger the emotional inclination towards achieving a goal, the stronger will be the thought process. If the opposite is true, then the thought process suffers and this ultimately ends up in forgetting or ignoring the intended outcome. Clearly, the emotional inclination is another important factor in the decision making process.

The environment includes all the entities which are outside the physical body of the entity i.e. the human being or the computers as discussed above. It includes friends, family and other non living being which serve as inputs for the experience that is to be used. In the case of computers, it will be other computers, humans interacting with subject computer as well as other physical entities as it is for humans. This will in turn have an impact when the computer is thinking. Scientific studies have shown [39] that the outside factors (environment) have a major impact on the human mind. Clearly, adding this factor is also important for the algorithmic calculations discussed below in this paper.

D. Formulae

The human thought process, represented by Th , can be defined as follows:

$$f(Th)n = Avg[f(Exp)n \times f(Ei)n \times f(Env)n \times f(Bh)n\ ]$$

$$Th[t=n](input[0\ till\ n]) = Avg[\ (Exp[t=n](input[0\ till\ n])$$

$$\times (Ei[t=n](input[0 \text{ till } n]) \times (Env[t=n](input[0 \text{ till } n]) \times (Bh[t=n](input[0 \text{ till } n])]$$

such that:

a. $0 < t < n < \infty$
b. $-1 < Ei < 1$ *and* $-1 < Env < 1$ *and*
c. $-1 < Bh < 1$

Where:

1. *t is the point in time for which the thought process is being generated, and*
2. *Exp is the experience collected by the machine using vision, audio and other auxiliary inputs,*
3. *Ei is the emotional inclination of the thought to become a reality, and which can be both positive and negative and represents fear, motivation and other factors which influence the thoughts in humans.*
4. *Env is the environment in the current state when the thought process is being formed, and*
5. *Bh is the brain health or the physical well being of the entity in which the thought process occurs.*

The authors present more information and explanation of each part of the above formulae to justify the application of the same as a software program to demonstrate its validity.

III. Formulae Explanation

We present here the rationale behind using the following factors in our formulae:-

A. Experience

The human mind collects information in the form of experiences. Each experience is a collection of thoughts which gets tied to a specific emotional inclination. Each emotional inclination is again tied to the goals and objectives of the entity. Clearly, this is one of the most important factors in the thought building process of the human mind. This is because the current thought process again depends on the past chain of thoughts which we call experience. Each experience is in turn obtained using a specific input mode such as hearing, reading, watching, etc. Each of the experiences will involve the observer and the other entities being captured in the input. This explained by the following polynomial equation: -

For t = 0 to n,

$$f(\text{Exp}) = f(\text{Exp})0 + f(\text{Exp})1 + f(\text{Exp})2 + \ldots + f(\text{Exp})n \quad \textbf{(3)}$$

This can be further summarized into the following simpler representation:

For t = 0 to n,

$$Exp[t=n](input[0 \text{ till } n]) = Avg(Exp[t](input[t-1]))$$

Or, in a more expanded form, it means:

$$Exp[t=n](input[0 \text{ till } n]) = Avg[\, Exp[t](input[t-1]) + Exp[t-1](input[t-2]) + Exp[t-2](input[t-3]) + \ldots + Exp[0](input[1])\,]$$

Where:

a. Exp[t=n](input[0 till n]) is denoted by the experience to be calculated for a given point in time, from t-1 until the current point in time, denoted by t,
b. Exp[t](input[t-1]) is denoted by the experience to be calculated for the range of points in time, starting from t=0 until the point t=1. In a way, this is the starting point in the range that we are trying to calculate.
c. Exp[t-1](input[t-2]) is denoted by the experience to be calculated for the range of points in time, starting from t=1 until the point t=2. In a way, this is the starting point in the range that we are trying to calculate i.e. $t=1\int t\, f(\text{Exp})$
and so on….

Thus, this experience for the given range can be summarized as a chain of thoughts, which were calculated in the past, until the current point in time, such that they give you a newer chain of thoughts, which in turn make a new experience. In short, we can say:

$$Exp[t](input[0 \text{ till } n]) = Avg[Exp[t](input[t-1]), \text{ for } t = 0 \text{ to } n] \quad (1)$$

In short, we are adding together all the experiences that the host entity has captured, starting from the time when t =0 (starting point in time), till when t = n (ending point in time). Also, past experiences, which from a biological point of view, form the activity in the neural networks, are being utilized for generation of the new thought process.

B. Emotional Inclination

The emotional inclination is defined by the motivational factors which decide the intensity with which the thought process will occur. It will also mean that the emotional quotient or certain non logical attributes which affect the past experience will also get triggered. For e.g. a soldier from a war who has seen a lot of death will have chances of past experiences getting triggered when they see a shootout in an action movie. While this may or may not be true for each person, there are different reasons and types of experiences which have their ‘attachments’ to the past experiences which occurred.

Thus, the possibility of the thought process moving forward will be affected negatively or positively affected based on the past inclination to the experience that the host entity had earlier. Again, this is very similar to the way in which the past experiences were calculated. However, there is a difference of the absoluteness of the inclination that is being calculated here. The Emotional Inclination(Ei) can be both positive (happiness, motivation, etc) or negative(fear, unhappiness, etc) and can be scaled into a numerical value between +1 (happy) to -1 (very unhappy). Every single experience which is being recorded or used above will be having an Ei quotient attached to it. Due to this, the Ei quotient value, even if present between -1 to +1, has the affect of making the entire thought process negative or positive. When multiple chain of thoughts are in process(an entity can have multiple thought process working in parallel), the presence of negative or positive factors can severely affect the ability of reaching a logical goal. This is a stage which we commonly refer to as ‘confusion’ in psychology. However, for the scope of the paper, the authors will discuss this term in the another paper submission.

In order to generalize the effect of the Ei quotient across each point in time, we have to average out the quotient taken for each point in time. This is similar to what we do for Experience factor as well as others discussed below. For e.g., let us imagine that for a range of points (t = 0 till 3), we have:

For e.g. Let us say that,

(Ei[1](input[0]) = 0.4;

(Ei[2](input[1]) = 0 ;

(Ei[3](input[2]) = -0.2 ;

Replacing the values, we will get.

(Ei[3](input[0 till 3]) = (0.4 + 0 + (-0.2)) / 3

= (0.4 + 0 – 0.2) / 3

= (Ei[3](input[0 till 3])

= 0.2 / 3 = 0.66

C. Environment

The environment is defined by Env and it denotes all the surrounding entities around the host entity. It also denotes the effect the surrounding entities may have on the host entity. For e.g. in the case of a human, it will be his/her family, home, community, weather etc. If the weather is not good or the relations with the neighbors are not good, then the impact of the support system is also going to be negative. However, it will be positive when the same factors have a net positive impact on the host entity. Except for the symbol, the calculations for the Env are the same as Ei.

D. Health Factor

The health factor is defined by Bh and it stands for health of the brain or the host entity which is controlling the thought process. In this case, it will be the computer's resources like RAM, ROM, CPU, etc. This is again an absolute number and has an impact similar to that of Env. The calculations of Bh are similar to Env and Ei as they are absolute in nature. Note that in all the above factors, we are taking the average of all of the numbers across each data point in time and then putting them together. The strategy is similar to what we have in Exp and Ei.

IV. Experiments

In order to test this research work, we implement some simple mathematical examples which can take some of the experiences pre-recorded as inputs (computers can use this as inputs). This in turn will help us to generate the formulae results in a scientific form. The intent will be to show how different thoughts are formed and how these make even more chains of thought processes. To test this formulae, we will take different predefined inputs as experiences and thus form different chains of events which give a logical outcome.

For t = 0 till n,

f(Th)n = Avg[f(Exp)n × f(Ei)n × f(Env)n × f(Bh)n]

where,

Th[t=n](input[0 till n]) = Avg[(Exp[t=n](input[0 till n])×
(Ei[t=n](input[0 till n])×
(Env[t=n](input[0 till n])×
(Bh[t=n](input[0 till n])]

Let us say that we have a thought process ranging from 0 till 3,

Avg[(Th[t=3](input[0 till 3]) =Avg[(Exp[t=3](input[0 till 3])

× (Ei[t=3](input[0 till 3])

× (Env[t=3](input[0 till 3])

× (Bh[t=3](input[0 till 3])]

Let us say that:

a) *(Exp[1](input[0]) = 0.6 ;*

(Exp[2](input[1]) = -0.2 ;

(Exp[3](input[2]) = 0.2 ;

b) *(Ei[1](input[0]) = 0.4 ;*

(Ei[2](input[1]) = 0 ;

(Ei[3](input[2]) = -0.2 ;

c) *(Env[1](input[0]) = 0.3 ;*

(Env[2](input[1]) = -0.1 ;

(Env[3](input[2]) = 0.2 ;

d) *(Bh[1](input[0]) = 0.3 ;*

(Bh[2](input[1]) = -0.4 ;

(Bh[3](input[2]) = 0.4 ;

Substituting the values here, we get:

Avg[(Th[t=3](input[0 till 3])

= [(Exp[t=1](input[0]) × (Ei[t=1](input[0]) ×

(Env[t=1](input[0]) × (Bh[t=1](input[0]) +

[(Exp[t=2](input[1])×(Ei[t=2](input[1])×
(Env[t=2](input[1])× (Bh[t=2](input[1])+

[(Exp[t=3](input[2])×(Ei[t=3](input[2])×
(Env[t=3](input[2]) × (Bh[t=3](input[2])] / 3

*= [(0.6 * 0.4 * 0.3 * 0.3) + (-0.2*0*-0.1*-0.4) + (0.2 * -0.2 * 0.2 * 0.4)] / 3*

= [0.0216 + 0 −0.016]/ 3

= 0.0056/ 3

Avg[(Th[t=3](input[0 till 3]) = 0.001866667

V. Observations

Thus, as you can see here, the thought process is almost always < 1 due to the fact that the mind is always having multiple thoughts. Also, as time progresses, the ability of the mind to keep evolving and thinking recursively on the same topic is also present. Thus, the above calculation for 3 points in time is present such that two or more of the thoughts maybe of the same nature or similar in nature. Moreover,since the range is almost always corresponding to the range 1< Avg(Th)

<-1 , we find that this can be used to mathematically represent thoughts even if new factors are later found besides the 4 factors found above. We also note that there are several chain of thoughts which are constantly in process of generating activity which can also be documented. These thoughts are constantly combining together to form bigger patterns. Some of these patterns include dreams, intuition and creativity. Some of these patterns have already been identified or are being discussed [40] widely in the scientific research at this moment. Thus, we will not be going in detail in this paper.

A very important factor that we have found which impacts the entire chain of thought process is the connection of the different chain of thoughts. It is clear that a single chain of thought process does not cause any change or a pattern to be called a dream or creativity. However, the hidden connection comes from the past experience for the thoughts which are coming into interaction with each other. For e.g. f(Th) 0 and f(Th)1 are two thoughts which come one after another. However, what holds them together is the fact that these thoughts interacted via their experience which had a association factor in them. We can explain the same in Fig. 1 attached below.

As stated above, for many chains of thoughts to connect together and form a pattern is very important. This cannot happen till :-

1. The past experience, starting with the last experience first is used to associate the future merged thought chain process. This means that when two chains of thoughts are occurring, the association factor between them is defined by the entities present in those thoughts. We call this proximity to each other as the association factor as the human mind tends to associate two or more different thoughts together using certain tendencies or goals which had a profound impact on the person. For e.g. a person A complementing person B on the food made by the latter will be called a thought process (say f(Th0)) and the point in time is denoted by t0. Now, when the person A meets person B in time t1, then the next thought process will start with the f(Th1) because for both the persons involved here, the past experience will have an association factor which will define the linear association.

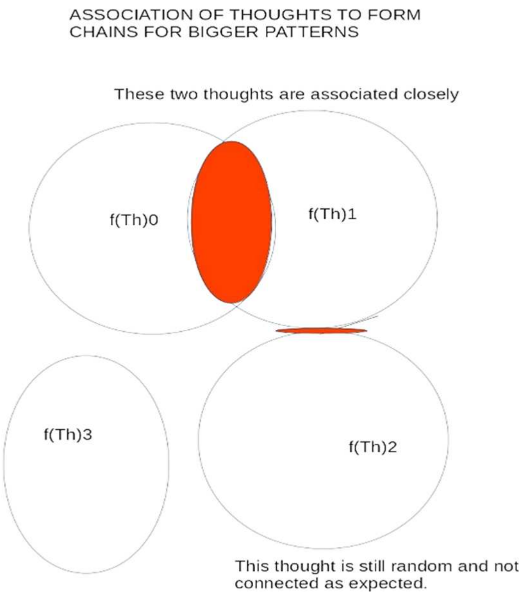

Fig. 1. Thoughts chaining together to form bigger thought patterns

2. Again, the goals and emotional inclinations come into picture here as defined by our thought process formulae and the association from the above point may be different, which in turn will cause a different outcome. Thus, it might be that person A does not like the food dish the next time that person B makes. The same thing happens for f(th)2

3. The above three points will continue to propagate and happen again and again as the thought process will never stop. It will continue to grow and make longer chains unless the association factor keeps coming down.

4. As shown in the above image, the thoughts keep coming up in different sections of the mind of the entity. However, it does not affect in making dreams[27], creativity or any other important factor. Instead, those thoughts which end up having a closer association factor (on a scale of 1-10, the higher the factor, the stronger is the association).

Lastly, we define the association factor as “the ability of two or more thoughts to associate between each other such that they provide a chain of thoughts that can form dreams in high emotional inclination scenarios and creativity in low emotional inclination scenarios”. Note that the impact of the association factor is not in defining the thoughts but rather in deciding which thoughts will chain together to form longer thought processes. The stronger the thought process, the stronger will be the chain which in turn helps in making thought processes which yield the goals as wanted by the entity owning it.

VI. Conclusion

We prove with the above work that the human thought process can be represented using a purely computational approach for a better understanding of the human mind. We also prove that the different abilities of the mind are indeed inference based and that they can be indeed presented as an probabilistic model based process. Also, as we work with a different approach when compared with the current research studied with a specific view on how chains of thoughts bond together to form creativity and dreams in the mind. While the work done in this paper sheds light on the way the human mind works, we hope that ability to automate the process is a step forward towards implementing this into computers. We believe that this research paper will help to discover deeper insights on other important areas such as dreams, intuition and creativity.

Acknowledgment

The authors confirm that no funding was received or utilized in order to pursue this research work. This has been done on the personal time for personal interests, using personal resources and efforts of the authors only. No support of any kind was taken from anyone else for this research work.

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