

Commentary: ANN involves a variation threshold logic that generated a broader artificial intelligence apps from deterministic chaos to fuzzy logic

Introduction

We wish to show how computational intelligence can be varied with different neuronal decision logic: (1) Donald Hebb neural networks: “neurons that fire together wire together”¹⁻³ with a Sigmoid Logic (SL) adopted for Artificial Neural Networks (ANN) (2) Mitchell Feigenbaum, a founding father of Chaos Theory,⁴ bifurcations for “guess-estimation” as deterministic Chaos Intelligence (CI); (3) Lotfi Zadeh open-set possibility thinking called Fuzzy Logic (FL).⁵ We wish to emphasize these underlying logic have been used for (1) computational intelligence called Artificial Intelligence (AI), Yann LaCun⁶ NYU Courant Inst. And together with computational simplification threshold logic adopted by Andrew Ng of Stanford⁷ Developed multiple layer convolution learning called Deep Learning in the massively parallel matrix algebra emulating Layer 1 to 5 at the cortex 17 back of our head HVS; (2) Possibility Intelligence (PI)

based on the deterministic chaos; (3) Fuzzy Intelligence (FI), an open-set possibility thinking.⁶

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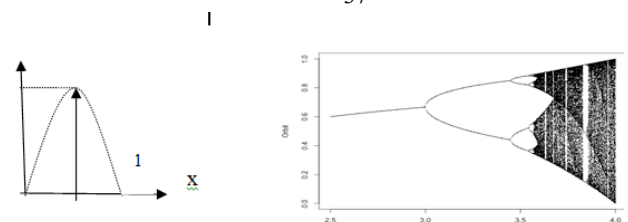
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Figure 1 Twenty to Twenty First Century: (a) Ludwig Boltzmann (1844–1906) head-stone: $S \equiv k_B \log W$; (b) Herman Helmholtz (1821–1894); (c) Donald Hebb (1904–1985) Hebbian Learning “firing together wiring together”; (d) Michelle Feigenbaum (1944–2019) deterministic Chaos; (e) Lotfi Zadeh (1921–2017), Fuzzy (open-set) Logic; (f) Academician William A. Hagins (1925–2012) of National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)’s discovered at 1970 the dark current when no incoming photon to a rod, and a single photon can disrupt the “dark current” leading to the detection mechanism. (g) Yann LeCun of NYU co-inventors of Deep Learning; (h) Andrew Ng of Stanford U of matrix coupled layers deep learning; The single photon can have EMF potential perturbed the membrane potential, as such the dark current is broken (i) “negate the converse” logic when there is no more dark current inhibiting the Ganglion cells, so that the information triggers the detection of a photon overcoming the thermal background noise energy about $(1/37)$ eV through the integration Ganglion cells using own energy to fire to the Cortex 17 area located at the back of our heads. This physiology trick is important to our cavern-dweller ancestors to be able to detect a single photon emitted from wolf eyes in a complete peach dark cavern. The Boltzmann constants can be compared at the hot room temperature 27°C and our own body temperature 37°C

This thermal energy is equivalent to the homeostasis temperature $T_o = 37^\circ\text{C}$ of the homo-sapiens about $\frac{1}{37} \text{ eV} \approx 3\% \text{ eV}$



Szu⁸ detailed how Hagins’ dark currents satisfy the Quantum Mechanics Uncertainty Principle. (1) First of all, as the single photon has not enough energy to sustain neuronal 100 Hz firing rates we have to forgo the need of information from the energy. (2) Secondly, we have physiologically keep 100 rods bundled together in a spatial uncertainty unit Δx for the dark currents. Then, when a single photon processes a sharp momentum $\Delta p \ll \hbar/\Delta x$ requires the support of a large spatial uncertainty Δx of 100 rods bundle of which the circulating dark current must go through the bundle in order to satisfy the Schrodinger-Dirac uncertainty principle: $\Delta x \Delta p \approx \hbar$;

Let’s consider the classical “ions” concept (large calcium ions outside the rods & small potassium ions insides the rods) They were

$$k_B T_o = k_B (27^\circ\text{C} + 273^\circ\text{K}) = k_B 300^\circ\text{K} = \frac{1}{40} \text{ eV} \approx 2.5\% \text{ eV}$$

circulating around 150 million rods, and detection “by means of the negate the converse detection logic” among 100 rods integrating Ganglion neurons (with the uncertainty in position; but sharp in single photon momentum). Furthermore, those ions currents follows one another, like “ducks” walking & quacking across the axon road, but ushered along by means of ten times more and ten times smaller house-cleaning neuralgia (glia: Greek: Glue) cells.

Artificial neuron model

Moreover; the Boltzmann entropy can be rewritten as the canonical probability in terms of Helmholtz free energy H_{brain}

$$W = \exp\left(\frac{S}{k_B}\right) = \exp\left(\frac{ST}{k_B T}\right) = \exp\left(\frac{E - ST}{k_B T}\right) / \exp\left(\frac{E}{k_B T}\right) \equiv \exp(-\beta H_{brain}) / \exp(-\beta E_{brain})$$

$$H_{brain}^{I/O} \equiv E_{brain}^{I/O} - ST_o; \beta \equiv \frac{1}{k_B T_o}$$

Artificial neural nets (ANN)¹ input/output (I/O) must be normalization with respect to an isothermal brain equilibrium, as the following isothermal logistic map defined the Donald Hebb sigmoid logic³

$$\frac{Input}{normalization} = \frac{\exp(-\beta H_{brain}^{input})}{\exp(-\beta H_{brain}^{input}) + \exp(-\beta H_{brain}^{output})} = \frac{1}{1 + \exp(-\beta(H_{brain}^{output} - H_{brain}^{input}))}$$

$$y = \sigma(x) = \frac{1}{1 + \exp(-x)} = [1 + \exp(-x)]^{-1}$$

It turns out that the slope of sigmoid logic is a mathematics basis of chaos:

$$\frac{dy}{dx} = \frac{d}{dx} [1 + \exp(-x)]^{-1} = \frac{(-1)^2 \exp(-x)}{[1 + \exp(-x)]^2} = \frac{[1 + \exp(-x)] - 1}{[1 + \exp(-x)]^2} = y - y^2 = y(1 - y)$$

$$= \int f(t, x - \Delta) \varphi(\Delta) d\Delta \equiv E\Delta [f(t, x - \Delta)] = f(t, x) \int \varphi(\Delta) d\Delta + \frac{\partial}{\partial x} f(t, x) \int \Delta \cdot \varphi(\Delta) d\Delta + \frac{\partial^2}{\partial x^2} f(t, x) \int \frac{\Delta^2}{2} \cdot \varphi(\Delta) d\Delta \equiv f(t, x) + 0 + D_o \frac{\partial^2}{\partial x^2} f(t, x)$$

$$\frac{\partial}{\partial t} f(t, x) = D_o \frac{\partial^2}{\partial x^2} f(t, x)$$

Scalar Diffusion constant, that's the reason why it's second order in space

$$D_o \equiv \left\langle \frac{\Delta^2}{2\tau} \right\rangle = \frac{1}{2\tau} \int \Delta^2 \cdot \varphi(\Delta) d\Delta$$



Figure 3 All phenomenology were related, from underground bifurcation leading to Chaos turbulent, Earth quake, and Fire Diffusion on the ground. A typical historical cases was On April 18, 1906, an earthquake and subsequent fires devastated San Francisco, California, leaving more than 3,000 people dead and destroying more than 28,000

This is equivalent to set Michelle Feigenbaum⁴ bifurcation logistic map lambda knob

Fig.2 (a) Feigenbaum logistic map; (b) bifurcation toward deterministic chaos

$$\frac{dy}{dx} = 4\lambda y(1 - y)$$

$$\text{Lambda knot } \frac{dy}{dx} = 1; 4\lambda = 1 \quad y = \lambda; x = \frac{1}{2}$$

Lambda knot λ generates the bifurcation cascades

Bifurcation led to deterministic chaos which with multiple origins can result into a collection of Einstein diffusion

Robert May followed its discrete approximation of the sigmoid logic, and showed $4\lambda \approx 2.3; \lambda \approx 0.575$ is the stable (bifurcation or fertility) birth rate per y_n -generation. “If it is too high in birth rates can breed severe competition, on the other hand the fertility were too low the population cannot sustain.”

$$\Delta y_{n+1} = 4\lambda y_n(1 - y_n); n = 1, 2, 3; \Delta x = 1; \lambda \approx 0.575$$

Since bifurcation helps mixing into diffusion, we shall furthermore derive Diffusion Equation in discrete time steps¹⁰ in the continuous random space Δ governed with the probability density $\int \varphi(\Delta) d\Delta = 1$

$$f(t, x) + \tau \frac{\partial}{\partial t} f(t, x) \Big|_{t'=t} + \dots = f(t = t + \tau, x) \text{ Taylor expansion}$$

buildings. The quake ruptured the San Andreas fault to the north and south of the city, for a total of 296 miles, and could be felt from southern Oregon to Los Angeles and inland to central Nevada.

Conclusion

All these results seem to be unrelated but confirm what Albert Einstein said all along “Science has nothing to do with the truth, but the consistency.” To substantiate this thinking, we have begun with Ludwig Boltzmann, so-called Entropy, S, to Herman Helmholtz free to-do-work energy, which has been derived from and degree of no-information, so-called entropy. Once again, we have demonstrated the fact that the scientific disciplines do not stand alone, but mutually dependent on by the consistency and simplicity. This fast emotional diffusion thinking is related to Kahneman Tvisky fast thinking autopilot versus slow AI computational logic thinking.

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Appendix

Appendix: Thermal mixing of chemical hormones signal in animal instant responses

1. Externally:

Einstein interpreted the botanist Brown observed phenomena, the so-called Brownian motions, as one can visually see, without using the microscope, the *thermally* agitating water molecules kicking incessantly around the macroscopic pollen. Likewise, the smoke coming out of the chimney initially in a linear motion and then in parabolic motion due to the air molecules kicking around the smoke particles incessantly.

2. Internally:

Homo sapiens (the wise one) have kept thermal equilibrium of core body energy at $T_o = (37^\circ\text{C} + 273\text{K})k_B \cong (1/37)eV$. According to Boltzmann the definition of entropy $S = k_B \text{Log} W$ is proportional

to the available phase space W , and the total entropy should be separated into internal and external $S = S_{in} + S_{out}$ then, the homo-sapiens isothermal equilibrium system turns out to be associated with the sigmoid logic derived as follows:

$$W = \exp\left(\frac{S}{k_B}\right) = \exp\left(\frac{ST_o}{k_B T_o}\right) = \exp\left(\frac{(S_{in} + S_{out})T_o}{k_B T_o}\right) = \exp(-\beta H_{in})$$

Where use is made of the conservation of thermal energy $E_{in} + S_{out}T_o = 0$; the short hand notation $\beta \equiv 1/k_B T$ and Helmholtz (internal) free (to do work) energy $H_{in} \equiv E_{in} - S_{in}T_o$

Neuronal logic is a weighted probability of the output with respect to the total probability defined as the following logistic sigmoid function

$$\sigma(x) = \frac{\exp(-\beta H_{out})}{\exp(-\beta H_{in}) + \exp(-\beta H_{out})} = \frac{1}{\exp(-\beta(H_{in} - H_{out})) + 1} \equiv \frac{1}{\exp(x) + 1}; \quad x \equiv \beta(H_{out} - H_{in})$$

Clearly, the Ricati equation follows:

$$\frac{d\sigma}{dx} = \frac{d}{dx}[\exp(x) + 1]^{-1} = -[\exp(x) + 1]^{-2}[\exp(x) + 1 - 1] = -\sigma + \sigma^2$$

We can apply the Baker or E. Hopf transform to linear-lize the pseudo nonlinearity to reduce to the second order diffusion equation as follows:

$$\text{Let } \sigma = -\frac{\varphi'}{\varphi} \left[= -\frac{d \log \varphi}{dx} \right]$$

$$\text{Then } \frac{d\sigma}{dx} = -\frac{\varphi''}{\varphi} + \frac{\varphi'^2}{\varphi^2};$$

Consequently from sigmoid defining equation $\frac{d\sigma}{dx} + \sigma = \sigma^2$ follows

$RHS = \left[\frac{\varphi'}{\varphi} \right]^2 = LHS = -\frac{\varphi''}{\varphi} + \frac{\varphi'^2}{\varphi^2} - \frac{\varphi'}{\varphi}$; One has arrived from the sigmoid logic the $\varphi'' = -\varphi' = \varphi_t$, where use is made of replacing the streaming with partial time derivative of Einstein equation of thermal diffusion of chemical hormone signals in rapid emotional response $\varphi'' = \varphi_t$

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10. Diffusion is utilized by the missing half of "electronic signals" AI called e-IQ, based on the "chemical signals" (macro-ion molecules called hormone, made of Pentagon or Hexagon with side chains, about hundreds in groups, e.g paracrine signals move by quick diffusion through extracellular matrix. Though they are too big to fit through wires; require to emulate emotional feeling for the future humanoids to take care of home-alone seniors on Earth or Astronauts at outerspace, e.g. Mars.