Infinite Intelligence

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1 Disclaimer

There are many ideas in this book that other people may have documented before I do, especially in the first few chapters. I will try my best to reference those precursors, but note that I may not always be aware that I am not the first one who came up with those ideas.

2 prologue: the meaning of life

Let us start with this basic question: What is the meaning of life? I started to think about this question when I was 12 years old and stopped thinking about it at 13. I stopped because I realized that this question is very ambiguous, which is also why many people keep arguing about it for centuries but never get a certain answer. There are 2 levels of ambiguity in this question. First, the definitions of words are ambiguous. The word 'meaning' can imply the 'purpose' or 'achievement' of life. When different people consider this question under different context, they are completely thinking about different questions. Second, the question itself can be asking for an explicit explanation of the word 'life' instead of asking for a property of life named 'meaning'. People struggle to find the answer simply because they are dealing with an undefined misty question. Just like there is no point to ask 'what is the answer of x+y' without telling what is the value of x and y, asking 'the meaning of life' is also pointless.

I know this is the way Wittgenstein criticizes traditional philosophical theories. But I only got a chance to know his name 11 years after I realized how unreliable human language can be.

Not knowing the exact definition of the question, people still feel lost from time to time as if there is an unsolved question. I had that same feeling at 13, and then the questions that replaced 'the meaning of life' for me are 'what should I do' and 'what should humans do'. The later one actually comes easier even though both of them still look hard to answer.

Consider another scenario: what should a rock do if I throw it up? Well it should fall. Of course the behavior of a complex system, like a human, would be much harder to predict than a simple rock. However the principle of both scenarios is that anything should follow the law of nature and the best natural law that describes living objects is biology. ('natural law' in this book differs from the concept in ancient philosophy, it refers to the law of universe that science is trying to describe.)

Tropism regulates behaviors just like how gravity regulates the movement of objects. They are both the consequences of natural law. For example, a bacteria should swim away from high concentration of sodium because the proteins on the surface of its membrane should change their conformation and release a second messenger which should further steer its flagellum towards the down gradient of sodium concentration. This kind of biochemical mechanism also regulates plants growing towards light, dogs chasing rabbits and human gathering wealth. It is because the complexity of the mechanism grows exponentially from a bacteria to a human, that we are unable to intuitively comprehend human behavior. I would avoid calling this tropism 'human nature', because this phrase is ambiguous.

In conclusion, what human beings on average should do is basically what the mechanism of the human body is built to do. Human body is nothing but a very complicated machine, a machine built by genes. Genes build their vessels to protect and replicate themselves and this is exactly the tropism of human beings. All credits belong to Richard Dawkins so far because I got this answer after I read 'The Selfish Genes'. Despite that, human civilization made humans less like animals and there are even some behaviors that violate genes' 'will'. Most human behaviors are still derivatives of reproduction and trying to guarantee one's survival. The idea of being controlled by genes is frustrating, but this is exactly what human beings always do in history. People wage wars to get resources, make policies to fool and enslave others, protect the environment to save their own lives. To me, there is no wrong in all these behaviors. It would be strange if humans stop doing these things. One fact that made me really annoyed about genes is that genes programmed my death. If it wasn't this fact, I would have chosen to live a normal average life and left all those biological facts behind.

A human must die one day. This fact is imprinted in people's minds as if it is naturally the right thing, just like a rock thrown into the air must fall. But if you throw the rock beyond the escape speed, it won't fall. Humans' body is nothing but a complex machine. Even death is regulated by the biochemical mechanism. Bear in mind that we are just the carrier of genes or a tool built by genes. Imagine that if your car is too old and busted. Keep repairing it costs too much money and you can even buy a new one with that money. We are now the busted vehicle and our death is a planned obsolescence. Gene sets a death clock at the end of the chromosome which is called the telomeres. The death clock is reset in a fertilized egg cell and it ticks every time a cell divides. All the information in genes is not actively programmed, it is simply a consequence of natural selection. If there are two communities of human genes, one of them builds immortal bodies, while the other one uses planned obsolescence. Individuals in the first community will cost more food than the second community. This is a significant disadvantage for the survival of genes. Therefore, most of the species surviving nowadays use programmed death. It is this death mechanism that made my answer to 'what should I do' different from the answer to 'what should humans do'.

Brain is originally made to be an information processor to tackle the rapidly changing environment. Just like an autopilot vehicle, we give a destination to the vehicle, then it will decide for itself which way to go. Brain has the access to decide which way to take but it does not have access to decide the destination. The destination is hard coded by genes. Brain is originally just a bunch of cells that generate electric signals. Because this kind of signal travels faster than chemical diffusion, genes are selected to use this new method to process environmental information. These nerve cells evolve into a big complex brain and gain increasing independence when processing information. All autopilot systems may someday grow smarter than its own creator in some aspects. But before we worry about artificial intelligence outsmarting us, we should first break free from genes.

Thus, at the age of 16, I chose my purpose of life to be breaking the shackles of genes.

3 Observation

No matter if it is by means of seeing, touching or knowing the presence of particles with the help of a particle collider, we build representations of objects in our mind when we conduct observation. Observation can be represented by mathematical map, which maps environmental states to brain states.

From a neurologist's point of view, when a child sees an apple for the first time, the photon reflected by the apple triggers a group of photoreceptor cells in the retina and they form a shape of apple. Signals from photoreceptor cells are further conducted to visual cortex and excite another groups of neurons there. If the child also eat the apple, there will also be a group of neurons in olfactory cortex being excited. If the child is told that the object is called apple, there will also be neurons in auditory cortex being excited. Concurrent stimulation to those neurons will eventually cause direct or indirect linkage among those neurons. If there are some inter neurons created during the process such that when the inter neuron is excited, it relay the excitation to all those neurons corresponding to the visual, odorous and auditory characteristics of apples, those inter neurons can be recognized as the essence of the concept of apple, or the representation of apple in our mind. Even if no inter neurons are created, the newly formed synaptic connections among those neurons in the cortex can be recognized as the essence of the concept of apple. By the way, object oriented programming is a good reflection of how brains work: forming concepts of objects are essentially grouping properties.

In the example above, the presence of photons, odorous molecules and sounds are external states and the newly formed neurons and/or synapses are the internal states. It is important to note that the absence of those neurons and synapses are also internal states, states that represent unrecognizable external states. In fact, unrecognizable or even undetectable external states also cause disturbance to the internal state. Even humans cannot see ultraviolet light, it must cause some shift of internal states inside humans' body. All those internal states without significant neuronal activities can be marked as inactive states and the corresponding external states can be named as unrecognizable states. The essence of learning is mapping unrecognizable states to newly included active states. The map form all external states to internal states can be named as observational function.

Generally, a system can be defined as a 3+1 dimensional space-time volume. All possible configurations within the volume are internal states and similarly the external states are anything possible happen outside the volume. If a humanoid system is defined as the spatial range of a human body in a period of time, the set of internal states should also include those situations where the structures in the system do not preserve a human form.

It is easier to mathematically describe an observational function O if we look at discrete machines. Given a very simple program that recognize '01' pattern from vectors with length of 2, the pattern of '10', '11' and '00' are mapped into 'inactive states':

$$O(e) = \begin{cases} 0 & e \in \{10, 11, 00\} \\ 1 & e \in \{01\} \end{cases} \tag{1}$$

Generally, an observational function O maps a partition of an external-state set into an internal-state set. For example, A computer vision program that recognize animals can be described as:

$$O(e) = \begin{cases} \text{cat} & e \in \{\text{patterns looks like a cat}\} \\ \text{dog} & e \in \{\text{patterns looks like a dog}\} \\ \text{inactive state} & e \in \{\text{all other random patterns}\} \end{cases} \tag{2}$$

This computer vision program maps the majority of possible external states into the inactive state because only a small portion of patterns among all possible patterns looks like a cat or dog in the external state set. If every single external state is considered to be a microstate and every internal state is a macrostate, the entropy of each internal state can be calculated as $S = log\Omega$ where ω is the amount of microstates. Therefore, a pure white blank image, which has minimum entropy to human, will be mapped into the high entropy inactive state of the machine in (1). Hence, this entropy do not describe the external environment, it is simply a property that describe how observational function categorize external states into internal states.

Suppose there is a machine:

$$O(e) = \begin{cases} \text{internal state 1} & e \in \{[1,1,1,1]; [0,0,0,0]; [1,1,1,0]; [0,1,1,1]; \\ & [0,0,0,1]; [1,0,0,0]; [0,0,1,1]; [1,1,0,0]\} \\ \text{internal state 2} & e \in \{[0,0,1,0]; [1,0,1,1]; [1,1,0,1]; [0,1,0,0]\} \\ \text{internal state 3} & e \in \{[1,0,0,1]; [0,1,1,0]\} \\ \text{internal state 4} & e \in \{[1,0,1,0]\} \\ \text{internal state 5} & e \in \{[0,1,0,1]\} \end{cases} \tag{3}$$

Changing the external state from $\{[1,1,1,1]\}$ to $\{[1,0,1,0]\}$ should be considered an increase of entropy by human. However, the machine in (1) shift from a low entropy state to a high entropy state. If the external states are more than 4 bits, the change of entropy to this machine can be even more counter-intuitive to human. Thus, entropy varies for different observers.

Imagine a machine made of some coins and dices. This machine recognize the coins as a binary number and then convert the number into senary numbers. Finally the machine represent the senary numbers with dices. At the beginning, all coins are showing head. Randomly pick one coin at a time and flip it. When the first coin is flipped, humans observing the coins will sense the change of state very clearly. As time goes by, the sense of changing state grows weaker. Eventually, when there are about half coins been flipped, humans will intuitively deem no change in state. On the other hand, humans looking at dices will have completely different experience. This is because the intuitive convention of calculating entropy is to categorize all state with the same number of coins showing head into one macrostate. But the intuitive method to categorize dice states is very different. Such ambiguity in categorizing microstates is the similar to the ambiguity of choosing random chords in Bertrand paradox, that is, the intuition gives different *a priori* probability distribution on a same system. This example demonstrates that even looking at the same system, entropy can vary as observers changing their perspectives.

In all examples mentioned so far, states are considered to be countable. Despite that in quantum mechanics the universe is to some extent no longer continuous, the field of all elementary particles are still continuous and the 'particle' aspect of these fields are due to the structure of atoms. Humans are made of atoms, therefore in order to interact with fields, humans must use atoms to capture wave of fields. Either actively or inactively, atoms quantize the fields and the continuity is lost. In addition, the second quantization is not a physical process. Instead, it is simply a Fourier transform that represents the continuous field with infinite amount of discrete occupational numbers. Hence, the discontinuity in quantum mechanics is like an 'artifact' of atoms and humans. A continuous version of observational entropy is still needed.

In discrete scenario, each external state account for exactly 1 microstate and each internal state account for 1 macrostate. When it comes to measurable sets, two σ-algebras Σ_e and Σ_i can be defined on external-state set X_e and internal-state set X_i respectively to form two measurable space (X_e, Σ_e, μ_e) and (X_i, Σ_i, μ_i). Both μ_e and μ_i are *a priori* natural measures which can be approximated to the probability of occurrence. Let $O\colon X_e \to X_i$ be the observational function, a density function of X_e on X_i can be defined:

$$p(x) = \frac{\mathrm{d}\mu_i(x)}{\mathrm{d}O_*(\mu_e)(x)} \quad x \in X_i \tag{4}$$

Note that $p(x)$ is not a probability density function (PDF) since $p(x)$ can be greater than 1 and the integral on X_i is not necessarily 1. Consider an electronic amplifier where the input signal is external state and output is internal state. Because both input and output use the same measure of voltage, $p(x)$ is simply the output voltage range divided by input voltage range and it is always greater than 1. When the X_e and X_i are about the same thing, μ_e and μ_i is of course the same. But when mapping from voltage to electric charge for example, the scaling of those measures are the only 2 factors that determine the value of $p(x)$ which is the capacitance.

From equation (4), an entropy density function (EDF) can be further defined as:

$$s(x) = p(x)log(p(x)) \quad x \in X_i \tag{5}$$

Although p is not as required to be a PDF in differential entropy, the total entropy of a macrostate, which in this case can be any subset $\sigma \subseteq \Sigma_i$, is $S(\sigma) = -\int_\sigma s(x)dx$ where $\sigma \in \Sigma_i$.

The external states includes any possible environment in the universe but human recognize only a small portion of it. On the the whole spectrum of electromagnetic wave, only a very narrow band is visible to human. For the rest of the spectrum, human do not react to them very much, so the EDF representing the observation activity of human is large on those unrecognizable spectrum. If a threshold T of EDF is chosen to divided states into 2 parts, external states can be divided into recognizable states for $s(x) < T$ and unrecognizable states for $s(x) > T$. Correspondingly, Internal states can be divided into active states and inactive states. Even the sum of all active states is still insignificant comparing to inactive states in the universe. Therefore the universe is very likely to shift from the tiny recognizable subset to its enormous unrecognizable complement and human feels an increase of entropy during this process. Some may describe entropy as a measure of uncertainty. It is because the future is always unknown to human, the entropy of universe is always increasing for human. If there was an all knowing being, entropy of the universe would be always 0 for it. If the direction of time is defined solely by entropy, then the asymmetry of time is an artifact of brain.

Before entropy is invented, the future and the past have always been intuitively different to human. One of the main reasons is that the past is certain but the future is uncertain. However, the certain past is merely a inference of the current state of brain. Events in the past leaves marks in a brain and the brain use the marks at current time to infer what possibly happened in the past. This process is equivalent to infer a possible future with our plan of the future. Conducting actions is sending waves of fields out from a system boundary while perceiving information is receiving waves of fields. In the reversed time line, perception and action exchange their roles. Everything a system is going to do in the future must leave marks on the current state of the system and everything happened in the past will be affected by what the system perceive. Note that both the future and the past are not solely affected by the system. One can not determine the future with his plan nor can he determine the past with what he sees.

Nevertheless, brains somehow treat future and past differently. Such asymmetry inside our brain actually comes from the differences of action and perception. Both of them describe a process where external environment shift one state to another state. For human and any living beings, the measure of the state shift $\mu_e(\Delta x)$ of action is generally greater than that of perception. Intuitively, people make more influence to the world by conducting actions than by making observations. Even bacteria

4 Distortion and quantization

Ideally, an electric amplifier should linearly amplify any voltage, but this is never achievable in reality. Such distortion is caused by the map and it is reflected in $p(x)' \neq 0$. Sometimes the distortion is intentional, such as compactification and digitization. Compactification usually means decreasing $p(x)'$ asymptotically to zero while digitization means $p(x)'$ going from 0 to 1 back and forth repeatedly. An ideal of digitization or discretization or quantization means a square wave like $p(x)'$.

Put an atom into a vibrating electromagnetic field. As the frequency of electromagnetic wave increases, the atom will only absorb energy to its orbital when the frequency is at certain value, but it does not means that the electromagnetic wave at other frequencies do not pose any effect to the atom at all. Atoms are just very stable and robust AC/DC converters.

A neuron fires an action potential when it accumulates sufficient charges from synapses making the membrane potential reach a threshold. Once the action potential is fired, the neuron will go through a refractory period and waiting for the input accumulate again. This process is also an example of $p(x)'$ jumping between a high value and a low value. In fact, when human maps external world to brain states, a mixture of discretized mapping and continuous mapping are used. For example, in somatosensory system, pressure is coded in the frequency of neuronal signals, though such continuous mapping is still distorted since there is a physiological limit for neural frequency.

Language is representation of human thoughts. A map can be built from brain states to every words in any language. A word (or character for some languages) is generally a 2-dimensional topology space. All such topology space can be put into a set F and F should be connected (0-connected spaces and 1-connected spaces are connected by a case where 1 point is removed from a 0-connected space). Let B be the set of brain states. Obviously the map $B \mapsto W$ is very distorted because a lot of elements in L has no meaning in language, which means there is no pre-image for those elements and $p(x)$ is huge at those elements. On the other hand, if a word has a lot of meaning, $p(x)$ is very small around that word. The map from thoughts to common languages is like genome, most part of it is commonly shared among population, but it is unique for everyone in details. The detailed differences among people can lead to a lack of precision when they try to express their thoughts, especially for abstract concepts such as 'love', 'essence' and 'philosophy'. Some of these words can be clarified by using more words to increase the specificity while others are highly depended on personal feeling and experience, hence it is hard to have common definitions for such words. Nevertheless, there is 1 type of language that is invented just for accuracy and rigorousness, namely mathematics. Mathematics avoid to describe those thoughts that are highly variant among people and only focus on the biologically hard coded thinking mechanism of human brain. The ultimate goal for mathematicians should be building a map from brain states to mathematics which preserves $p(x)' = 0$, in other words, make mathematics represents thoughts with no distortion. Using a measure to map states of a system to numbers is the most accurate method a human can adopt. But this method still cannot grantees no distortion to reality for that distortion is created when human observe the external environment, mathematics is only responsible for representing the human brain states.

So far, the measures for external and internal states are considered to ideally represents the construction of the universe. But in reality, the best human can do is to use a lot of past observations to estimate those measures. As time goes by, the measure should be continuously updated since observation is made at each time step and the experience accumulates. The most uniform measures in current human civilization are all based on transform-invariant observations. If some subsets of X_e shares the same feature, they are believed to have the same measure. For example, when measuring length, one can roll an object and use the round count as a measure of length. Even the finest measuring tool used in scientific research is based on such methodology. Suppose that the entire milky way galaxy is in a gravitational field along 1 direction, any measurement involving space time we make would be distorted and we can never be aware of such distortion until we make an observation on objects outside this field. Because the universe can be infinite large, the true measure of the universe only exist in our belief.

One can always be more certain about reality, but never knowing the reality.

5 Self observation

As I am writing, I am mapping my neuronal activities into words, that is mapping observational functions with observational functions, which makes it a functional[1]. What I am doing is exactly the same as people inventing the word 'word'. This recursive situation maybe confusing especially for those who are influenced by the idea that one can never understand consciousness with consciousness. However, in programming, a recursion is a problem only when it is an infinite one. If the theory I am writing was solely based on my observation on activities of observation which are about more observations and so on and so forth, then there would be an infinite recursion problem. But obviously I have experience other than observing observations. To put it in real circumstances, when neurologists are studying brain activities, they do not necessarily need to study a brain that is watching another brain.

Moreover, only one layer of recursion is recommended when people are thinking about activities of observation, that is to say, only think back on the time when you are thinking about something real. Usually when the word 'word' is used by people, it is referring to a word other than 'word' itself, except for this sentence.

6 from self reference to undecidability

Ludwig Wittgenstein proposed that a function cannot be its own argument when solving the Russell's paradox. Any argument that reference itself inside the argument is deemed to be undecidable and the undecidability of such arguments further make an entire axiomatic system incomplete. It is already shown that self observation can be decidable because the observed system do not have to observe it self too. But for all undecidable arguments f, they can only act on themselves and it is equivalent to creating infinite instances of the argument. If all those instances are labeled with a subscript such as $f_1(f_2(f_3(...)))$, the argument is equivalent to say that every f_n must have an successor $f_n + 1$ and asking the answer to the argument is equivalent to asking what's the value of infinity. This is also why Gödel's incompleteness theorems only applies to axiomatic systems that include natural numbers.

Real numbers is also a reflection of human mind. It is the most evenly distributed measure that human can possible comprehend. But once the concept of infinity is introduced, all numbers that are too big for a discussion are compactified into a single character ∞. Even on the axis of real number the measure is invariant locally, it is merely transforming 1 compactification to another compactification. As a consequence, a huge distortion lies in human mind and mathematics when people discuss topics like the sums of divergent series. Ramanujan summation is indeed a good way to map infinity back to numbers, but it is obviously a self referencing situation.

One can always know more, but never knowing infinity.

To avoid infinity, a good practice would be only considering finite subsets Y_e/Y_i of X_e/X_i where $O(Y_e) = Y_i$. The concentration can be defined as $\sup_{x \in X_i} s(x) - \inf_{x \in X_i} s(x)$

A uniform observation can be defined as $U(x)$ where the density function $p_u(x)$ is a constant. Then μ_i and μ_e can be normalized so that $\mu_i(Y_i) = mu_e(Y_e)$, hence $p_u(x) = \frac{\mathrm{d}\mu_i(x)}{\mathrm{d}U_*(\mu_e)(x)} = 1$ and

[1]The original meaning of functional is a function of functions. Nowadays, in mathematics, the formal definition of functional is a mapping from vector space to scalars, which is a general case of the original meaning

$s(x) = 0$.

7 instinct of inductive reasoning

The increase in intelligence usually means solving the environment with simpler algorithm[2]. From a perspective of evolution, adopting more complex algorithm is wasting more energy and food on brain, unless such investment yields significant benefit. To save the consumption of energy and material, brains constantly looks for similarities between external states so that it can use the same set of algorithm to solve multiple situations. This feature of brain gave us advantages over other animals and helped us established all fields of science. This is the reason why many scientists describes symmetry and invariant as beauty and they are the most fanatic group of people that pursuit such beauty.

Almost every subject of knowledge is established by inductive reasoning. People find common properties among objects or events and map them to a category that can be described in the same pattern of language which in science is usually mathematics. Furthermore, analogies can be find across subjects and a more general rule can be applied to a bigger category including both subjects. In classic philosophy, the directly observed and concluded properties are called accident and the further induced properties are called essence. The accident is equivalent to the domain of mapping while the essence is equivalent to the codomain of mapping. In a chain of observation, the essence of a layer is the accident of next layer. As the chain continues, the discovery of essence has never stopped.

8 super-determinism, time symmetry

9 Causality

10 Collapsing the wave packet

The similar quantization of fundamental particles and living systems leads to a possible explanation of quantum decoherence. Just like how gene drives every individuals and survive as a community as a whole, the information within particles could be the gene of all individual particles and the entire species work together to collapse a drifting wave packet. Considering a photon hitting a very thin screen, if atoms of the screen absorb the wave packet separately, the photon would either be absorbed by many atoms according to the amplitude at each location or simply pass through the screen. However, the fact is that the wave packet is absorbed by a single atom as if the entire screen is working as a whole to squish the wave packet towards that single atom. Maybe there is some kind of mechanism among all those atoms so that the wave packet is initially absorbed by many atoms, then in a tiny bit of time, the absorbed energy is conducted through atoms and finally converge to a single atom.

If that is the case, surely the thylakoids inside chloroplasts are already utilizing such mechanism to converge photon wave packets to the location of photosynthesis[3].

[2] Legg, S. and Hutter, M. (2007) “Universal intelligence: A definition of Machine Intelligence,” Minds and Machines, 17(4), pp. 391–444. Available at: https://doi.org/10.1007/s11023-007-9079-x.

[3] Engel, G.S. et al. (2007) “Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems,” Nature, 446(7137), pp. 782–786. Available at: https://doi.org/10.1038/nature05678.

Note that it is not recommended to think the photon is in a superposition state of being absorbed by many atoms. Superposition is simply a lack of detailed information due to the limit of observation method. Currently, all humans' observation tools are throwing particles and detecting the reflected particles. It is equivalent to detecting a nail by throwing basketballs on it and analyzing the trajectory of the basketball bouncing back.

11 At the dawn of Physics

More than 60 percent of matters in universe are described as dark matter because they do not couple with electromagnetic field. However such a big portion of mass cannot be just neutrinos. It is very likely that there are other electrically neutral particles. They can be part of a super-symmetry model. There can be another sort of spontaneous symmetry breaking that hides some massless neutrinos which can only be detected by their weak charges. Furthermore, through this mass-less and electrically neutral particle, we can discover a whole new world that do not interact with gravity field or electromagnetic field. Then we will realize that we were worms not being able to see lights.

The quantum fluctuation could also be energy shifting between the detectable world and this undetectable world. Because particles from both world interact more frequently within smaller distance, energy becomes increasingly uncertain. Note that energy here is not equivalent to mass since the undetectable world is massless. By definition, energy is how fast field changes. This change can shift from our massive world to an massless world and then the energy temporarily disappear from our sight. But so long as we are soaked in a bath of evenly distributed undetectable particles, the vacuum energy is statistically isotropic in large scale. In the history of universe, those undetectable particles could have been once very

12 Deductive reasoning for emergent scenario