Research Essay

A Model for Human, Artificial & Collective Consciousness (Part I)

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Abstract

Borrowing the functional modeling approach common in systems and software engineering, an implementable model of the functions of human consciousness proposed to have the capacity for general problem solving ability transferable to any domain, or true self-aware intelligence, is presented. Being a functional model that is independent of implementation, this model is proposed to also be applicable to artificial consciousness, and to platforms that organize individuals into what is defined here as a first order collective consciousness, or at higher orders into what is defined here as Nth order collective consciousness.

Part I of this two-part article includes: Summary; Introduction; Set of Postulates One; Set of Postulates Two; Overview of the Model; Model of Homeostasis; Model of the Functional Units; Model of the Body System; Model of the Other Basic Life Processes; Model of the Other Functional Systems; Model of Perceptions in the Perceptual Fields; Model of Body Processes as Paths in the Perceptual Field; & Model of Conscious Awareness.

Keywords: Functional modeling, human, artificial consciousness, collective consciousness.

Summary

In this model, human beings are functionally comprised of four systems, the body, the emotions, the mind, and the consciousness system. Each of these four functional systems is modeled as a hierarchy of functional units which implement a hierarchy of "basic life processes" as well as a set of conscious and unconscious processes executed within those basic life processes. Through this hierarchy of processes the organism gains the capacity to maintain its internal state in a stable range across a wider and wider range of environmental states. All these functional components are modeled as being governed by a single set of equations that display global stability in their dynamics despite potentially chaotic interactions with the environment. Where the models of certain functional components has not been explicitly defined here, working implementations have been identified from other fields of study. This overall model of consciousness is characterized by evolutionary reuse.

The basic life processes, are represented as a hierarchy beginning with homeostasis as the most basic property of life. Each basic life process is represented as having evolved as a slightly modified replica of the lower process in the evolutionary hierarchy. This hierarchy of life processes is represented as occurring in individual nodes (cells for the individual), or re-occurring at the level of groups of nodes such as the functional units, or at the level of the organism itself. One of these basic life processes is the "action" of choice, which is represented as the most basic form of consciousness that can occur in individual nodes as simple as cells.

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This simple consciousness is replicated at the level of functional systems which each display higher but different levels of conscious awareness. Following the pattern of evolutionary reuse, the functional systems also form a hierarchy that begins with the body which in this model displays sensory awareness, and that ends with the consciousness system as the highest functional system, which displays conscious self-awareness.

In the body, sensory signals are processed through the hierarchy of functional units to become sensory perceptions and eventually awareness of sensory perceptions (sensory awareness). This basic model for achieving meta-stable sensory awareness in the body is replicated in the emotional system of this model to produce emotional awareness, in the mind system to produce cognitive awareness, and in the consciousness system to produce conscious self-awareness of perceptions in each other functional system. Thus conscious self-awareness is represented in this model as having evolved from a single globally stable process of homeostasis beginning in one cell, and replicated by evolution at progressively higher order groupings of cells into functional components, and in groupings of those functional units into entire functional systems such as the mind. These globally stable dynamics at all levels are modeled by the single set of equations which govern the homeostasis.

Introduction

A human being consists of some 100 billion cells. All human functions, including the ability to move, the ability to feel emotions, intelligence, and consciousness self-awareness, are modeled here as a composition of N collaborative processes involving M cells. Furthermore a human being is assumed to be a composition of differentiated copies of a single initial cell, where each cell can execute at most some subset of the same bounded set of all functions every cell is confined to. Because of this we would expect that the potentially unbounded number of processes through which the human body, emotions, mind, and consciousness system achieve a potentially unbounded set of functions, might be decomposed into a manageable set of functions that act as basic building blocks. This functional modeling approach borrowed from systems and software engineering doesn't require any knowledge of how the human organism implements any of these functions. That is, in technology terms it requires no knowledge of how the human software has been coded or how the human hardware has been built to implement the functions. And because it is implementation independent, such a model of human consciousness might be replicable to a system of artificial cognition such as an AI, or to a platform that organizes individual human beings into a first or even an Nth order collective intelligence.

Set of Postulates One: Regarding Use of Lorenz Equations to Model Homeostasis

This paper postulates that if the internal state of an organism is a function of Z variables, homeostasis is a globally stable state in some subset N of the dimensions of the living organism as a Z dimensional system. This globally stable state is locally unstable in each of the N dimensions. Assume that {S} is the set of all functions of N dimensions that govern globally stable, locally unstable dynamics. If homeostasis exists in all living organisms then for each instance of homeostasis in an N dimensional subset of the internal state space of the organism, there must be a set of functions {F} that exists within {S} which governs the global stability of the state of the organism in that subspace.

Furthermore, consider the dynamics of the internal state of a functional model of a living organism. This paper postulates that under certain conditions the dynamics of the functional model will demonstrate homeostasis if based on any set of functions {F} that produce globally stable, locally unstable (fractal) dynamics in N variables. If the set of actions the organism is capable of executing is represented by the set of functions {A}, where each function in A may be a function of the Z variables, the conditions under which {F} may govern a homeostasis are that the subspace Z is sufficiently greater than the subspace N so that there exists some sequence of actions {A(Z)} that approaches {F(N)}. In other words, if the range of actions are great enough the actions of the organism in the functional model can drive global stability by matching the forces required by {F}. Therefore, given that the system is capable of executing such a set of actions, any set of functions that produce globally stable, locally unstable dynamics in sufficiently few dimensions may be the basis of a homeostasis. Since they produce such globally stable, locally unstable dynamics, this includes the Lorenz equations governing convection.

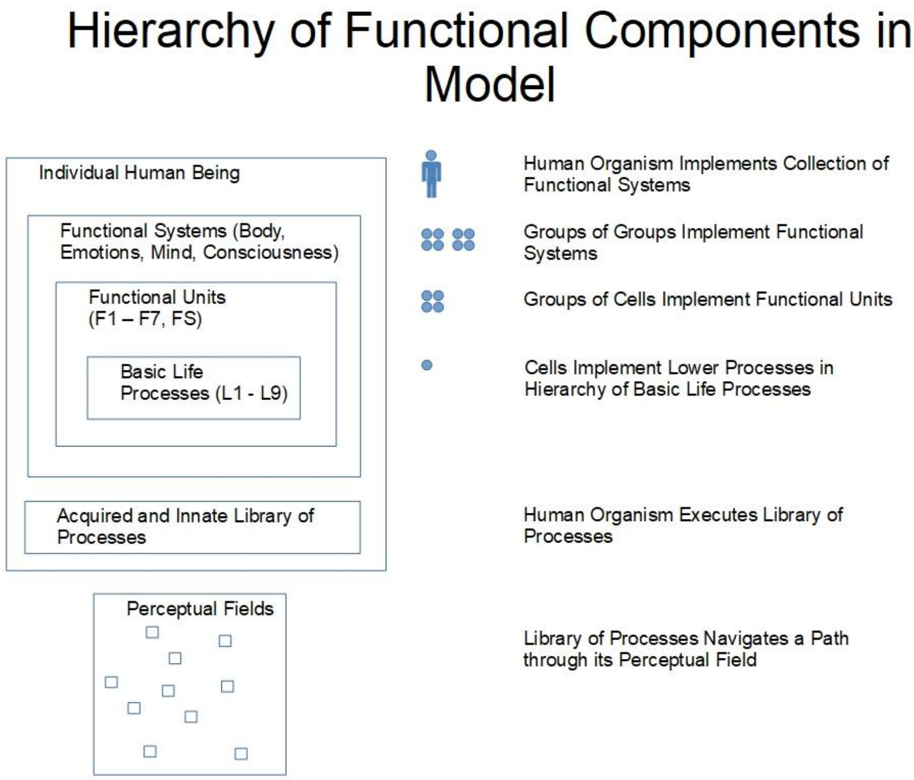
This paper also postulates that if the dynamics of a system (such as a cell) are governed by a set of equations {F} that displays global stability despite local instability, and if that system is coupled to other systems (such as cells in a multi-cellular organism) each governed by {F}, then the global stability in a collection of such systems is also governed by {F} or some other set of equations demonstrating global stability, as will a globally stable collection of such collections of systems. Components of a functional model (functional components) are by definition stable units of functionality. Therefore the dynamics governed by {F} or some other set of equations demonstrating global stability are expected at all levels of functional components.

Set of Postulates Two: Regarding Use of Homeostasis to Model All Basic Life Processes

Each of the basic life processes and other functional components described in this paper may be represented as a process of global stability or homeostasis in some property or function of the living system. For example, homeostasis is proposed to be a global stability in the physical materials constituting the organism, reproduction is proposed to be a global stability in the ability of the organism to copy itself. And where reproduction is proposed to be a global stability in the ability of the organism to copy itself, evolution is proposed to be a global stability in the ability of the organism to change the copies, and so forth up the hierarchy of basic life processes. By this reasoning, each of the basic life processes and functional components may be represented by the same equations governing global stability within that underlying homeostasis.

Overview of the Model

This model consists of two groups of components. One is a hierarchy of functional components with dynamics governed by the same single equation. This hierarchy consists of homeostasis and other basic life processes that work together within functional units, functional units that work together within functional systems, and functional systems that work together in the individual human. The other is a set of functional components whose dynamics are not governed by those equations. These are the library of processes in each functional system, and the perceptual fields those processes navigate.



This model starts both from the bottom upwards and from the top down. From the top down, starting with what is easiest to observe, the model begins with the highest level at which the potentially unlimited human functionality can be decomposed into a closed set of systems having a bounded set of functions. After the broad yogic tradition, these functional systems have been defined as the body, the emotions, the mind, and the consciousness system [31]. The yogic tradition was leveraged because it is experiential. That is, the definitions of the functional components have been proved over thousands of years in the awareness countless practitioners have developed of their own experience. This proof is being successful in achieving the practitioner's intended goal of facilitating stable, and perhaps even rare, states of well-being.

The next step after decomposing the functionality into these four systems is to decompose these functional systems into a set of functional units that in turn collaborate to provide the functionality of those systems. The next step after all functional units have been defined is to decompose those functional units into N collaborative processes involving M nodes, where in the case of individual human consciousness these nodes are cells, and in the case of a collective consciousness these nodes are individual human beings.

Through each function of each system the organism interacts with the world. The next step is to build a model of each interaction with each subset of the environment so that as the environment is traversed the models build up over time into a coherent model of the world. That is, to build up a library of sensations in the body, to build up a library of feelings in the emotions, to build up a library of perceptions in the mind, and to build up a library of awareness in the consciousness system. And the final step is to build up a library of processes, each with its own function, which each functional system can use to navigate this model of the world. That is, to build up a library of movements in the body, to build up a library of motivations in the emotions, to build up a library of reasoning in the mind, and to build up a library of processes of awareness in the consciousness system.

From the bottom upwards this model defines a hierarchy of life processes that individual nodes (cells in the case of human consciousness) must implement or cooperate to implement. Each process in the library of conscious and unconscious processes is assigned a "fitness" in achieving each function. These life processes (homeostasis, autopoiesis, etc.) use the fitness of each process in achieving each function to select which function to execute. The basic life processes form a hierarchy of increasing complexity in terms of their increasing ability to navigate non-uniformity in the external environment.

The proposed model defines the functional systems, and the life processes, as well as the equations which govern them, and in addition defines the functional units and provides references to applications in other fields that have implemented those functional units. This model follows from the two sets of postulates above that are presented without proof. The first states that any set of functions that displays globally stable and locally unstable (fractal) dynamics in sufficiently few dimensions can be the basis of a working functional model of consciousness. The second states that intelligent self-aware consciousness consists of a hierarchy of functional components, each of which is governed by this same set of functions. If true, these postulates validate the use of the Lorenz equations as the basis for the global stability in this model. But because the model allows the current set of equations to be replaced by any other set that demonstrate greater "fitness" in achieving global stability, where that set may potentially use different variables, there may be another set of equations that are valid even if the postulates are false, and even if the Lorenz equations don't prove to be globally stable in the variables chosen. Therefore these postulates don't need to be universally true in order for the model to be valid. Since these postulates are sufficient, but not necessary to validate the model, these proofs are left for others.

Model of Homeostasis

A model of homeostasis is provided here but it's important to emphasize that the details of this model are less important than the approach. In this functional modeling approach every component in a process, in this case the process of achieving global stability, is defined only by its function. In the "functional decomposition" aspect of this approach those components of functionality are broken down into a hierarchy that starts with the highest level functionality and that ends with their most basic building blocks. And in the "functional fitness" aspect of this approach every one of these functional components is assigned some actual and projected fitness in achieving that function. So if any functional component is broken in the sense that it doesn't achieve its targeted outcome, or it doesn't achieve the optimal level of that outcome, it can be replaced with one that works to achieve the targeted outcome, or one that works better. And because this replacement can be made at any level of functional component or sub-component, an error in one part of the model need not invalidate the model itself. For this reason whether there might be any errors or omissions in this model for homeostasis is less important than the fact that this approach uses the combination of functional modeling, functional decomposition, and functional fitness to target the outcome of global stability, and to steadily improve the solution so that it converges on that outcome.

Creating a simple logical model of each activity in the homeostasis process, input to each activity and execution of each activity has a cost in terms of the internal stability of the organism (homeostasis). And each activity produces outputs. The outcomes are some function of those outputs. The outcomes have a cost and value in terms of that homeostasis. Payment into that cost can rise to the point that there are insufficient resources and subsequent activities are no longer possible. At that point the internal state dissipates and the organism "dies". Or payment into the cost of the current activity can be decreased to the point that no available activity can occur to restore the internal state as it dissipates. At that point the program also dies. Within the stable region the organism continues to live.

The process of homeostasis is modeled as projecting the value minus cost of each activity being executed (its "fitness" in achieving its targeted outcome) and continually measuring actual outcomes to update those projections, then either investing resources into the current activity until complete, or discontinuing the current activity to invest resources into the next activity. The targeted outcome in the case of homeostasis is maintaining the cumulative value of outcomes minus cost within a stable range. The projected value minus cost of the current activity is one axis of the dynamics of the homeostasis process in this model. The actual value of the resources invested into the current process is the second axis of these dynamics. And the value of the resources available to be invested into the next process is the third axis of these dynamics.

The homeostasis process keeps resources invested in a stable range between the boundaries of being insufficient for any current activity to occur, and being too great for any subsequent activities to occur. The sequence of activities selected to be executed by the homeostasis process functions to maximize stability in terms of keeping the internal state as close as possible to the center of a stable range, and not allowing that stable range to be exited. By executing activities in a sequence that keeps the internal state within a stable range, the homeostasis process navigates the internal state space as well as the state space of the environment.

If the first set of postulates described in this paper are true (homeostasis is created by set of functions that produce globally stable, locally unstable dynamics), the functional model of this homeostasis process will demonstrate global stability if its dynamics in these three dimensions are governed by the globally stable and locally unstable Lorenz equations. And the dynamics will be governed by the Lorenz equations if the activities executed create forces that drive the system in a way that matches the forces in the Lorenz equations.

The homeostasis process has a set of activities {A} that it can execute. Each of these activities A_i has inputs constrained to some subspace I_i and outputs constrained to some subspace U_i. Outcome "h" is a function of the output U_i so that every activity achieves an outcome "h" with a fitness P_{ih}. Assume that the homeostasis in the internal state of the organism exists in a set of properties {X} which for each X_i must stay between the values X_{iMIN} and X_{iMAX} for the organism to remain alive, and which for each X_i is optimized at $X_{iOPTIMAL}$. Model the value of executing a given activity as the decrease in radial distance from the projected position $X_{PROJECTED}$ to $X_{OPTIMAL}$. Model the cost of executing a given activity as the increase in radial distance between the position $X_{THRESHHOLD}$ required to initiate the activity and the current position $X_{CURRENT}$. And model the investment into an activity as the increase in radial distance from the initial position $X_{INITIAL}$ to the current position $X_{CURRENT}$.

A conceptual model for selecting activities is proposed below. The activities in this process along the projected value minus cost axis are:

Project Value of Current Function to the Homeostasis Process
Calculate the value minus cost of the projected outcome of the current activity with regards to homeostasis, project the current distance to the boundary of homeostasis, and the velocity towards that boundary. After acting, measure the actual outcome and update the projections.
If the velocity towards optimal outcomes is negative then select and implement the activity with force along this axis having positive projected magnitude F_x(Direction of Value Minus Cost, Distance to Boundary, Velocity).
If the velocity towards optimal outcomes is positive then select and implement the counter-measure activity with force along this axis having negative projected magnitude F_x(Direction of Value Minus Cost, Distance to Boundary, Velocity).

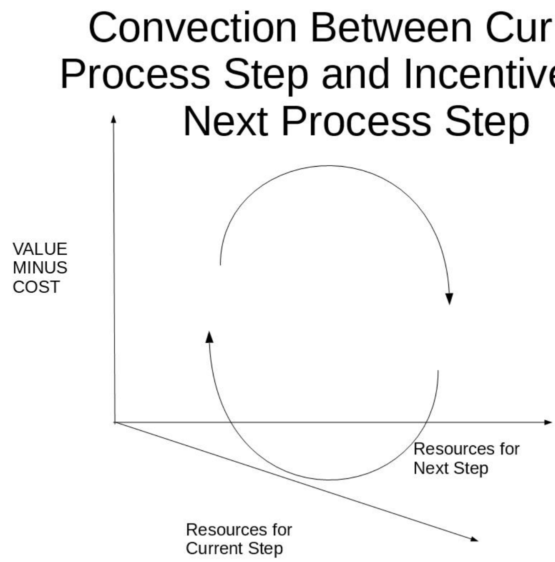
The activities in this process along the current resources axis are:

Measure Investment in Current Function of Homeostasis Process
Measure the value of resources invested in the current activity with regards to homeostasis, project the current distance to the boundary of homeostasis, and the velocity towards that boundary.
If the velocity towards optimal investment is negative then decrease investment in the activity with force along this axis having positive magnitude F_y(Direction of Value Minus Cost, Distance to Boundary, Velocity).
If the velocity towards optimal investment is positive then increase investment in the activity with force along this axis having positive magnitude F_y(Direction of Value Minus Cost, Distance to Boundary, Velocity).

The activities in this process along the remaining resources axis are:

Measure Resources Remaining to Invest in Next Function of Homeostasis Process
Measure the value of remaining resources with regards to homeostasis, project the current distance to the boundary of homeostasis, and the velocity towards that boundary.
If the velocity towards optimal resources remaining is negative then increase resources remaining for the next activity with force along this axis having positive projected magnitude F_z(Direction of Value Minus Cost, Distance to Boundary, Velocity).
If the velocity towards optimal resources remaining is positive then decrease resources remaining for the next activity with force along this axis having negative projected magnitude F_z(Direction of Value Minus Cost, Distance to Boundary, Velocity).

The path must be globally stable, and at the same time will be locally unstable since the disturbance created by the environment may be arbitrary, resulting in the curve not following any closed path. Choosing the forces F_x to be the upwards and downwards forces in the Lorenz model of atmospheric convection, and the forces F_y, and F_z to be the horizontal forces in that model, the dynamics of these variables will form a kind of convection.



To set the forces F to match the Lorenz model of atmospheric convection, choose the values of F_x, F_x, and F_x to match the second derivatives with time of the equations for the x, y, and z coordinates in the Lorenz equations. Select and implement the activity with the greatest projected fitness in executing the force (F_x, F_y, F_z). To do so select the activity with the highest projected fitness in matching F_x, increase investment into it to match F_y, and switch investment to the next activity according to actual measured results to match F_z.

This basic model is replicated in all other life processes in this larger model, as described in detail elsewhere [13]. For example, the process for reproduction measures the value-cost of each activity involved in reproduction and either invests resources into the current process and completes it, or discontinues it to invest resources into the next. And in that way navigates the reproductive process.

This model for homeostasis remains a thought experiment. A complete set of models for activities, models for the properties determining the internal state of the organism, and other functional components, have not yet been constructed and simulated to demonstrate that the Lorenz equations can produce globally stable dynamics along the axes described above. But while such an implementation would be valuable in confirming that the above model is complete and self-consistent, the lack of such validation doesn't negate the core value of this approach.

Because the core elements of the approach are functional modeling, functional decomposition, and functional fitness to model the key function of global stability, as well as replication of a common pattern of solution for global stability from the lowest level of functional component to the highest. Any part of this model may be sub-optimal or incorrect and the core approach itself will still be valid. The projected value and/or the projected cost functions chosen in this example may not be optimal in displaying stability. The Lorenz equations may not optimal in providing global stability. The variables described may not actually have the capacity to be confined by that convection. Parts of this conceptual process required to actually achieve global stability may prove to be missing when an attempt is made to actually implement it. But the truth of the global stability itself can be observed within our awareness that human beings and all our hierarchy of functional components don't spontaneously form or dissolve. And the truth that this pattern of stability must be repeated at higher levels of functional components can be observed in the fact that this must be the case for a continuous evolutionary path from a lower level to a higher level component to exist, and the fact that a discontinuous evolutionary path is not within our awareness of this existence.

In this functional modeling approach all functionality is represented by some functional component. And in this "functional decomposition" approach every element of functionality can be decomposed into a separate functional component. And in this "functional fitness" approach every one of these functional components is assigned some actual and projected fitness in achieving that function. So if any functional component is broken or not optimal, it can be replaced with one that works to achieve the targeted outcome, or one that works better. For this reason none of these possible errors invalidates the combination of functional modeling, functional decomposition, and functional fitness used in this approach, and its capacity to converge on a working solution.

Since the other life processes provide a hierarchy of mechanisms to evolve and otherwise adapt any function, then any function can potentially be replaced by one that has a better fitness in producing the targeted outcome, even where it uses different input variables to do so. The initial choice to base all the life processes on the Lorenz model of convection, and whether the particular variables chosen can exhibit that convection, are therefore less important than whether there is any set of variables for which this globally stable dynamics can occur, and that the model for the life processes can adapt through being replaced by one that is more fit.

Model of the Functional Units

Each functional unit has a set of functions it achieves, and it has some mechanism enabling it to have a stable set of functionality. To achieve stability in the set of functionality this paper proposes that each functional unit FU maps some N dimensional input space I to some N dimensional output space U by executing a set of activities in sequence, where these activities are represented by the set of functions {A}, and where each A_i is a function of the Z variables in the larger system. Representing each outcome O_h as some function of the output U_h, each A_i can be assign a projected fitness P_{hi} in achieving the outcome O_h. Constrain FU to obey globally stable dynamics governed by a set of functions {F}. Representing the set of variables determining the state of the organism that are outside of the N variables of {F} as forming a space that we will call the "context of execution" C, then if the projected fitness P_{hi} is dependent on variables in the context C, then since they display global stability and local instability in N dimensions the Lorenz equations for atmospheric convection may be used for {F} under the following conditions. These conditions are N is equal to three and that P_{hi} can be made to vary so that the dynamics of the system are driven in a way that approach the forces driving the Lorenz equations in each of the three dimensions governing those equations. Assume the first dimension is the value minus cost of the action A_i, the second dimension is the value of resources that have been invested in the current action A_j, and the third dimension is the value of resources remaining to be invested in the next action A_k. The first set of postulate in this paper essentially state that if the volume of C is sufficiently great, and if each action varies smoothly with input I, then the sequence of actions may be selected so that P_{hi} varies in a way that approaches the forces driving the Lorenz equations. In this case execution of the set of actions {A} is dynamically stable, where that stability is governed by the Lorenz equations. As a consequence, where an existing implementation of the transformations of a functional unit may be modeled by a set of functions {A}, those transformations might under certain conditions be combined into a functional unit governed by the Lorenz equations, where that functional unit displays global stability.

Model of the Body System

In this model the sequence of actions that the bodily system takes is driven by its need to keep well-being within a bounded region. Well-being is measured here as capacity to execute the body's capabilities on a scale from 0 (dead with no capacity) to 1 (alive with complete capacity). The dynamics of this well-being in this model are governed by a similar global stability as described with the homeostasis process, in this case global stability between well-being of the body, the resources invested in the current bodily process, and the resources available to invest in the next one. This well-being is measured in the capacity of the system to execute the processes within its capabilities.

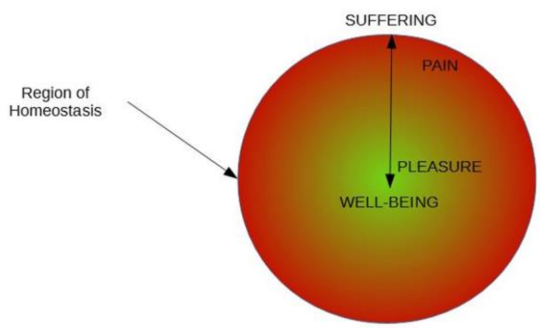


Figure 1: Single Valued Metric for State in Conscious Processes

Conscious homeostasis requires a common way of measuring well-being in each functional system (body, mind, emotions, consciousness) so the individual can find their way to a stable state of well-being. This mechanism is our perception *of pleasantness or unpleasantness.*

If well-being represents the capacity to execute all of the bodies capabilities, and if the body's capabilities are represented as paths between points in the sensory field, then a well-being value of one represents full capability to navigate all its library of paths between points in the body's sensory field.

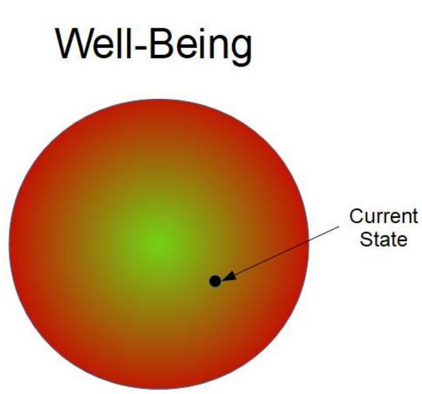
Repeating the pattern of global stability defined for homeostasis, investment of resources into the current action, and conservation of resources for the next action, in this model is driven by forces that produce global stability. In the case of the body these forces are proposed in this model to be pain and pleasure. This force is negative in the case of pain which drives the body away from a state of lacking well-being, and positive in the case of pleasure which drives the body towards a state of increased well-being. Just as homeostasis selects actions to keep the functional component in a stable range of states, the body's sensory awareness is governed by a global stability that selects and executes a sequence of functions targeting outputs that are known in the perceptual field, and involving entire dynamically stable functional components. Or in other words the body's sensory awareness is governed by a global stability that "chooses" actions. This choice is conscious at the level of sensory awareness.

The dynamics of this global stability drives the organism's motion through the sensory field, through the external environment represented within that sensory field, and also through the well-being space defined by the metric of well-being.

In this model all the senses are represented as evolutionary branches of the sense of touch. Within the body functional system of this model a separate but identical processing path of functional units exists for each set of sense signals (tactile, auditory, gustatory, olfactory, and visual). This results in a separate set of sensory perceptions for touch, for sound, for taste, for smell, and for sight. These perceptions form a "perceptual field" for each sense. As described later in this paper, this field differs from the raw input signals in that the perceptions label the external environment and the body itself in a way that enables the body and the external environment to be reliably and repeatably navigated despite signal noise, where this navigation is even possible by life processes like evolution which span generations.

The body system, and each other functional system as an evolutionary branch of the body, is modeled as navigating its environment through both conscious and unconscious physical processes. Conscious processes are modeled as a library of functions that operate on input from a perceptual field to produce output to the perceptual field, as well as producing an outcome in terms of changes to the internal state of the organism, and potentially to the state of the external environment. These state changes impact the body functional system through a change in its well-being, which is defined as a function representing the body's capacity to execute all its capabilities (that is, to execute all its processes).

This change in well-being drives the choice of the next conscious process to be executed. Well-being in each functional system has a current state, and a rate of change in that current state.



Each outcome has a projected impact on this well-being and it's rate of change. Each functional system has a library of conscious processes. Each process in the library executes a function.

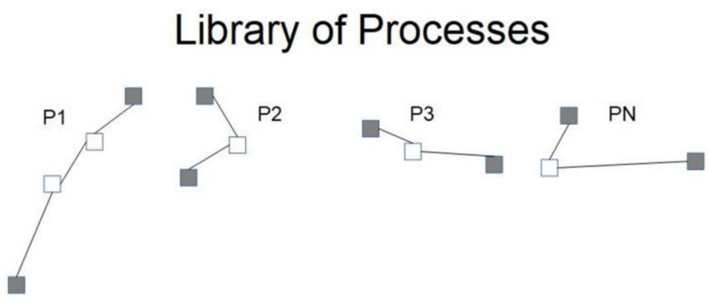
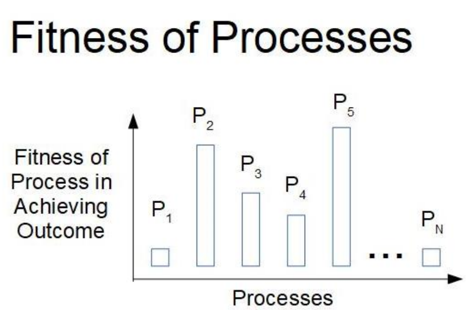


Figure 2: Each process navigates a path through the perceptual field.

Each function has a projected fitness in achieving an outcome.



Where a given outcome is targeted, this projected fitness enables selection by the functional system of the process that best functions to accomplish that outcome. Selection at the level of the "homeostasis" basic life process is proposed to be distinguished from conscious choice at the level of the "action" basic life process in that homeostasis is a highly variable response to highly variable signals whereas action (choice) is a repeatable response to more invariant perceptions. In other words, in order to choose the organism must be aware of the outcomes. In order for it to be possible to be aware of the outcomes it must perceive them. In order to perceive outcomes those perceptions must be stable patterns that can be detected in the signals from sensory receptors.

The function representing the library process being executed by the functional system requires inputs and produces outputs, including the outcome, which is some function of that output. Aside from its inputs, the function representing each process is influenced by additional variables which might change its fitness in achieving an outcome. These additional variables form the "context" of execution. Fitness is then also dependent on context. The awareness process within the functional system dynamically "chooses" to execute whichever process it retrieves from the library that is projected to maximize well-being. Unlike the transitory signals which cells may be aware of at the individual level, the inputs to and outputs from this awareness process are persistent patterns of signals that here are called perceptions.

In this model the choice of which processes are retrieved to be executed next depends in part on an internal mapping between the sensory perceptual field, the emotional field, the mental field, and the consciousness field. This internal mapping is stored in a repository that is metaphorically called the "soul", as justified in the conclusions to this paper. This additional system is not described here.

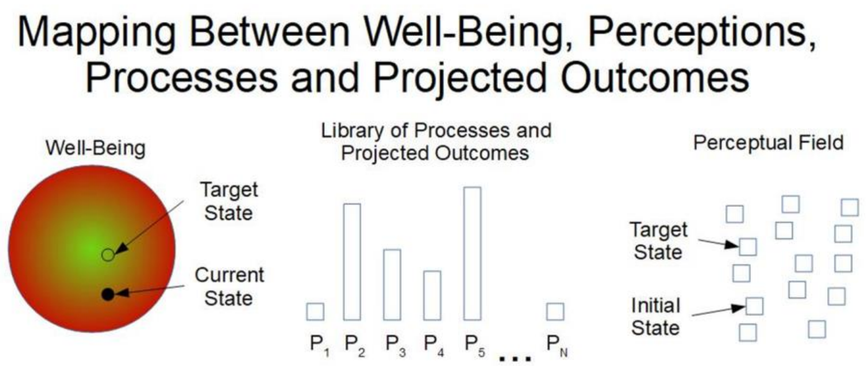


Figure 3: A repository tracks the varying levels of fitness of processes in mapping between the initial and target states in both well-being and perceptions. The process of “choice” retrieves candidate processes from the repository and chooses the process with the maximum projected fitness in impacting well-being.

Executing this dynamically chosen sequence of processes causes the organism to navigate a dynamically stable path through perceptual space as well as through the state space of the environment.

Since a problem is the lack of a path from one perception to another, and since each perception represents an internal state, this globally stable navigation solves problems presented by the environment through its capacity to navigate from an initial internal state to a more stable final internal state.

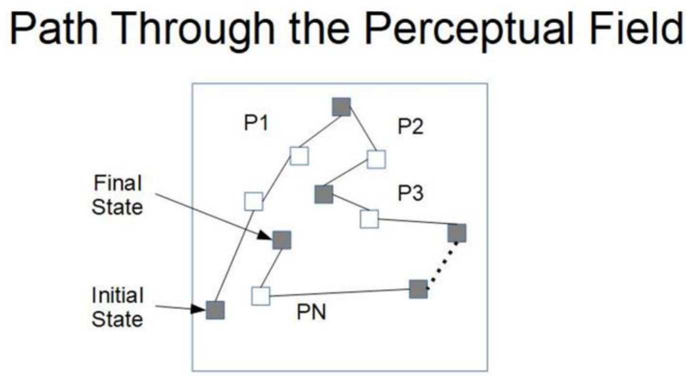


Figure 4: The sequences of processes navigate a conscious path through the perceptual field.

Taking the sense of touch as an example, after input signals from the sensory receptors have been processed through the hierarchy of functional units to become perceptions in the body's sensory awareness, the body's sensory awareness system may send the perceptions as input to conscious or unconscious physical processes that the body's sensory awareness system executes within the body. Each of these processes accomplishes a function that impacts the body's well-being in a way that drives choice of the next process.

These processes include motion. From the point of view of this model, the body's movement processes function to process input consisting of a sequences of perceptions describing the movement required to take the sensory field representing a body part from where it is perceived to be in the existential space, to what is perceived to be its intended destination. Through these physical processes the body may change its state, or the body's state may be changed by the environment. These internal or environmental changes are associated with a change in physical well-being, which the body measures. Through this of well-being, the body effectively assigns each of the body processes a projected, and actual measured "fitness" with which the process achieves the targeted function. This "fitness" is used by the hierarchy of "life processes" within the body to evolve, grow, and otherwise adapt the function so that it achieves better outcomes in a wider range of states of the environment.

The other functional systems in this model (emotions, mind, consciousness system) navigate their own perceptual field through executing their own processes in a similar way, where the dynamics of that navigation are also governed by the fitness of each process in achieving well-being.

Model of the Other Basic Life Processes

The model for the homeostasis process is virtually identical to the model for each of the remaining basic life processes, the difference being the function in which the global stability is maintained. For this reason models of those processes are provided at the same level of detail as above elsewhere [35].

Model of the Other Functional Systems

There are four perceptual fields in this model. One is the sensory field of the body, consisting of a composition of the tactile, auditory, gustatory, olfactory, and visual fields. The others are the emotional field of the emotions, the mental field of the mind, and the existential field of the consciousness. Conscious activity in the body consists of a sequence of physical processes that navigate from one point in sensory space to another point in the same sensory space. This sensory awareness is represented by the same global stability described in the "homeostasis" life process. This global stability and resulting sensory awareness and capacity to navigate sensory space is essentially replicated in this model to generate emotional awareness in the emotional system, mental awareness in the mental system, and conscious self-awareness in the conscious system. A number of researchers have similarly proposed that consciousness arose first at the sensory level from the sensing the physical environment at increasing levels of complexity [9], [10].

The body, emotions, mind, and consciousness system in this model all obey their own globally stable dynamics governed by their own single-valued property for "well-being" or "pleasantness", which is measured in the capacity of the system to execute the processes within its capabilities. In the case of the emotional system, globally stable convection in the Lorenz equations is analogous to the positive and negative forces in the cart-pole balancing example used by Bozinovski in proposing a model of emotion-cognition interaction in reinforcement learning, in his review of methods for modeling the emotion-cognition interaction since 1981 [30].

Model of Perceptions in the Perceptual Fields

In this model signals from a distribution of sensory receptors become "perceptions" when they are labeled in a way that enables those signals to be located again. The hierarchy of functional units in this model accomplish this localization of sensory signals into perceptions.

Consider sensory receptors sending signals that the body must interpret as the sense of touch. If each signal can occur at any time T from time zero in the life of the organism to the time of death, and can occur in any one of N receptors located in a physical volume V of the organism, and in addition can occur with changing signal strength S, then any given signal cannot have a recurring position in the volume of the spatial-temporal signal space. Because time is changing, the volume of the space is changing as the organism grows, the receptors themselves may change as cells die or reproduce, and other variables may also change. Some higher order function of the input signals must be defined with sufficient invariance to be the same "perception" to a group of cells. The functional units in this model provide this invariance. In other words consider a set of signals [S_1(t) …, S_N(t)] from a set of receptors [R_1, …, R_N]. In mapping the signal to a perception the composition of functional units FU performs a mapping from the signal space S to the perception space P where the volume occupied by the perception in P (in terms of information required to represent it) is much smaller than the volume occupied by all the signals in S.

Some degree of invariance is required because a pattern of signal in that spatial-temporal signal space might mean the subject "stubbed his toe". But with the large number of potential signals and receptors and their potential to change in time, without this invariance the subject can't repeatably and reliably locate the "stubbing the toe" pattern and distinguish that pattern from "blinking an eyelid", or for that matter from random signal noise. For the subject to have the capacity to recognize a signal pattern as stubbing his toe he must be able to reliably locate that pattern in some volume defined by all possible perceptions. Therefore, in terms of the tactile sense, in order to have the capacity to "perceive" its internal state or to perceive its environment and thereby to have the capacity to navigate by those perceptions, the organism must have the capacity to find patterns in the signals from its sensory receptors and to localize those patterns as points in a field of tactile perceptions, or a "tactile field".

Model of Body Processes as Paths in the Perceptual Field

A body part, such as the tip of a finger, is represented by a set of points in a "sensory field". These points in the field have a position in the awareness (a position in "existential space"). Having a subject move the tip of a finger from the tip of their nose to their lips is represented by moving the set of points representing the finger tip from a position in existential space near the set of points that represents the tip of the subject's nose, towards the position in existential space of the set of points that represents the subject's lips. The body system may be moved simultaneously by a variety of different external forces, though that movement will be constrained by the degrees of freedom the body allows that movement. All of these movements will be represented by the movement of points in the sensory field. However in this model conscious awareness can only choose one movement at a time. Movements of multiple parts are considered as single compound action. This compound action is represented by multiple sets of points in the sensory field tracing multiple paths through the existential space. In addition, parts of any action, such as reflexes, can be driven by the sensory rather than conscious awareness. These reflexes are also represented as movement of the sensory field in the same way. The difference is that the consciousness chooses the first set of paths and is simply aware of the second.

Navigating the physical environment with the body is modeled as executing a sequence of physical processes that each function to cause multiple units in the sensory field to trace paths through the existential space. Sensations such as heat or cold change the state of the unit in the sensory field.

Therefore each physical process from the point of view of a single point on the body is in essence a function that acts on a unit in a sensory field at a position in an existential space to change the state or position of that unit.

Just as a physical awareness is a unit in a sensory field that moves through an existential space, a concept is a unit in a conceptual field that moves through the existential space. Concepts may be conceived of, or perceived by, the mind. Just as the tactile sense of the body navigates a "tactile field" of sensory perceptions that may be input to or output from physical processes, in this model the mind navigates a "conceptual field" defined by mental perceptions (concepts) that may be input to or output from mental processes.

By the same reasoning that sensory perceptions must be localized in the sensory perceptual field in order for them to be located, mental processes, whether rational methodical reasoning or intuition, and the concepts input to for output from them, must also be localized. In order for a mental process to be localized it need only be consistent in mapping one concept to another. It need not be true. For example, the question of how many angels can fit on the head of a pin may have a well-defined answer in a given reasoning process. But that answer may or may not be true.

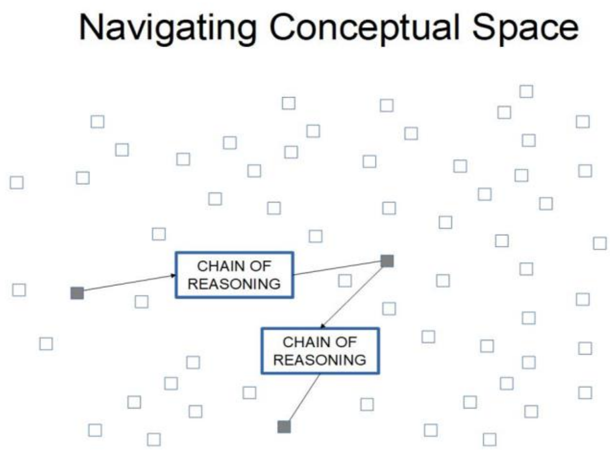


Figure 5: Representation of navigating between points in the conceptual field using reasoning processes.

Replicating the process of awareness from the body to the consciousness system, an abstract awareness is a unit in an existential field that moves through the existential space. The consciousness functional system in this model navigates a field defined by each awareness that may be input to or output from processes of awareness. By the same reasoning as given above for the sensory and conceptual fields, each awareness must also be localized. Because each point in this field represents something observed within the subject's awareness of his experience, it is in this sense a field of existential truths, or an "existential field".

Replicating the process of awareness from the body to the consciousness system, an emotional awareness is part of an emotional field that moves through the existential space. The emotions functional system in this model similarly navigates an "emotional field".

Model of Conscious Awareness

In this model awareness of state becomes "conscious" when the organism can "act" to choose whether and how to respond to that awareness. Organisms even at the single-celled level may select actions in response to signals regarding their state. However, for a single cell only a subset of signals might be repeatably locatable. For signals to be detectable and repeatably located by groups of cells those signals must be combined into patterns of spatially distributed sequences of signals that here are called perceptions. The hierarchy of functional units in each functional system (body, emotions, mind, and consciousness) accomplish creating awareness of the perceptions within each system.

The most basic characteristic of living things is homeostasis. In this model there are two basic approaches a collective of nodes (e.g. cells) can use to achieve homeostasis as the environment becomes increasingly more non-uniform and resources become progressively more sparse, or as the organism progressively seeks more and more sparse resources of higher value, and the path the organism must navigate between points in the state space of the external environment at which it can achieve internal stability becomes more complex. One approach is to develop a single increasingly complex life process that all nodes cooperate to execute. The other approach is to develop many complex processes which the nodes in the collective cooperate to choose and then cooperate to execute. In this model this is the distinction between plants that simply respond to their environment, and animals which can consciously act.

Whether for an organism consisting of one node (cell) or multiple nodes, when multiple processes can be executed, and each process forms a different possible path to homeostasis, the organism must "choose". In this model this capacity for choice is "action", the lowest form of consciousness.

For living things to demonstrate homeostasis there must be some stability in their dynamics through the space formed by all possible internal states of the system (internal state space). This stability represents some form of pattern in those dynamics. The ability to select between multiple globally stable, locally unstable dynamical paths enables an emergence into an entirely new level of complexity [6],[7]. There are different levels at which this selection can occur. The selection can be driven by highly variable signals from the environment, in which case the selection will also be highly variable. Or the selection can be driven by perceptions that are more invariant functions of those signals, in which case the selection may emerge into a repeatable "choice". From this perspective organisms emerge into "consciousness" at the basic cellular level when they can "act" through this choice. Animals are organisms that can "act" in this sense to pursue different dynamical paths to a stable internal state.

The actual dynamics of a living organism through its internal state space are expected to follow a globally stable, locally unstable attractor, but in the conceptual diagram below a simple organism is represented as having two processes for interacting with its environment, and the dynamical path of each process through state space is represented by a circle. The dynamical path of the "choice process" through state space is represented by the oval connecting the two circles. In this model this choice is conscious action. And it is this conscious action which couples two globally stable paths by a third globally stable path to enable the emergence of a higher complexity of dynamics. This complexity dramatically increases the region in the state of the external environment (external state space) in which the organism can maintain a stable internal state [7].

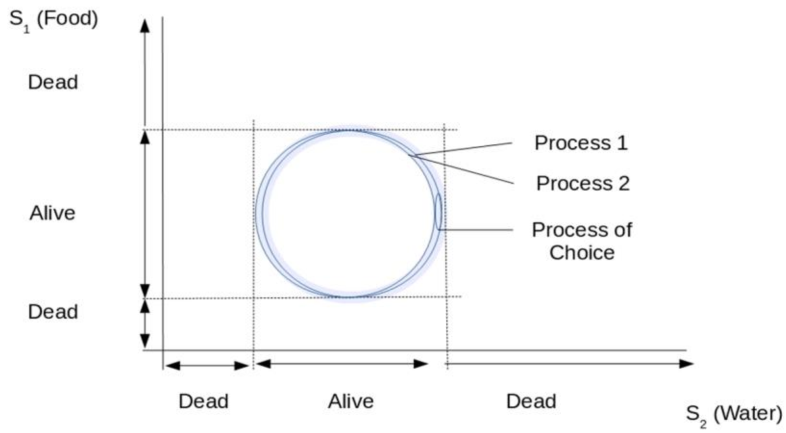


Figure 6: Multiple Paths to Homeostasis

Multiple paths to homeostasis exist within a region of stability. The Organism must “choose”.

When only a single process can be executed, whether the organism consists of one node (cell) or multiple nodes, then that node executes that single process, or each of those nodes independently reacts to its environment in a way that collectively executes that single process, giving the organism the capacity to respond to the environment.

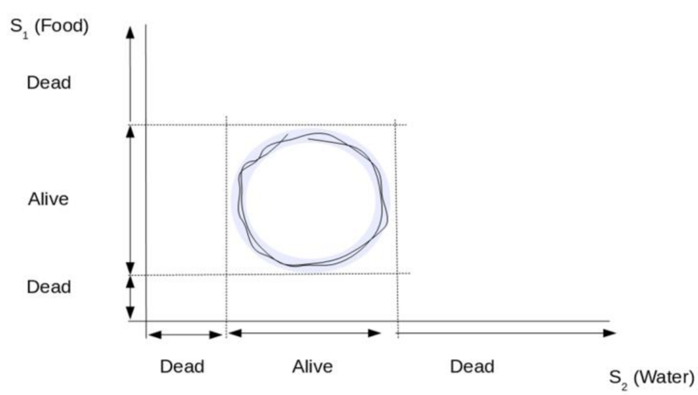


Figure 7: Single Path to Homeostasis

A single complex path to homeostasis exists within a region of stability. The organism simply follows the path to “respond”.

In this model plants and other non-animal life can only “respond” to their environment. Where cells that can “act” have basic consciousness in this model, at a higher level, in the body functional system, this mechanism of consciousness produces sensory awareness that provides the capacity to choose responses to sensory perceptions. In the emotions this mechanism is replicated to produce emotional awareness that provides the capacity to choose responses to perceived emotions. In the mind this mechanism produces cognitive awareness that provides the capacity to choose a reasoning process in response to a perceived cognitive problem. And in the consciousness system it produces conscious self-awareness that provides the capacity to choose which input from which functional system the awareness will be focused on, that is, whether to focus conscious attention on the body, mind, emotions, or consciousness itself.

There are a number of models of consciousness [1],[2],[3],[4]. This model differs in defining consciousness at its lowest level in simple organisms as above. That is, as a globally stable dynamical path that acts as a bridge providing this capacity to switch between two or more other globally stable dynamical paths.

(*Continued on Part II*)