



Title:

**Architecture for a Robust CAD Kernel built on the Principles of Energy Medicine-based Healing**

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Introduction:

CAD system development, based on NURBS as kernels, has been predominantly capability based, i.e. functionality superseded almost everything else, including one of the key elements of software systems, *robustness* [8]. CAD model repair, due to faulty software, accounts for a sizeable amount of cost per year [1,2], not counting the downtime as a result of crashes or improperly functioning systems. CAD systems have become very sophisticated, covering the entire range of production, from conceptual design to documentation. Complexity always comes at a price: maintenance becomes a nightmare, bug fixes require lengthy regression testing, and the learning curve of becoming proficient in the system is measured in years.

There is a peculiar difference between the system of our bodies and that of a CAD kernel. We do not grow new body parts (add more code to the program) to get things done more efficiently, but rather, we make more intelligent uses of existing parts. That is, our complexity is constant, only we do things better over time by constantly trying new things and learning from our mistakes. The other relevant peculiarity is that our failures are smoothly integrated into our daily activities, e.g. we do not “crash” if something does not work, but rather we try the same activity in a different way and remember the experience to avoid the mistake in the future. Our bodies are very intelligent entities, the results of millions of years of evolution (biological system development) and survival, well worth a closer look to see if the laws of nature have any relevance in CAD software development. As it turns out, there is a great similarity between the body and the CAD software, if one finds the right angle of investigation. The angle we found quite revealing is that of *energy-based healing* [3-7]. This system has been around for over 5,000 years and has proven to provide a solid theory for a biological system maintenance and prevention.

This paper examines how the principles of energy-based healing can be carried over to developing a NURBS-based modeling kernel (we use NURBS because they are the standard, however, the principles are useful for any kernel). More specifically, we examine four facets of energy medicine: (1) healing, (2) memory, (3) learning, and (4) imagination. We outline some important principles, body components, system components, functional requirements, and design two major architectures, one for the body and one for the system itself.

System Development Framework:

The framework we use in this work relies on four facets of energy-based healing: healing, memory, learning and imagination. The elements of each are presented in the tables below. The first, Table 1, draws a parallel between the body and the CAD system in terms of how healing takes place in the body. The similarities are quite obvious: both are looking for equilibrium (a state of balance); both are motivated away from incorrect (pain) to correct (pleasure); both admit that there is no such thing as health (correctness) only different levels of sickness (unexpected behavior); and system health is not to

eliminate bugs (external influences) but to keep them under a certain threshold. The only difference is the lack of an immune system in most software packages.

The second table, Table 2, shows the difference between the body and the kernel in terms of the definition and the use of memory. As it is quite visible, the notion of body memory is quite different from that of the CAD system memory: the body has memory everywhere not just in a central location; the memory is not a storage device but rather an information processor that transmits information from one body part to another; the memory is not data but the movement of data in various patterns; and the body parts are linked together via association in which the brain serves as a mediator.

HEALING	
Body System	CAD Systems
<b>Healing:</b> a process towards equilibrium	<b>Correction:</b> a process towards expected behavior
<b>Health:</b> various levels of sickness	<b>Health:</b> levels of deviation from expected behavior
<b>Body:</b> movement from pain to pleasure	<b>System:</b> movement from incorrect to correct
<b>Immune system:</b> keeps attackers at bay	<b>Immune system:</b> keeps errors at minimum
<b>Intent:</b> conscious and sub-conscious	<b>Intent:</b> manual and/or automatic
<b>Goal:</b> towards balance and low level of sickness	<b>Goal:</b> minimum errors and proper error handling

Tab. 1: How healing (correction) takes place in the body (CAD kernel).

MEMORY	
Body System	CAD Systems
<b>Location:</b> in every part of the body	<b>Location:</b> in every part of the system
<b>Function:</b> learn and remember	<b>Function:</b> learn and remember
<b>Brain:</b> transmits signals from/to body parts	<b>Brain:</b> transmits data from/to system parts
<b>Memory:</b> pattern of movement	<b>Memory:</b> pattern of information movement
<b>Association:</b> memories are linked by association	<b>Association:</b> data items are linked by association
<b>Goal:</b> learning and remembering	<b>Goal:</b> learning and remembering

Tab. 2: A comparison of the concept and the use of memory in the two systems.

Table 3 illustrates learning, the best quality of the body-mind complex, to learn and to remember. As we mature our knowledge base constantly expands that can be mined to find solutions to external as well as internal influences. The body does not grow new parts to handle tasks more effectively, it makes use of existing body parts more intelligently, i.e. our body (software) is never patched up but rather novel methods are introduced (obtained via trial-and-error) that can be executed by existing parts. This is a constant complexity system where only our experiences (knowledge base) grow not the complexity of our anatomy.

LEARNING	
Body System	CAD Systems
<b>Framework:</b> needs benefit and motivation	<b>Framework:</b> needs benefits and motivation
<b>Components:</b> experience, feedback, memorizing	<b>Components:</b> experimentation, feedback, storage
<b>Memorizing:</b> if works remember, otherwise forget	<b>Memorizing:</b> if works remember, otherwise forget
<b>Mechanism:</b> scan - match - reaction	<b>Mechanism:</b> scan - match - execute
<b>Types:</b> generic, experience based, copy behavior	<b>Types:</b> done before, knows, think knows
<b>Goal:</b> selective learning and experience building	<b>Goal:</b> learning and knowledge base building

Tab. 3: Learning in the body-mind complex and its extension to CAD.

Imagination, the ability of the mind to imagine in the past, present and future is analyzed in Table 4. Imagination cannot distinguish between past, present and future; all the mind remembers is an image (the system on the other hand can attach a time stamp to events). The mind can move the body via

imagination and so can the healing machine via predictions. The motivation of the healing machine (and that of the mind) is to move away from wrong (pain) and in the direction of right (pleasure). Finally, the brain and the mind are not necessarily the same [4] which means that in addition to the main memory we may need an entity whose job is to predict and not to store and transmit information.

IMAGINATION	
Body System	CAD Systems
<b>Mind:</b> imagines	<b>System:</b> predicts
<b>Talents:</b> from analysis to creativity	<b>Talents:</b> from analysis to creativity
<b>Imagine:</b> what is, is not, was, was not, will be	<b>Predicts:</b> what is happening, may happen
<b>Body-Mind:</b> mind imagines body follows	<b>Machine-System:</b> machine predicts system follows
<b>Motivation:</b> wrongs needs to be righted	<b>Motivation:</b> ill functioning needs to be corrected
<b>Goal:</b> imagine - execute - heal	<b>Goal:</b> predict - execute - correct

Tab. 4: From the mind and imagination to system and prediction.

System Components for Self-healing:

Based on the framework above, the main body components for energy-based healing are as follows: *Brain*: an information processor whose job is to analyze pattern of movement; *Mind*: its job is to imagine; *Memory*: information storage that resides in every part of the body; *Heart*: a data pump that constantly moves blood to every organ; *Organs*: the main organs that guarantee our existence; *Immune system*: a system that keeps the unwanted bugs under control; *Scanner*: a device that scans our memory to find the right response; *Balance checker*: its job is to check if there is equilibrium in the body.

To create a software system that is based on the principles of energy-based healing, the components of the body above are carried over to the system as follows: *Main memory*: an information processor and data transmitter; *Data pattern analyzer*: pattern analyzer and behavior predictor; *Data pumper*: constantly pumps fresh data through the entire system; *Data base*: fresh data for testing and pattern analysis; *Knowledge base*: the storage of experiments and experiences; *Knowledge updater*: the module that assists to learn and remembers; *Immune system*: the system that keep errors under control and at a minimum; *Modules*: the traditional software modules; *Capability vault*: storage of functional know-how; *Local memory cells*: memories for each local entity; *Scanner*: software that scans the knowledge base for the right response; *Balance checker*: looks for typical imbalances in the system.

At the functional level the following capabilities need to be developed: *Failure analysis*: analyze failures to update the knowledge base and to invoke better methods; *Balance check*: checks for consistent and expected system behavior; *Pattern movement*: analyses data pattern movements; *Association*: links data and knowledge together; *Knowledge base builder*: learns, remembers and builds a knowledge base; *Error management*: handle, analyze and learn from error; *Knowledge driven computation*: compute on knowledge-type instead of raw data-type only; *Prediction*: predict - analyze options - execute; *Learn via trial-and-error*: allow the system to fail and learn from it without service outage.

Architecture of the Self-healing Body:

The architecture of the body, for energy-based self-healing, is shown in Figure 1 below. At the center is the heart that constantly pumps blood to the mind as well as to the organs that have their own memories. The foundation of the entire system is the immune system whose job is to keep the attackers out of harm’s way. Blood (mixing with air) delivers the nutrients necessary to feed the body and to keep the immune system strong.

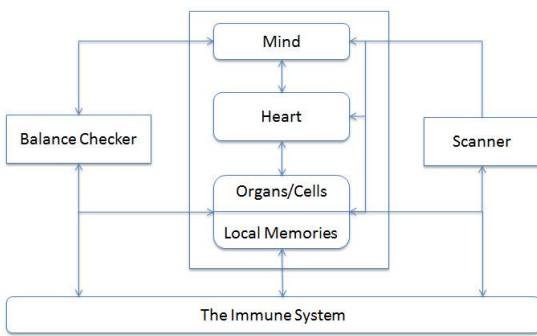


Fig. 1: Architecture of the self-healing body.

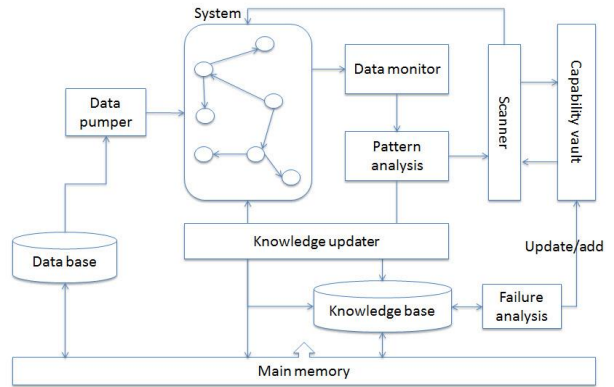


Fig. 2: Architecture of a CAD kernel.

The two functionalities that are always in “on” mode are the balance checker and the scanner. The balance checker is constantly monitors the health of the body and is looking for deviation from equilibrium. If something is not right, the scanner is invoked to scan the body memory to find the right response. The body memory is the culmination of millions of years of evolution and it tells the body how to respond to external as well as internal influences. If the right response is found, the appropriate action is dispatched and self-healing begins, i.e. the body moves away from pain (discomfort) toward pleasure (comfort). For example, an itchy throat invokes the cough response to eliminate the discomfort.

#### Architecture of a Biologically-inspired System:

Inspired by the body’s ability to heal itself, we can design an architecture for a CAD kernel, perhaps based upon NURBS, that is more robust than traditional systems and over time it becomes smarter as its knowledge base expands.

The core of the system consists of individual units (modules) with their own memories, just like each body part, Figure 2. These memories hold critical information necessary for self-reproduction, e.g. the local memory of a fitting function has all the knowledge necessary to reproduce the best use of this function. The two other main modules are the knowledge and data bases. The knowledge base records all experiences, failures (not to repeat them again), and all other information necessary to use any capability the proper way. The data base contains all sorts of data the system runs on: from data for typical use to nonsensical data for robustness and failure handling tests. The data pumper flushes the system with fresh data at all time, i.e. the system is never in idle more.

Once the system is in use, it is constantly monitored by the data monitor, i.e. when data is moved from part to part, the data is checked for correctness, accuracy, etc. The pattern in which the data is moved is also checked and if anything suspicious or incorrect is found, two things happen: (1) the scanner is invoked to find a more appropriate capability from the vault, and (2) the knowledge base is updated with this new experience. If the system is still in incorrect mode, i.e. there is something wrong to be corrected the scanner continues to fetch new capabilities until one delivers the right result.

The failure is then analyzed and either the functions in the vault are updated or new capabilities are introduced. As the system matures, only the knowledge base and the capability vault increase in size, the complexity of the system remains constant.

#### Conclusions:

Biologically-inspired systems show great promise in safety critical and robustness sensitive system development. CAD systems are notoriously unreliable due to the nature of the uncertainties with geometrical arrangements. Modeling the process of maturity is, in our belief, one of the best ways to increase robustness and reliability.

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