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# The 3rd wave AI requirements

## Abstract

We review 3rd Waves of Artificial Intelligence (AI). The 1st Wave is 5 decades ago MIT Marvin Minsky with Seymour Papert proposed rule based "Perception": "If so so, Then so so" system against the brain base "Perception" by Cornell Frank Rosenblat (1928-1971). The 2nd Wave is circa March 15 2016 "learn-able Rule Based system" with supervised learning with labeled data "from A to B" that Alpha-Go Brain had beat human (Korean genius Lee Sedol) in Go Chess Games (democratic black-white territorial game) 4 to 1. The revolution is due to (1) Massive Parallel Distributed (MPD) Compute (e.g. miniaturized GPU, as PC backplane), (2) matching MPD software (without the need of slow-down inner do-loop, Python: Tensor Flow, e.g. Stanford Course RA, MIT AGI), and (3) immense amount training data (e.g. in the Cloud, or Tesla Model 3-new Electrek collecting real world driving data from owners paid inexpensively at $35K). The paper describes 3rd Wave of AI that has human Fuzzy Linguistic Thinking using Unsupervised Learning of Homo sapiens at a constant temperature $T_0$ in the sensory pairs called the power of pairs, e.g. "Agree, the Signal; Disagree, Noise" in terms of two LIDAR's, RADAR's, Videos' pairs operated by their relaxation toward the Minimum Helmholtz Free Energy.

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## Introduction

In the 3rd Wave AI, we are not making robots thinking like a human, but robots can recognize human imprecise (to computer) thinking. We are not demand the computer robot to have the human-like intuitive, artistic and creative thinking utilizing both logical side and emotional side of brain. For example, how can machine define in the linguistic Sense, e.g. "Beauty, or Beautiful' or."Young, or Youthful", these emotional words which are all open sets of possibilities. They cannot be normalized as the unit probability, but the open set possibilities which could be infinite and are powerful human thinking. It may be referred to Fuzzy Membership Function Logic, (FMFL) as first introduced by the former Prof. Lotfi Zadeh (LZ passed away at 98 years old 2017), confided once to the author (HS) as a founder of International Neural Net Society (INNS) that the logic is not fuzzy but the membership is; but he dropped the MF while he was Chairman of ECE of UC Berkeley becoming FL for funding reasons) (Figure 1). However, it was late Prof. Walter Freeman (WF) at UC Berkeley (passed away at 89 years 2017) recognized the open possibility could not be loaded in the von Neumann finite state machine, namely computer, but Homo sapiens, namely our species, adopted both sides of brain in estimating approach, not by a look up table, but generating them by experience, (if you will unbounded table smart approach). Of course, we shall replace "human intuitive estimation" with the next best fast MPD computational ensemble approach averaged with all possible initial and boundary conditions. However, when the Boolean Logic "union & intersect" the Young with the Beautiful, the result becomes much sharper in the meaning that all human understood. An anecdote story, during one of the 30th INNS board meeting, was between WF and HS the typical French Mathematician Peano's theorem of real positive integer, that are not unbounded, non-denumerable, to be put in the finite state computer; but computational dynamical approach can, If it defines Real Positive Integer to be $I$,

$$\text{If } I = 1,2,3, \text{ etc. Then Compute } I' = I + 1 \text{ . Q.E.D.} \quad (1)$$

This task computer can easily handle.


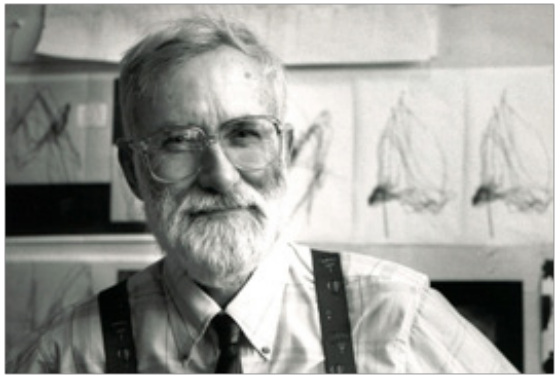

**Figure 1** Late Professors Lotfi Zadeh and Walter Freeman were associated with UC Berkeley and the lead Author HS at International Neural Network Society during the last 30 years.

According to the Science Magazine on December 15, 2017 weekly issue "When will we get there?" we found the Level 4 Automation of Autonomous Vehicle (AV) will take another 13 years.[1,2] (The final stage will be Level 5, with no human at all). In spite of early efforts of NASA space landing of Martian Cruiser, and DARPA Grant Challenge of Road Follower (Figure 2) that were able to differentiate a pot hole from tree shadows in a so-called "no-man land."


**Figure 2** NASA Martian Cruiser, and DARPA Road Follower , that can eventually differentiate a shadow from real pot-hole to go off the road; but aal have done in a no-man land.

The 1st Wave AI was competing between MIT Marvin Minsky show that single layer cannot solve the EXOR logic and Cornell Frank Rosenblatt one-layer "perception" (Figure 3) (Figure 4). Modern Google and Volvo/Uber spent $ billions investment (since Volvo/Uber AV killed an intoxicated woman crossing intersection with pink pike in Temple Arizona), the Highway TSA committee nevertheless said it will take another 13 years for Automation Level 4 for Autonomous Vehicle (AV).[3,4] This might be due to that in current computer scientists thinking and designs of an AV are missing about "*Human is creative animal we may abide the law but violate the rules*. We suggest that one of the shortfalls might be that the computer scientist's community is not familiar with "*Orifice-like focusing logic*" that begins with all possibility inputs and end up much focused result as follows.

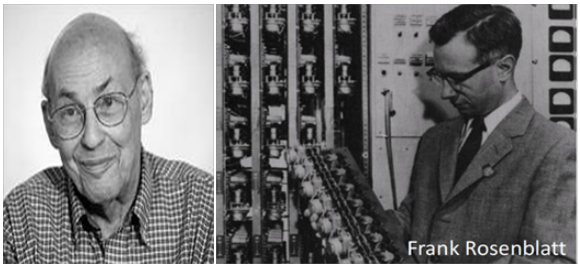


**Figure 3** The historical lesson initiated the multiple layer studies by MIT PDP book in backward error propagation called "Deep Learning, simulating Human Visual System V1(edge)-V2(shape)-V3(contour)-,V4 (Aided Target Recognition) layer by layer that have defeated Korean Genius Go Chess player.


**Figure 4** The 2nd Wave of AI can observed human play habit in a *Learnable Rule Based System*, e.g. Google Alpha Go that can anticipate rapidly many steps deep than human.

## Approach

We shall compute all 5 dynamic equations with lab model car simulation results, e.g.

a) Newtonian dynamics of inertial centrifugal force in freeway tuning

b) Road-tire friction Langevin equation with variable road and weather conditions

c) Lyaponov Control theory equation at aforementioned MFE.,

d) Global Positioning Satellite Orbital Intersection Systems to increase to one feet resolution

e) Power of Pairs Sensors (Radar's, LIDAR's,Video's) forming the situation awareness.

The guiding principle will be minimizing the Herman Helmholtz free energy H defined by the Boltzmann irreversible thermodynamics of the Entropy S (as the measure of the degree of uniformity, e.g. beach white sands have more entropy than mountain top rocks).Then, A.M. Lyaponov defined the monotonic decay control theory We ask how to make machine understand human. We assume the bases of homo sapiens natural survival intelligence (or in short Natural Intelligence (NI) as opposed to AI). NI assumes the homeostasis: namely two attributes are

A. Quick response with Power of Pairs sensors (two eyes, two ears, two nostrils, two sides of tongue) accomplish "While the agreed, the signal; disagreed, the noise"

B. Effortless unsupervised learning at Helmholtz's Minimum Free Energy (MFE) not supervised Least Mean Squares (LMS) errors. Anatomically speaking, brain consists of 10 billion neurons using Calcium ions as the communication vesicles positive current modulated at the synaptic gap junction with the help 10 times smaller and 10 times more (about 100 billion) of house-keeping glial cells, keeping the ions in the line of axon, "While one pops in, the other pops out instantaneously". What is the internal energy of brain that is free to do the work? According to Ludwig Boltzmann, the measure of useless thermal energy is called the entropy when multiplied with the Kelvin temperature".

$$Total\ Entropy = S_{brain} + S_{reservoir} = K_B\, Log\, W\ ; \tag{1}$$

$$W = \exp\left(\frac{S_{brain}+S_{reservoir}}{K_B}K_B\right) = \exp\left[\frac{S_{brain}+S_{reservoir}}{K_B T_0}\right] = exp\left[S_{brain}T_o - E_{brain}\right) / k_B T_o = exp\left[-H_{brain}/k_B T_o\right] \tag{2}$$

Herman Helmholtz has the first derived from canonical ensemble from the thermodynamic free energy; we applied it to the human brain

$$H_{brain} \equiv E_{brain} - S_{brain} T_o \tag{3}$$

Use is made of the conservation of energy the brain internal energy $\Delta E_{brain} + \Delta S_{reservoir} T_o = 0$ in equilibrium with the thermal reservoir heat energy $\Delta S_{reservoir} T_o$. We can drop the integration constant as the normalization constant. When the input pair sensors agree, the stimuli are added up as a double in the brain. It shall be relaxed to the base noise level at constant temperature.

Homeostasis: human $T_o = 37^o C$, chicken $40^o C$; but the hotter is not any smarter;

Prof: "we ate chicken, not vice versa, Q.E.D."

Thus, we have arrived at the MFE as the guiding principle of human being.

$$Min.H_{brain\downarrow} \equiv E_{brain} - T_o S_{brain}$$

A.M Lyaponov control theory follows

$$min.H \downarrow = E \downarrow - T_o S \uparrow \tag{4}$$

$$\frac{\Delta H}{\Delta t} = \frac{\Delta H}{\Delta E}\frac{\Delta E}{\Delta t} = -\left(\frac{\Delta H}{\Delta E}\right)^2 \le 0; \tag{5}$$

$$f \text{ and only if } \frac{\Delta E}{\Delta t} = -\frac{\Delta H}{\Delta E} \text{ Newtonian dynamics} \tag{6}$$

Similar to the botanist Brown observing the mysterious pollen ceaseless zigzag motions in the water pound, Albert Einstein understood that he saw by his naked eyes the molecules thermal motion and he emulate the smoke particles kicking randomly by air molecules in the diffusion trajectory in the air (Figure 5). Mean square displacement is no longer quadratic but linear

$$\left\langle \vec{r}(t)\cdot\vec{r}(t+\tau)\right\rangle = \iint \left\langle \vec{v}(t)\cdot\vec{v}(t+\tau)\right\rangle dt\, d(t+\tau) = \frac{D}{k_B T_o \mu} v^2 \delta(\tau) \tag{7}$$

**Figure 5** Brownian motion is similar to UAT in a road test of microscopic road-tire friction and weather condition varying. We shall take the envelop trajectory.

We compute all five dynamic equations on the fly, and the result is tabulated into 5 Fuzzy Membership Functions (FMF's). Then the Boolean Logic at the decision time at a red traffic light in a desert town, at the midnight the AV shall slow down and glide over the red light. "A rule is made to break in a truly human intelligence behavior".

## Application and conclusion

We believe that the multiple FMF's approach to simulation data might be the missing sciences that can shorten the sensible AV results from 13 years to time 6.5 years without the violation of the Cardinal rules; "Thou shall do no harm to human". Otherwise, the impatient human driver might take over the control of AV, and coast over slowly through a red light in the midnight of desert.

The impact area will be Unmanned Autonomous Truck (UAT) boosting the US economics.

There have been historically three economic impacts, namely'

A. The 1st economic Booming: President Eisenhower built the Interstate Highways for missile launcher , but stimulated Interstate Goods exchanges

B. The 2nd economic Booming: President John F. Kennedy to compete against Russian satellite landed human on the moon developing the precision electronics and feedback control theory those producing high power computers.

C. The 3rd economic Booming, Vice-President Al Gore recognized ARPA internet linked all PI'S to PM, to all agencies, to all societies.

D. The 4th economic Booming: we anticipate being Unmanned Autonomous Trucks (UAT) Figure 6 that link highway depots to depots, while drivers become depot managers having more salary.

**Figure 6** Unmanned Autonomous Trucks (UAT) from highway fixed depots to depots while drives working as depot managers to save the most costly element human drivers ( we believe Amazon might not need East Coast Head Quarter at National Landing Crystal City , and other Supermarket chain stores etc. can all reduce the cost of retail goods). Thus, an early development of a scaled down model conducting the road test in a room should be shortened in 3~5 years.

We acknowledged ONR Code 321 initial seed money to make this planning possible. Experimental simulation results will be finalized and published elsewhere. This is a short proposal to precede multiple universities and multiple year's collaboration, under the guidance of DARPA Dir.Dr. Steven Walker unveiled $2B effort to develop the next wave of AI.[5,6]

 

Artificial Intelligence (AI) and Deep Learning (DL) are what everyone is talking about these days. In fact, talks of AI and DL are not new and they actually started in 1988 or even earlier than the formation of International Neural Network Society (INNS) (cf. Youtube ACM Interview of Harold Szu Dec 2018). Deep Learning has been based on multiple layers feature extraction; which one layer feature extraction follows the other to build up the complexity of features). DL is not limited to visual pattern recognition, e.g. from the edge extraction V1, connected to contourV2, followed with convex or concave curvatureV3, etc. including Human Visual System having red color Rhodopsin (while animals have only Green grass & Blue sky) for the pattern recognition. AI_DL can help biomedical data mining to fulfill NIH 4P Goals (Private, Precision, and Preventive, as well as Pre-emptive). Novelty discovery can save public health system from the imminent bankruptcy. One of the major reason popularity in AI and DL research activities was going up and down the performance due to the trinity :(a) hardware , (b) software and (c) training data (in the cloud). Today, we have collective Smartphone's computing power as the" fan pop" club, as if bigger than a miniaturized GPU from a room size to a PC backplane, as the cost-efficient way to store DRAM, transfer and compute a massive amount of data in a way that was never possible before. In the near future, AI and DL will become once again 3 wave AI hot topics, no doubt, the development will be limited by the bottleneck caused by (a,b,c).

The applications for AI DL consist of a wide range including computer science, automation, gaming, virtual reality (VR) or augment reality (AR) education, finance, medical wellness data, hospitals diagnosis and medicine discovery, development, marketing, media and music, arts, news and publishing, and even legal services. There are three major stages in a common AI architecture (1st). commands or environment information input, (2nd). AI algorithm processor, and (3rd). decision outputs. In order to implement AI DL to a variety of applications, stage-1 is the interfaces need to meet all the requirements for different applications. There are two types of information inputs to stage-1 which are real-time and non-real-time input. Certain industries require real-time input, from both humans and the environment, for the AI system, which becomes more and more challenging for the modern AI system. For example, the Unmanned Autonomous Trucks that are badly needed for retail Supermarket e.g. Amazon, from depot to depot will generate the 4th Economic Booming in the US.(since Eisenhower built the Interstates after WWII, John F Kenney Precision Electronic for Moon Landing, Al Gore extended ARPA Internet to WWW). As now, the State of Art of UAV on Market might be Tesla Model 3, selling worldwide at $35K. AI_DL have helped the VR/AR systems, robot team weep dried bushed in CA, and the combat systems on the battlefield. The well-known human-machine interfaces are implemented by mechanical devices or entities such as mouse, keyboard, joystick, vehicle handles, paddles, voice, and so on. However, these input devices require physical operations, which may not be applicable to some applications such as with disabilities, military operations that require silent or stealth input activities and capabilities, or driver concentration monitor systems.

The brain computer interfaces (BCIs) could potentially lead to sophisticated neural control bionic prosthetics and other receiver devices for the above applications. The history of brain–computer interfaces (BCIs) starts with Hans Berger's discovery of the electrical activity of the human brain and the development of electroencephalography (EEG). Recent years, BCI researchers have focused on invasive, partially invasive, and non-invasive BCI. Furthermore, EEG can also be applied to telepathic communications which could provide the basis for brain-based communication using imagined speech. It is possible to use EEG signals to discriminate the vowels and consonants embedded in spoken and in imagined words and apply it to military products. In this section, we begin with an example of using high density EEG with high electrode density and analysis the results by using BCIs. The BCIs in this work is enhanced by a field-programmable gate array (FPGA) board with optimized two-dimension (2D) image Fast Fourier Transform (FFT) or Adaptive Wavelet Transform (AWT) analysis. According to Nyquist-Shannon sampling theory, the two degrees of freedom (d. o. f.) per node as the information comes out of the brain which requires the brainwaves reach 5-30 Hz frequency range. Thus, it has not enough frequency content to code the complex brain information processing. Where the information content resides become a reasonable question. The information must reside beyond the frequency content at the spatiotemporal responses in the sense of the stimulus and the response. Thus, based on Nyquist-Shannon sampling theory, it establishes a sufficient condition between a signal's bandwidth and the sample rate that permits a discrete sequence of samples to capture all the information from the continuous-time signal.

Conventionally, the commercial laboratory already has a tethered and wired high density EEG head mount. However, the constriction upon users' movements cannot invoke a natural stimulus and response. Therefore, we proposed an inexpensive and wireless EEG hat device.

In addition, we further design a platform to enable the proposed wireless EEG helmet to connect to the Smartphone and/or personal computer system. There are many challenges, included hardware and software, as well as cloud Databases that bar the conventional AI_DL_ EEG to accomplish the above goals. First of all, there are huge amounts of internally mixing states for $10^{10}$ Neurons and $10^{11}$ glial cells, as well as $10^{10}$ *external* electrodes. The large amount of mixing states requires high processing demand to accomplish the above applications, especially when we target to real-time processing.

Secondly, the EEG connectivity requires blind sources separation (BSS) to identification underlying causes. Since the chief difficulty of the problem is the under-determination, methods for blind source separation generally seek to narrow the set of possible solutions in a way that is unlikely to exclude the desired solution. A possible solution to decrease the hardware and software requirements is to impose structural constraints on the source signals. These structural constraints may be derived from a generative model of the signal but are more commonly heuristics justified by good empirical performance. A common theme in the approach is to impose some kind of low-complexity constraint on the signal, such as sparsity in some basis for the signal space. This approach can be particularly effective if one requires not the whole signal, but merely its most salient features. Thirdly, there will be a spatiotemporal delay to be considered while we do the integration. This delay will impact the final analysis of the brainwaves, therefore, needs to be resolved by hardware prior to sending the information for final analysis. Fourth, the stimulus causes and the responses effects are uncertain. Therefore, reliable analytical software is required after the RAW data has been processed and passed through the filters. In addition, the wireless mobile has to deal with environment noise, e.g. 60 Hz power line and other electronic instruments. In conclusion, the above discussed challenges will need to be resolved with real-time situational processing.

In theory, the Brain Computer Interface (BCI) will be enhanced by a FPGA board with Optimized two-dimensional (2D) image FFT analysis. According to Nyquist Shannon information theory that

two degrees of freedom (d. o. f.) per mode as the information, the brainwaves DTAB (5~30 Hz) do not have enough frequency content to code the complex brain information processing, then the question is where is the info content reside?

The information must reside beyond the frequency content at the spatiotemporal responses in the sense of the stimulus and the response. Commercial laboratory already has already a tethered and wired high density EEG head mount as.. Why do we need a wireless high-density EEG in mobile applications? Basically, the constriction upon users' movements cannot invoke a natural stimulus and response. Therefore, we have demonstrated the implementation for higher density EEG probes to measure brainwaves simultaneously. In this example, the total number of proposed electronic nodes is about twenty. We propose to implement a processor to receive the RAW data collected from these electronic nodes sensed the customer/patient's head. A DFT filter bank will be implemented in the processor. Therefore, the proposed hardware can provide enough sampling rate to satisfy SNR and further filter out the noise cause by scalp or even the customer/patient's hair. In order to further improve the processing time to meet real-time in-situ process as discussed previously by Jerry Wu et al.,[7] a digital signal processing (DSP) module is designed in this work with Broadcom, Altera, and Apple cell phone as examples hardware. The brainwave module is designed to accommodate the user-friendly application interact and capable of management by users in either wired or wireless environments. Thus, the data analysis module is implemented by hardware and software co-design method. Since the device is implemented wirelessly, the above discussed configurations maybe also adjusted by the user or medical center remotely. In addition, the user and medical center or researcher will be able to monitor the status remotely 24 hours a day, while the patient/customer may not even aware of it. The current wireless mobile EEG follows the state of art standard 10 & 20, namely 10 nodes at 20 degrees apart. As previously discussed, it provides the wireless interface with high flexibility for re-configuration. In other to further improve the quality and/or SNR, we added adaptive noise cancellation (ANC) especially for 60 Hz power line, and Natural Impedance Balance (NIB) to sense through the hair all the way to the frontal lobe without the hair. We have followed in the accompanying paper, the column-only Charge Couple Device (CCD) for the column summation of each of 10 nodes leading another 9 nodes time sequentially behind the frontal node along the longitudinal direction from the frontal lobe having no hair to the 17 visual cortex at the back of the head with hairs. Since the neuronal information response is estimated at ¼ sec for a phoneme, and brain neuron firing rate is about 15 Hz, one can support each of 9 sequential read-out nodes divided 1 MHz clock cycles per column with enough SNR integration per nodes. The tools simulated the filter design prior to implement to proposed FPGA hardware. The prototype FPGA system, as shown in we implemented in this work is running by minimum 25MHz of the system clocks. Nonetheless, we are optimistic that when there is need there will be solution collectively from the Interdisciplinary community led by INNS & IEEE/CIS in annual World Congress of Neural Network Assembly.

## Conflicts of interest

Authors declare that there is no conflict of interest.

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3. https://www.motor1.com/news/237427/uber-volvo-autonomous-tech-crash/
4. Many Automobile companies including Tesla, Toyota, Volvo have spent at the tone of multiple billions dollars investment on Autonomous Vehicle; unfortunately one subsidiary of Volvo/Uber have accidently killed an (intoxicated?) woman pushing a pink pike crossing the traffic intersection in Temple Arizona. Insurance paid off the dead woman; but suited the car design company which has violated the fundamental.
5. An alternative to the Hippocratic Oath for Physician*:* "Thou shall do no harm to human is not give up on patients" for the future robot machine physician society. This is one of the ethic rules that are of concern to the professional society, such as ACM, IEEE/CIS, etc.
6. DARPA director, Dr. Steven Walker, officially unveiled Announces $2 Billion Campaign to Develop Next Wave of AI... https://www.darpa.mil› News And Events Sep 7, 2018 Opportunities. DARPA sees this next generation of AI *as a* third wave of technological advance, one of contextual adaptation called the "AI Next" campaign.
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